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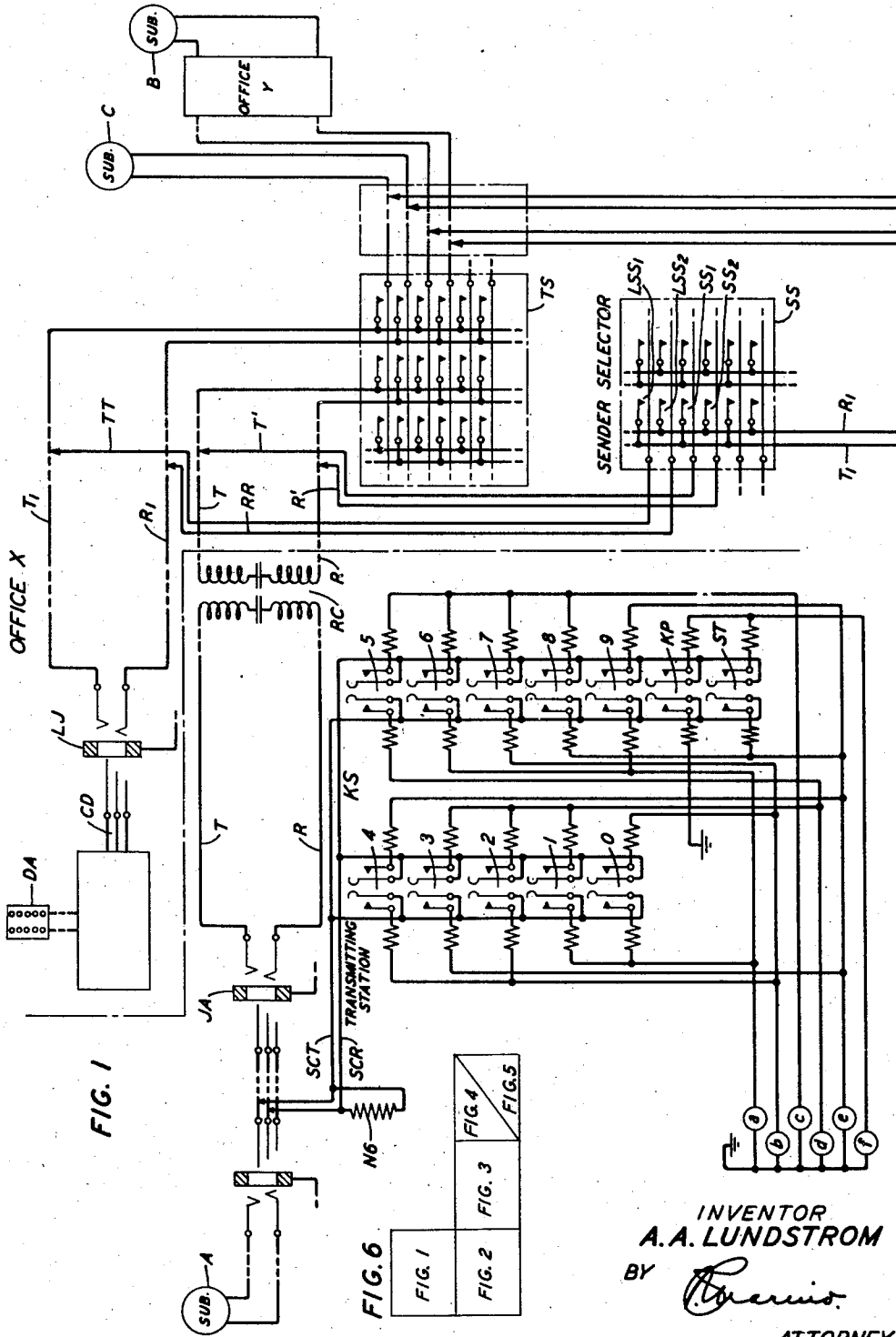
A. A. LUNDSTROM

2,356,330

SIGNALING SYSTEM

Filed April 9, 1943

5 Sheets-Sheet 1



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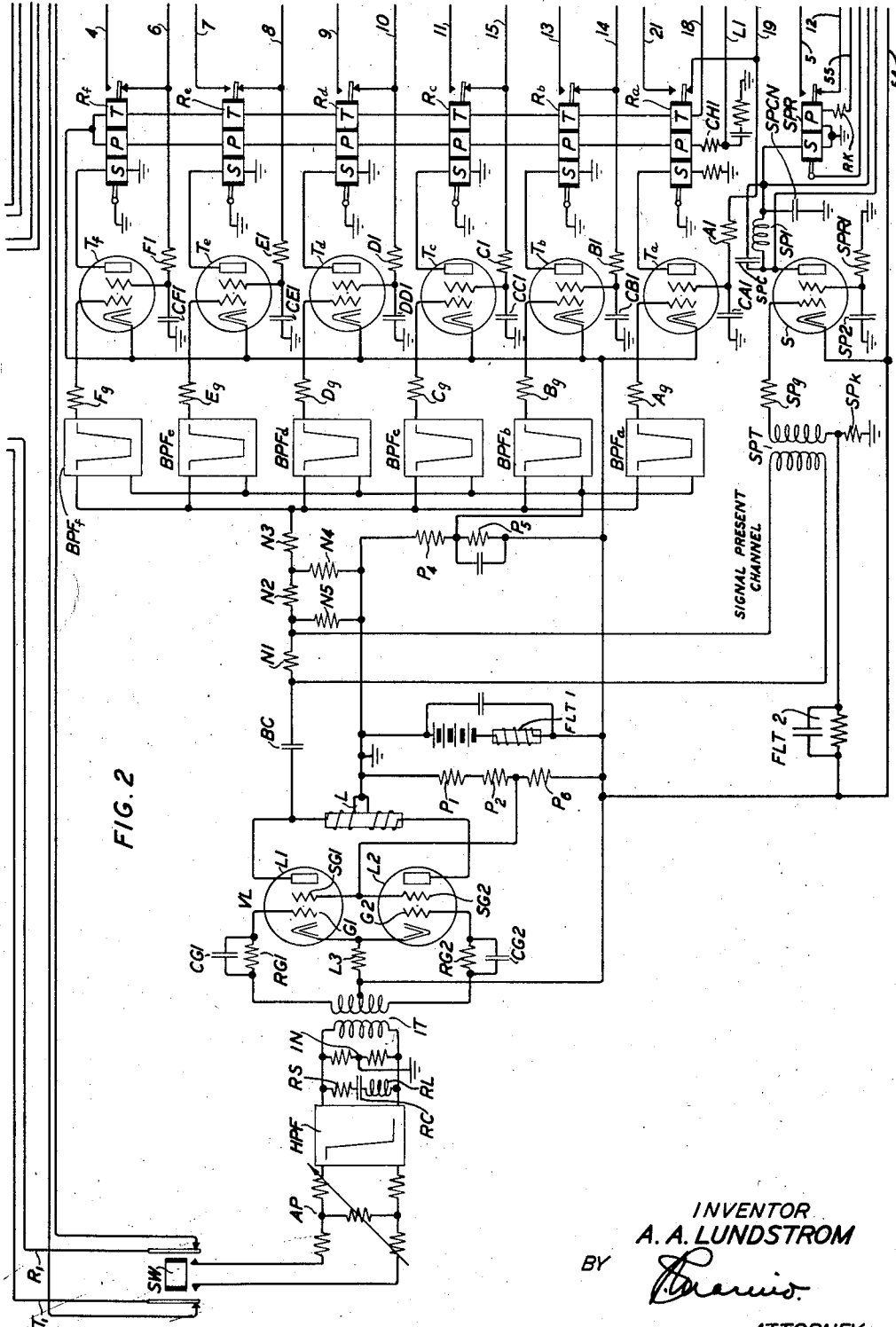
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SIGNALING SYSTEM

Filed April 9, 1943

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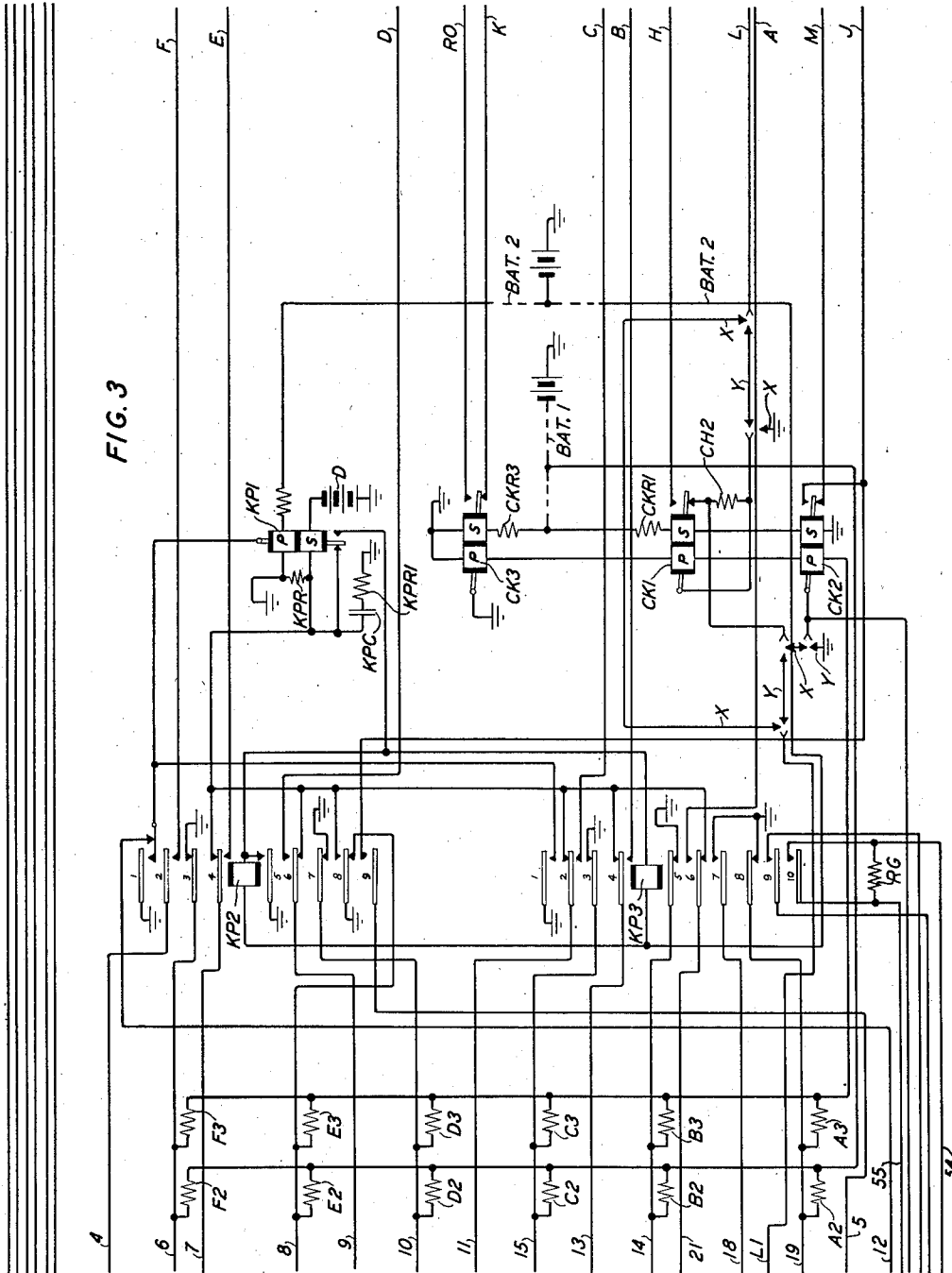
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SIGNALING SYSTEM

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FIG. 3



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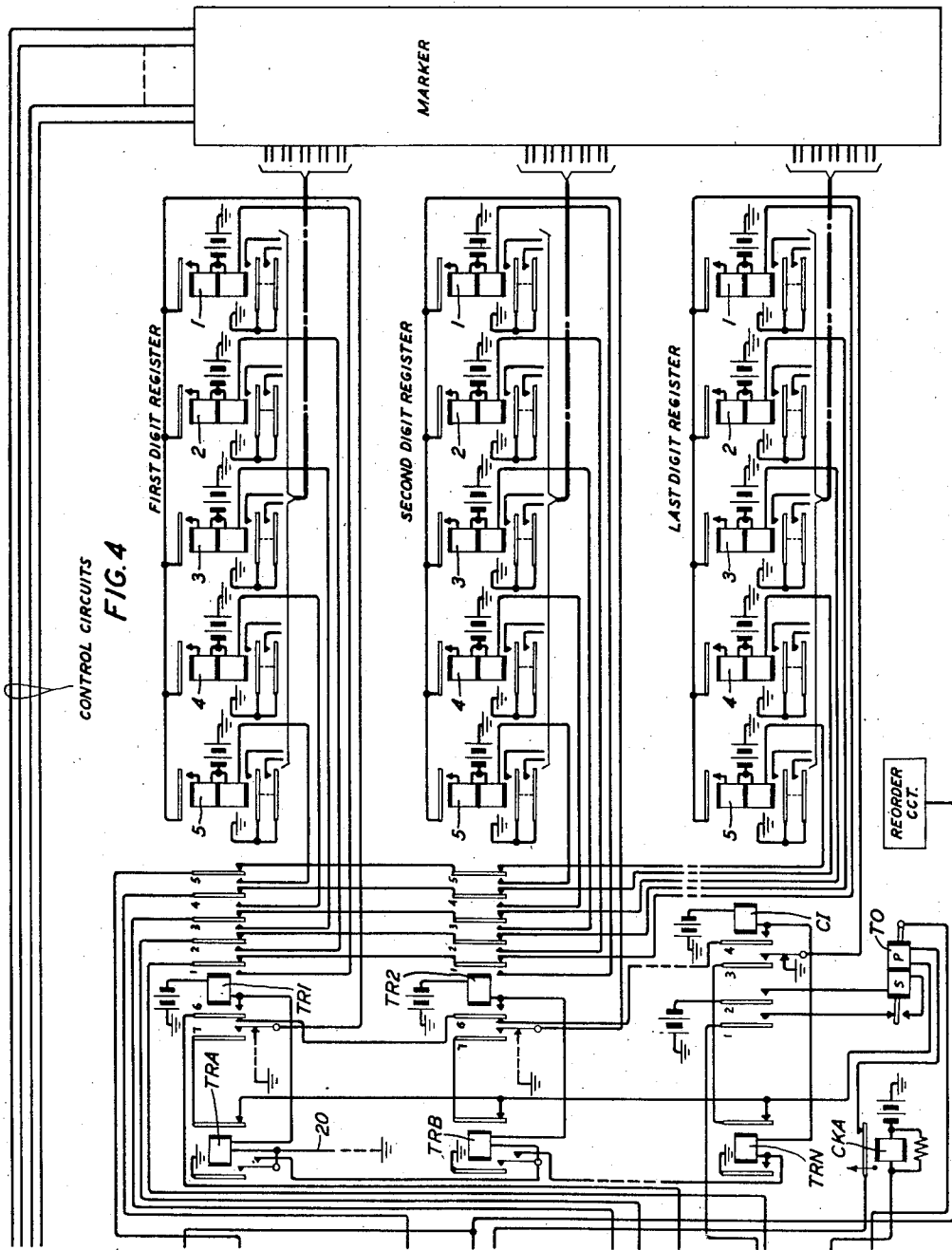
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SIGNALING SYSTEM

Filed April 9, 1943

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Aug. 22, 1944.

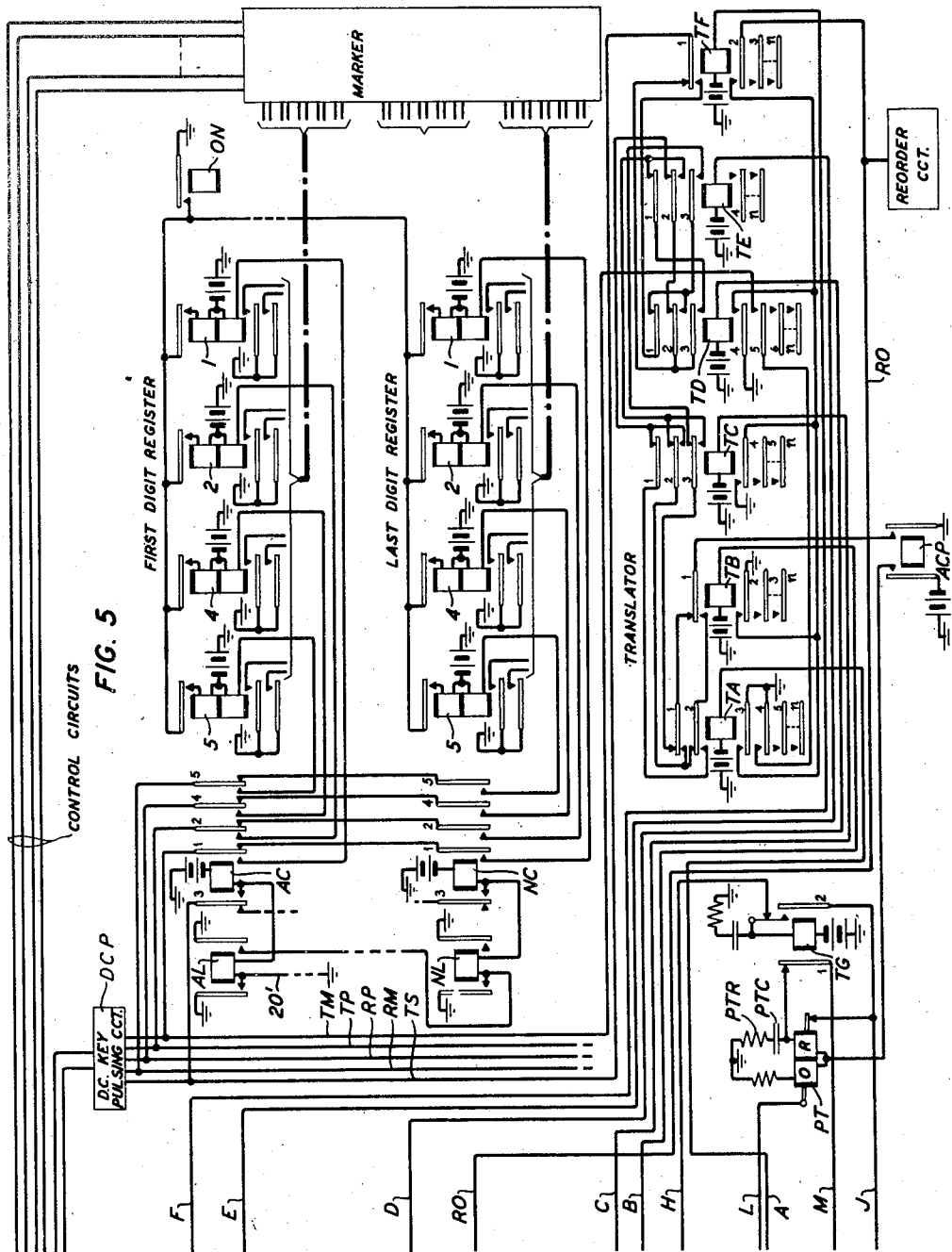
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SIGNALING SYSTEM

Filed April 9, 1943

5 Sheets-Sheet 5



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UNITED STATES PATENT OFFICE

2,356,330

SIGNALING SYSTEM

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Application April 9, 1943, Serial No. 482,358

8 Claims. (Cl. 179-27)

This invention relates to signaling systems and more particularly to a signaling system of the type disclosed in Patent No. 2,332,912 issued to G. Hecht, A. A. Lundstrom and E. R. Taylor on Oct. 26, 1943, in which means are provided for transmitting and receiving, over a suitable transmitting medium, alternating current pulses composed of combinations of frequencies preferably within the voice frequency range.

In the signaling system forming the subject-matter of the above-mentioned copending application, there is shown an alternating current pulse receiver which comprises a signal channel for each frequency in the signals, a "signal present" channel which is adapted to respond to an applied signal of any frequency composition to prepare the signal channels for response to their respective signal frequencies when the latter are applied to the receiver, a group of settable registers for recording the impulses, and a guard relay network which, when operated by the two signal channels that respond to a preliminary impulse of two frequencies applied to the receiver for a predetermined duration, prepares the registers to record the signal impulses that will follow the preliminary impulse.

The main object of the present invention is to improve the immunity of the signal channels against false operation by currents induced by noise and speech, and to carry out this improvement by means of a novel "signal present" channel which responds to a preliminary impulse of a single start or "KP" frequency within the signal frequency range if applied for a predetermined interval and will not respond on an impulse of this frequency if another frequency or frequencies are present with it, it being assumed that this and the other frequency or frequencies will have been induced by noise, speech or other disturbances and, therefore, that the signal channels are to be "guarded" against false operation on subsequent impulses since these impulses, like the false unlocking "KP" impulse, may themselves include combinations of frequencies induced by noise, speech or the like, to cause a false number registration prior to the sending of the true and wanted frequency signals when the circuit is made quiet.

Another object of the invention is the conversion of the signal present channel after its operation on the KP impulse, from an electrical network responsive to said impulse into another electrical network which will respond to the regular signal impulses that follow the unlocking "KP" impulse, the signal present channel func-

tioning, in this latter case, to make effective the operation of the signal channels for registering the impulses in settable registers.

Still another object of the invention is the use of a selective shunt across the incoming terminals of the receiver which, being resonant to the unlocking "KP" frequency and non-resonant to all other frequencies, introduces an energy loss for the unlocking frequency that will cause the unattenuated frequency or frequencies which are usually simultaneously present with the false unlocking "KP" frequency generated by speech or noise to exert a predominant influence upon the signal present channel and thereby increase its guarding action. It is assumed that, prior to impressing the legitimate "KP" signal on the line, noises and speech currents may be present which will tend falsely to operate the frequency key pulse receiving equipment. However, subsequent to the sending of the true KP signal, it is assumed that the circuit is so arranged that these noises are greatly reduced and will cause little or no trouble.

A more specific object of the invention is a novel signal present channel which combines the function of a limiter, a band-pass filter and a detector with the use of only one vacuum tube, a tuned circuit and a relay.

These and other objects of the invention will be more readily ascertained from the following description and appended claims, taken in connection with the following drawings, in which:

Fig. 1 shows the transmitting station, a trunk line to which such station may be connected, selecting apparatus by means of which the receiver may be connected to a trunk and to the transmitting station; and a skeletonized showing of two telephone connections which may be established by settable apparatus responsive to the operation of the receiver;

Fig. 2 shows the amplifier and detector circuits of the receiver into which has been incorporated the signal present channel of the present invention;

Fig. 3 shows the "check" circuit for checking the accuracy of the received impulses and the circuit which responds to the "KP" impulse;

Fig. 4 shows a group of conventional registers settable in response to the received impulses, and a conventional showing of a circuit known as a "marker" which is adapted to operate in response to the setting of some of the registers to select an outgoing trunk in the wanted direction;

Fig. 5 shows an alternative arrangement of settable registers; while

Fig. 6 shows the manner in which Figs. 1 to 5, inclusive, are to be arranged relative to each other in order to disclose the invention completely.

It will be readily understood by those skilled in the signaling arts that a signaling system arranged for transmitting and receiving alternating current impulses is adaptable to a wide variety of uses, especially indicated by the application to be made of the intelligence conveyed by the impulses transmitted over the system. My invention may, of course, be utilized in any alternating current receiver in which it is desired to protect the signal channels thereof against false operations by speech currents and the like, and in order to describe my invention, its operation and flexibility, I have chosen to disclose it in connection with its adaptation to the alternating current receiver forming a part of the telephone system shown in the above-mentioned copending application of G. Hecht et al. In this system, a calling subscriber, desiring a connection with a distant station which can be reached only by trunking facilities accessible through an operator's position in an office within the dialing area of the calling subscriber, dials the operator who, upon receiving from the calling subscriber the office and line number of the desired station, selects a trunk extending in the desired direction and causes a group of alternating current impulses indicative of the called office and station designations to be transmitted thereover into an alternating current pulse receiver which controls settable apparatus at the office in which the trunk terminates, wherefrom this apparatus, when set in response to the operation of the receiver, then controls the selective positioning of a suitable number of switches by means of which the trunk connection is further extended to the desired station. It is obvious, however, that while the invention as incorporated in such a receiver will illustrate its purpose, scope and operation, the invention itself is readily adaptable to other uses readily appreciated by those skilled in the signaling art.

Referring now to the drawings, the subscriber A establishes a connection to the operator's position within his dialing area by the well-known means and, at said position, herein referred to as the "transmitting station," informs the operator thereat that he desires to establish a connection to subscriber B whose station terminates in office Y which can be reached from the transmitting station over a trunk line that interconnects the transmitting station with office X and by another trunk which interconnects office X and office Y, said other trunk being selectively connectable to the trunk between the transmitting station and office X by equipment at office X which operates in response to the receiving circuit after the latter has received the pulses designating the wanted connection. The operator, upon learning of the desired office and station from the calling station A, selects an available trunk, say the trunk which terminates in jack JA having the conductors T and R extending to the office X, and by suitable equipment of the type disclosed in Patent 2,288,251, issued to P. B. Murphy on June 30, 1942, for example, causes conductors SCT and SCR of the key-set KS at her position to become connected through the right-hand plug of the cord and jack JA to conductors T and R respectively, of the trunk thus taken into use.

The key-set KS at the operator's position comprises a series of digit keys 0-9, a key ST and a

key KP, and all of said keys are suitably wired to six separate sources of alternating current frequencies $a \dots f$ within the voice frequency range, in a manner such that the depression of each of the keys except key KP will cause two of the frequencies to be applied across conductors T and R of the trunk via conductors SCT and SCR in the following combinations through circuits completed from the sources of frequencies involved and the undesignated resistances connected to the stationary springs of the keys:

Key	Frequencies
0	a, b,
1	a, d,
2	b, d,
3	d, e,
4	b, e,
5	c, d,
6	a, c,
7	b, c,
8	c, e,
9	a, e,
KP	f,
ST	e, f,

At office X, the trunk selected by the operator automatically causes the connection thereto of an idle "register sender" over suitable selecting equipment, for example, a sender selector device SS comprising a cross bar switch and circuits for the control thereof. Into this register sender is incorporated the receiving circuit to which my invention is applied; that is, the circuit which receives the alternating current impulses that will be transmitted by the operator through the manipulation of the key-set KS, and this receiving circuit, upon receiving the impulses, first checks them for accuracy and then causes them to become set up on groups of settable registers connected to the receiver. From the registers, the registration therein is then transferred to a "marker" which, in response to the transferred registration, then controls the operation of a cross bar trunk selector TS by which the trunk T, R, between the transmitting station and office X, is selectively positioned into connection with another trunk that extends between office X and office Y, at which latter office the sender at office X then transmits over the trunk to a sender in office Y pulses that designate the called number, whereupon the sender at office Y then initiates operations by which the connection is further extended to the terminals of the called line.

In view of the fact that the sender and marker are well-known equipment elements now extensively utilized in automatic telephony, and since the present invention is confined to a signaling system the receiving portion of which is incorporated in such a sender only by way of disclosing the parts, principles and operation of the receiving circuit, neither the sender nor the marker is disclosed except by conventional indications, the disclosure of the sender being confined to the incorporated signal-receiving circuit in its entirety, to the modification thereof to include the elements of my invention, and to a schematic showing of typical settable registers operating in response to the receiver.

The receiving circuit to which my invention is applied by way of illustration is shown in Figs. 2 and 3, and is essentially a circuit for receiving and translating alternating current signal impulses consisting of various combinations of frequencies sent out from the transmitting station two at a time, into direct current indications suit-

able for registration in an associated settable register which, comprising a part of the sender, operates in response to the registration to complete the call in the usual manner.

The receiver comprises a volume limiter VL; the "signal present" channel of this invention which includes the step-up transformer SPT, a vacuum tube S, a polarized relay SPR and associated circuit, and the resonant network made up of the inductance SPI and capacity SPC bridged thereacross, and the condenser SPCN connected to ground and to the common terminal of the left winding of relay SPR, the inductance SPI and the condenser SPC; a plurality of receiving channels, one for each frequency in the entire signal band $a \dots f$ each of which comprises a band-pass filter BPF—, a vacuum tube T— and a polarized relay R— such as, for instance, the channel reserved for frequency a which is made up of band-pass filter BPF_a, a vacuum tube T_a, and a relay R_a; the "key-pulse" signal circuit comprising relays KP1 . . . KP3 and associated circuits which operate in response to the operation of relay SPR of the signal present channel when said channel is activated by the application of frequency f as a consequence of the operation of key KP at the transmitting station as hereinafter set forth; and the check circuits comprising relays CK1 . . . CK3 and associated networks which operate in the manner hereinafter set forth to check the pulses as they are received by the various channels affected by the frequencies in said pulses.

The alternating current signals, which are alternating current voltages available across conductors T and R of the trunk, are received and applied to the input elements of the receiving circuit after relay SW is operated in any suitable manner. The input elements of the receiving circuit comprise the adjustable pad AP, which is a means for adjusting the sensitivity of the receiving circuit to the minimum required since, by keeping the sensitivity as low as possible, the likelihood of false operation on currents which may be produced by speech or noise is materially reduced; the high-pass filter HPF which is designed to filter out all low frequencies, below, say, 500 cycles, the frequency selective shunt made up of resistor RS, condenser RC and inductance RL, the latter two being tuned to the KP frequency f so that they exert a loss across the line at this frequency as determined by the value of resistor RS; the terminating resistance IN, the center tap of which is grounded; and the input transformer IT, the input winding of which is connected to the terminals of resistor IN and the output winding of which is connected to the common terminal of resistor RG1 and paralleled condenser CG1, and the common terminal of resistor RG2 and paralleled condenser CG2. The other common terminal of resistor RG1 and condenser CG1 is, in turn, connected to grid G1 of vacuum tube L1 while the other common terminal of resistor RG2 and condenser CG2 is connected to grid G2 of vacuum tube L2.

The volume limiter VL comprises the pentode vacuum tubes L1 and L2 and their associated input and output circuits. The tubes are operated in the well-known "push-pull" relation with the output of their respective anodes connected together through retardation coil L and delivered, through the blocking condenser BC and resistor N1, to resistors N4 and N5. The volume limiter provides adequate amplification of the incoming alternating current impulses to cause operation

of the desired channels but, however, limits its output signal voltage to such a value that channels other than those intended to be responsive to the frequencies in the signal will not operate on the transient currents generated at channel filter outputs of filters BPF_a . . . BPF_f by said signals when they start and stop.

The limiting action of the volume limiter VL is obtained by means of the control grid resistors and condensers RG1, CG1, and RG2, CG2 connected, respectively, to the grids of the tubes L1 and L2, which resistors and condensers cause the grid bias to become more negative when the alternating signal voltage on the grids becomes high enough to cause them to draw current during the positive half waves. When this condition is reached, the power output of the limiter becomes approximately constant regardless of further increases in the grid voltage. The actual point at which limiting occurs is controlled by the bias voltage on the screen grids SG1 and SG2, by the bias voltage on the control grids G1 and G2, by the inherent limitation on maximum plate current with zero control grid potential, and, of course, by the plate potential. The desired value of bias potential for the screen grids is obtained from the potentiometer consisting of resistors P1, P2 and P3. The grids G1 and G2 are held negative in the normal condition by the voltage drop across the cathode resistor L3.

The output of the limiter VL is divided into two parts by the resistors N1 and N5. The voltage across the resistor N1 is applied to the "signal present" channel which, as before stated, comprises the input step-up transformer SPT, vacuum tube S, polarized relay SPR and the resonant network SPI and SPC. This network is resonant for the KP frequency f only, and it will be shown that when an impulse of frequency f is applied to the receiver and this network is in circuit, the signal present channel will respond to the small signal voltage developed across resistor N1 which signal voltage, being stepped up by the input transformer SPT, is applied to the grid of the pentode vacuum tube S, which functions as a rectifier by virtue of the normal positive grid bias applied to the control grid via the positive potential available at the lower terminal of the right winding of transformer SPT from ground through resistor SP_k in parallel with battery through filter coil FLT1 and filter network FLT2 to the right winding of transformer SPT, and resistor SP_e. It will further be shown that after the KP impulse of frequency f has been applied alone to the receiver, and the signal present channel has responded thereto for the performance of certain functions to be noted hereinafter, the resonant network SPI—SPC is removed from circuit and the signal present channel will thereafter respond to the voltage developed across resistor N1 by the impulses that follow the KP impulse so as to cause the channel to perform certain other functions having to do with the registration of these impulses. The signal voltage across resistor N5 is passed through the resistor network comprising resistors N2, N3 and N4 to the inputs of filters BPF_a . . . BPF_f; the latter acting to separate the signaling frequencies into the bands corresponding to the mid-band frequencies a, b, c, d, e and f , respectively.

The resistor network N2, N3 and N4 serves a three-fold purpose: (1) It provides attenuation to produce the desired relationship between channel sensitivity and the output of the volume limiter VL; (2) it provides a relatively constant

impedance termination between the filters and the widely varying output impedance of the volume limiter; and (3) it attenuates transient disturbances reflected back from the filters to such an extent that they do not cause objectionable chatter of relay SPR.

As above stated, the control grid of the tube S is normally held positive by the voltage obtained from battery filtered through FLT2 and resistor SPk, the ohmic value of which is selected to provide that bias potential to insure tube saturation. This positive bias, together with the reduced screen grid voltage obtained by the use of resistor SPR1 connected to the screen grid of the tube, improves the operation of the circuit and reduces the effect of tube variations. Condenser SP2 is provided to by-pass the alternating current around resistor SPR1. Relay SPR has its secondary winding S connected in the plate circuit of the tube S, while its primary winding P is connected to battery through the series resistors RK, RG and the filtering retard coil FLT1 in opposition to the secondary winding S. When there is no signal of any kind present on the trunk and, therefore, no signal voltage is available across resistor N1 for application to the grid of the vacuum tube S via the transformer SPT, the plate current flowing through the winding S of the relay SPR is sufficiently large to overcome the effect of the current normally flowing through the primary winding P, and the relay remains normal; that is, with its armature resting on its lower contact. But when an alternating current signal voltage is available across N1 and the same is applied to the grid of the tube after having been stepped up by the transformer SPT, the plate current may or may not be reduced because of the change in the potential of the grid, and the current through the winding P of the relay SPR may or may not overcome the reduced current through the winding S sufficiently to cause the operation of the relay. As will be shown, the factors which determine the reduction of plate current in the tube and, therefore, through the winding S of relay SPR, are the resonant network SPI—SPC and the frequency or frequencies of the applied signal voltage.

Referring now to the control circuit of Fig. 3 (X wiring) and to the register of Fig. 4, the armatures of relays SPR and CK2 are multiplied together and connected to ground through the normal contact and armature of relay CK1 and resistor CH2. The upper contact of relays SPR is connected to conductor 5 which extends to the armature of the No. 9 contact set of relay KP2 while the stationary contact of said No. 9 contact set is connected to the upper contact of relay CK2 and to conductor J, the latter extending to the armature of polarized relay TO and thence via the upper contact thereof and the No. 1 contacts of relay CI, which is assumed to be operated at the time relays SPR and CK2 come into play as will be described hereinafter, to conductor L, conductor L1, resistor CH1, and thence to the operate P windings of relays Ra . . . Rf to negative battery through retard coil FLT1. Now it will be shown that when relay SPR operates in response to the KP signal of a single frequency, relays KP2 and KP3 will operate in consequence thereof, and when relay SPR operates thereafter in response to the impulses that follow the KP impulse, it will apply ground through the No. 9 contacts of relay KP2, serially over conductors J and L1 to the operate windings P of all of the

channel relays Ra . . . Rf, preparing the same for operation when their associated channels will have responded to the frequencies in the signal as hereinafter set forth. It may be noted here, however, that the operation of relay CK2 has the same effect as the operation of relay SPR upon the impulses that follow the KP impulse and, also, that when relay CK1 operates, it removes the short-circuit around resistor CH2 and causes the same to be inserted in the ground being supplied to the armatures of relays SPR and CK2 for a purpose which will be explained later.

When the register of Fig. 5 is used, however, and Y wiring is provided in Fig. 3, the armatures of relays SPR and CK2 are connected directly to ground and, after the operation of relay KP2, their respective upper contacts which are multiplied together and connected to conductor J and further extended to the bottom contact and armature of polarized relay PT and the armature of the No. 2 contacts of relay TG, are again extended to conductor L, which is connected to resistor CH2 and to the armature of polarized relay CK1. It will be noted, however, that the operate windings P of the channel relays Ra . . . Rf are connected to conductor L1, which is connected to the other end of resistor CH2 and to the lower contact of relay CK1, so that conductor L1 joins conductor L either directly through the armature and lower contact of relay CK1 when said relay is released, or via resistor CH2 when said relay is operated. Hence when, subsequent to the operation of relay KP2, relay SPR operates in response to a signal forthcoming over the trunk, or when relay CK2 operates as hereinafter set forth, ground is applied serially over conductors J, L and L1 to the operate windings P of all the channel relays Ra . . . Rf, preparing the same for operation when their associated channels will have responded to the frequencies in the signal as hereinafter set forth.

Since the "signal present" channel is connected to the volume limiter VL ahead of the channel filters BPFa . . . BPFr (by virtue of its connection across the terminals of resistor N1), and since no filter immediately precedes the grid of tube S, any signal of sufficient magnitude available at the output of the limiter will be applied to the grid of said tube with consequences to relay SPR which, as explained hereinafter, will depend upon the frequency of the signal and upon whether or not the resonant network SPI—SPC and resistor RG are in circuit. The channel relays Ra . . . Rf, on the other hand, will be operated only when frequencies passable through their associated channel filters are present in the signal. Now in any signaling system where speed of transmission is essential to insure the maximum utilization of a minimum quantity of apparatus, and the signals are transmitted under manual control of a kind that the signals and the time interval between the signals may not be of uniform duration, it is necessary to register a received signal as quickly as possible upon appropriate settable register relays connected to the contacts of the channel relays, to prepare the channels for reception of the next signal by releasing the operated channel relays immediately the registration is completed, to connect the contacts of the channel relays to the next settable register even though the signal is still present and yet prevent a duplicate registration of the said signal on this next settable register. The "signal present" channel, in connection with a circuit controlled by the settable

registers as hereinafter set forth, insures the correct performance of these functions by providing means that will cause the operate circuits of the channel relays to remain open once they are opened even though the signal is still present, and will cause them to remain open until the signal is no longer present.

In order to understand how these and other functions are performed, the description of the remaining elements of the receiver will be given in connection with their operation.

When a sender is seized via the sender-selector apparatus SS and connected to the trunk taken into use by the operator at the transmitting station, conductors T and R of the trunk are connected to the signaling conductors T' and R' and thence via the sender-selector SS to leads T₁ and R₁, respectively, of the receiver circuit incorporated in the sender, and operations are then initiated in the sender whereby positively grounded battery is connected to conductors BAT₁ and BAT₂, it being understood that suitable sources of current (not shown) have previously been or are continuously connected to the filaments of all the electronic tubes of the receiver. Battery on conductor BAT₁ completes an obvious circuit through the secondary S, or bias, windings of polarized relays CK₁, CK₂ and CK₃ thereby causing the energization of these windings but not the operation of the armatures of the relays, the normal condition of each of said armatures being assumed as in engagement with their respective lower contact as shown. Battery over conductor BAT₁ is also connected to resistors A₂ . . . F₂ in preparation for changes in the potential applied to the screen grid electrodes of the channel vacuum tubes Ta . . . Tf. Battery on conductor BAT₂ completes an obvious circuit to the primary winding P of polarized relay KP₁, but this relay remains with its armature engaged with its left contact because the secondary winding S of the relay is also energized from battery D connected directly thereto, completing a circuit over the left contact and armature, No. 1 normally made contacts of relay KP₂, conductor I₂, armature and lower contact, contact of relay SPR to ground aforetraced thereon. Battery on conductor BAT₂ is also connected to the windings of relays KP₂ and KP₃ in preparation for their subsequent operation as described hereinafter.

When the receiving circuit is thus cut through to the transmitting station at the beginning of a call, there is a brief period during which the receiver may be exposed to speech or noise currents which, if the receiving circuit were ready to receive signal frequency impulses and were connected to the impulse registers, might cause it to operate falsely and thereby cause a false setting of the register. To prevent this, the receiving circuit is normally held in a condition in which signal impulses cannot be registered until after a definite timed pulse consisting of frequency f only is received, which impulse is transmitted from the transmitting station by the operation of key KP thereat which, over its right contacts, causes frequency source f to be applied to conductor SCR. This conductor, via resistor N₆ which is bridged across conductors SCT and SCR to supply a matched terminating impedance for the trunk during the time that it is connected to the key-set, joins with trunk conductor R and causes a circuit to be completed over the left windings of repeating coil RC, conductor T, conductor SCT, left contacts of key KP to ground.

The current of frequency f flowing over this path causes a similar current to be induced in the path including the right windings of the repeating coil RC, the trunk conductors T and R, the conductors T' and R', the contacts SS₁ and SS₂ at the sender selector cross bar switch SS, conductors T₁ and R₁, the front contacts of relay SW (which is assumed to have been operated in any suitable manner), and thence through the pad AP, the high-pass filter HPF, the frequency selective shunt RS—RC—RL and the left winding of transformer IT with the grounded resistances IN bridged thereacross. The signal voltage thereby developed in the left winding of transformer IT is induced into its right winding, amplified through the limiter VL, and then applied, partly across resistor N₁ and partly across resistor N₅, the former being applied to the left winding of transformer SPT of the "signal present" channel and the latter, through resistors N₂, N₃ and N₄, to the input terminals of the channel filters BPF_a . . . BPF_r. Since only the filter BPF_r is tuned to the passage therethrough of frequency f , the voltage thereof is applied to the grid electrodes of vacuum tube Tf through resistor Fg but not to any of the other channel tubes.

Now each of the channel tubes Ta . . . Tf (which are pentode tubes) is provided with a positive grid bias from positive battery through coil FLT₁ and resistors P₄ and P₅, and a control grid resistance Ag . . . Fg, respectively, to make the tubes function as detectors. Each signal channel is also provided, as before stated, with its own individual relay Ra . . . Rf, the secondary winding S of each of which is connected in the anode circuit of its associated vacuum tube. The primary windings P of these channel relays are connected in series and obtain battery through filter coil FLT₁. The other end of the series connection of the primary windings P of relays Ra . . . Rf terminates in resistor CH₁ and thence to conductor L₁ whence the path traces back to the upper contact of relay SPR and the upper contact of relay CK₂ as already shown.

Returning, now, to the operation of the circuit, the operator will depress the key KP before depressing any of the digit keys, and thereby transmit to the receiver frequency f in the manner already described. The frequency selective shunt RS—RC—RL is tuned to the KP frequency f , and when this frequency is applied to the receiver, a loss is introduced across the incoming terminals of the receiver which is determined by the ohmic value of the resistor RS. Before considering the function of the selective shunt, however, let it be supposed that this shunt is not available, and that the KP frequency f is applied to the line. The voltage across N₁ resulting from the limiter amplification of the voltage at this frequency is applied to the primary winding of transformer SPT. This transformer is a step-up transformer the windings of which, for example, may have a 1:2 ratio. Consequently the voltage at frequency f which is applied to the control grid of tube S is twice that applied to the input of the transformer. The reason for the step-up in operation will become apparent when we consider the part played by selective shunt RS—RC—RL in aiding the circuit to discriminate between a pure KP frequency and such a frequency applied to the receiver concurrently with another frequency or frequencies but, for the present, it may be stated that the application of the stepped-up start frequency voltage to the control grid of tube S will cause relay SPR to operate. The

reason for the operation of this relay will be evident from the following considerations:

Relay SPR is polarized and its windings S and P are differently connected. The primary winding P normally draws current over a circuit which may be traced from ground, primary winding P, series resistances RK and RG, retard coil FLT1 to negative battery. This current is in a direction such that if no current is flowing through the secondary winding S, the armature of the relay would be urged into engagement with its upper contact. The secondary winding S is connected to the anode of tube S via the resonant network SPC—SPI which, it will be remembered, is tuned for frequency f . Normally the control grid of the tube S is biased positively at such a value as to cause maximum current to flow through its cathode-anode path, and since the secondary winding S forms part of this path, current flows through the secondary winding S, the circuit thereof being traced from ground through said secondary winding S, inductance coil SPI, anode-cathode space path of the tube, to negative battery through coil FLT1. This current is in a direction to cause the armature of the relay to engage its lower contact and since the current through the primary winding P is flowing in the opposite direction and is insufficient to overcome the current through the secondary winding S, the armature of the relay will remain engaged with its lower contact.

Now when the voltage at frequency f is applied to the control grid of tube S, and we remember that the positive potential normally available at the control grid is such as to produce maximum current through the cathode-anode circuit, the positive half cycle of the voltage at frequency f will produce no increase in the cathode-anode current flow since the tube being normally at saturation, further increments of positive bias to the control grid will produce no appreciable increase in plate current. Hence for the positive cycle of the signal voltage, the current flowing through the secondary winding S is practically limited to what that current is without the signal voltage being applied. The negative half cycle of the signal voltage, however, will reduce the positive bias and may even be high enough to swing the bias to negative cut-off, in which event the current through the secondary winding S may be reduced to zero. Hence the application of a signal voltage f to the control grid of tube S may cause the plate current to oscillate between maximum current on the positive cycle of the applied signal voltage and minimum current on the negative cycle of the applied signal voltage. If the resonant network SPC—SPI were not included in the anode circuit of the tube, this alternate on and off switching action of the tube would cause relay SPR not to operate since, on the positive cycle, both windings of the relay would draw full but opposing currents, charging condenser SPCN which would discharge to ground through the secondary winding S on the negative cycle and thereby maintain enough magnetic opposition that would cause the armature of the relay to remain engaged with its lower contact. The resonant network SPC—SPI, however, functions in this case to reduce the cathode-anode current so that the relay will be affected only by the current flowing through its primary winding.

As before stated, this network is tuned to the KP frequency f ; that is, the inductance SPI and

the capacity SPC are so matched as to cause a dissipation within themselves of any energy applied to the two terminals thereof which is caused to oscillate at frequency f . Since this network is connected between the plate of the tube S and the winding S of relay SPR, it follows that when a voltage of frequency f is applied to the control grid of the tube, the network offers a practically infinite impedance to the passage of any cathode-anode current. Under these circumstances there is practically no current flowing through the secondary winding S of relay SPR, and since this relay is now influenced only by the steady current flowing through its primary winding P, the armature thereof will move into engagement with its upper contact to perform functions to be described hereinafter, said armature remaining in the operated position as long as the voltage at frequency f continues to be applied to the control grid.

Let it now be supposed that the KP frequency f is concurrently applied with an unwanted frequency X, say a frequency induced by speech or noise which is higher than any frequency that may be suppressed by the high-pass filter HPF. As before, the amplified voltage made available at N1 is stepped up by transformer SPT and applied to the control grid of tube S. The fluctuations of the grid potential are now those due to frequencies f and X, and since the network SPC—SPI is not tuned for any energy oscillating at this or any other combination of frequencies, the impedance introduced thereby in the cathode-anode circuit is considerably reduced; so much so, in fact, that current will now flow through the cathode-anode circuit, the quantity flowing being influenced by the extent to which the voltage at frequency X exceeds that at frequency f . Obviously if the voltage at frequency X were to be applied to the control grid alone, or with voltages carried by frequencies other than f , the impedance would be practically nil since the network SPC—SPI is not resonant with respect to any frequency but frequency f . Under these circumstances full current will flow through the secondary winding S of relay SPR and the armature of the relay will thus be prevented from leaving its lower contact. Since the object of the circuit is to cause relay SPR to operate when the voltage applied to the control grid is due to frequency f only and to cause it not to operate when this voltage is applied simultaneously with a voltage at any other frequency or frequencies, it is apparent that, to obtain the full effect of the resonant network SPC—SPI in offering high impedance in the first case and little or no impedance in the second, the voltages carried by the unwanted frequencies must exercise a preponderant influence, which they can do only if these voltages are greater than the voltage at frequency f . To produce this effect, the selective shunt RS—RC—RL is bridged across the line between the high-pass filter HPF and the mid-grounded resistors IN. It may here be remarked parenthetically that a signal channel is provided for frequency f , namely the channel comprising the filter BPF_r, the tube T_r and relay R_r. That part of the signal voltage at frequency f which is available at resistor N5 is, of course, applied to the channels and causes the operation of relay R_r. However, since relay KP2 is normal at this time and will not be operated until the signal present channel has completed its function in response to frequency f , the operation of relay R_r

during the operation of the signal present channel will have no effect. The signal channel for frequency f is provided to supply the proper combination of two frequencies (e and f) for the start signal transmitted from the transmitting station. This start signal is not to be confused with the KP signal, the latter being transmitted before the digital impulses and the former being transmitted thereafter. When no start signal is required, the channel for frequency f may, of course, be omitted.

The shunt RS—RC—RL is resonant at frequency f , and the ohmic value of the resistor RS is so chosen that the loss in voltage introduced thereby at frequency f is equal to the gain in voltage attained through the step-up characteristics of transformer SPT. But although the voltage lost at frequency f is equal to that gained through the transformer, the fact that the selective shunt is tuned to frequency f will cause the voltage at any other frequency concurrently applied to go through undiminished in intensity since, for this other frequency, the shunt offers a very high impedance to the passage of current therethrough. The result is that while that component of the voltage at frequency f is reduced by the shunt, the component due to some other simultaneously applied frequency or frequencies is not, and since both components are amplified in proportion by the volume limiter VL and raised in proportion by the transformer SPT, it follows that the voltage at the frequency simultaneously applied to the control grid of tube S with frequency f will have a greater effect than the voltage at the latter frequency. Therefore, under the circumstances of a simultaneous application to the control grid of tube S of a voltage component due to frequency f and a voltage component due to some other frequency or frequencies, the resonant network SPC—SPI introduces very little impedance in the cathode-anode circuit of the tube and current of an intensity sufficient to overcome the current through the primary winding P of relay SPR will flow through the secondary winding S of said relay to cause the armature thereof to remain in engagement with the lower contact. In other words, the signal present channel "guards" the receiver by refusing to respond to the KP signal frequency f which makes up this signal is simultaneously applied to the receiver with any other frequency. If frequency f is applied alone, the impedance of the resonant network SPC—SPI is very high and the current through the cathode-anode circuit of the tube S and the secondary winding S of relay SPR is reduced to a quantity that will be insufficient to overcome the current flowing through the primary winding P, and the armature of the relay will, on this account, be caused to move into engagement with the upper contact. If the frequency f is applied simultaneously with some other frequency or frequencies, the voltage at frequency f is reduced by the selective shunt RS—RC—RL, the voltage at the other frequency is undiminished and both voltages after being stepped up, are applied to the control grid of tube S. Since the resonant network SPC—SPI is not tuned to the combination of frequencies, and since the voltage at the frequency for which the network is not tuned is greater than the voltage at the frequency for which it is tuned, the network offers very little impedance to the passage of current through the cathode-anode path, with the result that the current in the secondary winding S of relay SPR

will overbalance the current in the primary winding and cause the armature of the relay to remain in engagement with its lower contact.

Having described the electrical characteristics of those elements of my invention which cause it to guard the receiver from operating when the preliminary or KP frequency f is not transmitted alone from the transmitting station, I will now describe the operation of the remainder of the receiver together with the registration of the signals transmitted after the KP frequency, and show how the signal present channel first operates in response to the KP frequency f to extend a group of conductors from the signal responsive relays of the various signal channels to a group of settable registers and how, thereafter, it responds to the regular signal impulses to prepare the channel tubes Ta . . . Tj for response to these impulses.

When the operator depresses key KP, the frequency f is applied to the line with effects upon relay SPR which have already been noted, namely, that the relay is caused to operate and remove ground from the secondary winding of relay KP1. When key KP is released and frequency f is removed from the line, relay SPR is released, thereby closing the circuit through the secondary winding S of relay KP1 and causing this relay to operate slowly on its primary winding, the slowness of its operation being due to the charging current for condenser KPC flowing through its secondary winding S, which current opposes the current flowing through the primary winding P. When the condenser KPC is completely charged, the current flowing through the winding S of the relay is limited by the high resistance KPR, and since the resulting magnetic flux is smaller than that produced by the current flowing through the primary P winding, the relay is caused to operate. It is assumed that key KP is kept in an operated position long enough to insure the operation of relay KP1.

Resistor KPR is provided to insure that the armature of relay KP1 shall always engage its left contact when the circuit is idle. If this resistor were omitted, the removal of battery from conductor BAT2 during the time between the breaking of the left contact of relay KP1 and the operation of relays KP2 and KP3 would leave the circuit blocked since condenser KPC would be then charged and no current would be flowing in the secondary winding S of relay KP1 to release it.

With relay KP1 operated and relay SPR in its normal condition after the termination of the KP signal, a circuit is completed for relays KP2 and KP3 extending from aforetraced ground on the armature and lower contact of relay SPR, conductor 12, No. 1 normally made contacts of relay KP2, armature and right contact of relay KP1, windings of relays KP2 and KP3 in parallel to battery on conductor BAT2. Both relays operate on this circuit and lock to ground on the No. 5 contacts of relay KP2, the No. 1 front contacts of relays KP2 and KP3 maintaining the ground via the armature and contact of relay KP1 as relays KP2 and KP3 operate. Relay KP2, over its No. 8 front contacts, now re-applies ground to the secondary winding S of relay KP1, increasing the current flow there-through in consequence thereof and causing relay KP1 to release and reestablish its armature into engagement with the left contact.

Relay KP2, over its No. 9 contacts, extends conductor 5 to conductor J and thus connects the

upper contact of relay SPR to said last-mentioned conductor for purposes hereinafter set forth. Relay KP3, through its No. 9 contacts, on the other hand, short-circuits the resonant network SCP—SPI thereby removing this network from the cathode-anode circuit of the tube S and short-circuits resistor RG through its No. 10 contacts to increase the bias current in the P winding of relay SPR, and causing the current through the secondary winding S of this relay thereafter to be reduced by not more than 50 per cent due to the reduction of anode-cathode current in every other half cycle regardless of the frequency of the signal applied. However, the increase of current through winding P by short-circuiting resistance RG allows relay SPR to operate on current reductions in S of 50 per cent and something less so that the operation of this relay will be independent of frequency and will be suitable for use as a signal present relay for digit signals subsequent to the KP signal. It is to be noted that, for the start signal after digit signals have been received, a frequency combination of $e \dots f$ is used. Since frequency f would then be attenuated by the shunt resonant network RS—RC—RL ahead of transformer IT, this network can either be removed by the use of a contact on the relays KP3 or KP2, upon the reception of the KP signal or the sensitivity of detector f channel be increased to compensate for it. Another alternative is to increase the intensity of the frequency f signal with respect to the other frequencies to compensate for the added loss at this frequency.

Relays KP2 and KP3, upon operating, perform the general function of extending the upper contacts of the channel relays $Ra \dots Rf$ to conductors A $\dots$ F, five of which, in the register of Fig. 4, extend through contacts on a previously operated "steering" relay TR1 to the lower windings of the relays of the first digit register in which the first operations of the relays $Ra \dots Rf$ in the proper combinations will be registered. In the register of Fig. 5, an extra translating step is required, as explained hereinafter, so the five registering conductors A $\dots$ F are connected directly to the windings of five translating relays the contacts of which are connected through contacts on a previously operated steering relay AC to the lower windings of the relays of the first digit register. With either arrangement, subsequent operations of relays $Ra \dots Rf$ in the proper combination will be registered in the first and succeeding groups of register relays. Relays KP2 and KP3, upon operating, also remove ground from the vacuum tube side of the resistors A2, A3 $\dots$ F2, F3, but ground is still maintained on each pair of resistors (as, for example, resistors A2, A3) through the lower contact of each channel relay to maintain the screen grid electrode of the corresponding channel tube at the required potential. As explained in detail later, when the circuit is in this condition, the screen grid potential of each channel tube T— is changed when the corresponding channel relay operates, whereas in the original condition of the circuit with relays KP2 and KP3 normal, the operation of the channel relays has no such effect. In addition, relay KP3, over its No. 7 contacts and conductor 18, supplies ground to the serially connected tertiary windings T of all the channel relays $Ra \dots Rf$. These tertiary windings are poled to oppose the primary windings P of said

relays and, for certain operations described hereinafter, function to release the relays.

As previously indicated, it is necessary that frequency f be received for a definite length of time without any other frequency if the circuit is to unlock; that is, if relay KP1 is to operate and relays KP2 and KP3 are to operate in consequence of the operation of relay KP1. If an impulse containing one or more of the signal frequencies $a \dots f$ should appear at any time before relays KP2 and KP3 will have been operated, the corresponding channel relay, or relays, will, of course, operate. But since relays KP2 and KP3 are normal, their operation will have no effect so that, upon the termination of the impulse, the relays will restore since with the removal of the grid potential from the associated tube by the termination of the impulse, the full plate current is restored which, flowing through the secondary winding S of the associated channel relay, will cause the latter to restore. It will be noted that during these assumed operations, the screen grid electrode of each tube remains grounded through appropriate contacts of relays KP2 and KP3 and, therefore, will have no effect upon the intensity of the plate current when the signal potential is removed from the grid. That is, prior to the reception of the "KP" signal, the channel relays $Ra \dots Rf$ are free to operate and release in accordance with the application and removal of the incoming alternating current signals to the control grids of their respective tubes. The reason for this is because the screen grids of the several channel tubes, being grounded at the contacts of relays KP2 and/or KP3, are powerless to change the intensity of the associated plate currents when the latter increase to their normal strength upon the removal of impulse potential, in consequence of which the several channel relays restore to normal in response to the preponderating bias current flowing through their respective secondary S windings. After the "KP" signal has been received, however, and relays KP2 and KP3 have been operated in consequence thereof, direct ground formerly supplied via their back contacts to the screen grid electrodes of all the channel tubes is removed and these electrodes are connected to ground only as long as their respective channel relays remain on their back contacts. The result is that, when a channel relay operates, the screen grid potential of its associated vacuum tube is changed in such a way that the relay is locked up. This locking action is caused by the fact that when a channel relay operates, after the anode current flowing through its bias winding S has been reduced sufficiently by the incoming signal, the operated relay, by causing its grounded armature to break with its associated lower contact, removes ground from the screen grid of its associated vacuum tube and causes the latter to be connected to a potentiometer which supplies a much lower voltage than normal between screen grid and cathode. In consequence, the plate current of the tube remains reduced after the signal has terminated and the control grid electrode has been restored to its normal potential in consequence thereof.

Thus if we assume that a signal composed of frequencies a and b is transmitted before the "KP" frequency f is transmitted and, therefore, before relays KP2 and KP3 are operated, the signal voltage due to the frequencies a and b is applied to the control grids of channel tubes Ta

and Tb, respectively, and the current through their respective anode circuits (including the secondary S windings of relays Ra and Rb) is reduced and relays Ra and Rb will operate on the current flowing serially through their primary windings. When operated, relay Ra opens one of the two paths by which ground reaches conductor 19, and relay Rb opens one of the two paths by which ground reaches conductor 14. Since relays KP2 and KP3 are normal, ground is still applied to the screen grid electrodes of tubes Ta and Tb via conductors 19 and 14, respectively, over contacts 8 and 5, respectively, of relay KP3. The presence of ground on these electrodes will cause the reduction of the anode current to be determined exclusively by the potential of the signal applied to the control grids of the respective tubes so that, when the signal ceases, the anode current is restored to its original value and relays Ra and Rb release. When, however, the signal is transmitted after the operation of relays KP2 and KP3 and the consequent removal of ground supplied over their back contacts to leads 6, 8, 10, 14, 15 and 19, the channel relays corresponding to the two frequencies in the signal now operate as before but, in so doing, remove ground from the screen electrodes of their respective tubes as, for example, tubes Ta and Tb. With ground removed these electrodes are connected to a potentiometer comprising resistors A2 and C2, A3 . . . F3, and the P windings of relays CK1 . . . CK3, as follows: Resistors A2 and C2 connected to battery over conductor BAT1, while resistors A3 and C3 connected to ground via a circuit consisting of the serially connected primary windings P of relays CK1, CK2, and CK3 shunted by the four resistors B3, D3, E3 and F3 in parallel. The potential applied by this network to each of the screen grid electrodes of the tubes Ta and Tb is lower than that available thereto by the previous ground connection and this will cause a further reduction in the anode current. When the signal voltage ceases, the control grids are restored to their normally positively biased state, but since a low potential is still available at the screen grid electrodes from the potentiometer network, the anode current will still be reduced notwithstanding the restoration of the control grid electrodes to their normal state, causing relays Ra and Rb thereby to remain in an operated condition until their operate P windings are opened.

It will be noted that when relay KP2 operates, it applies ground over its No. 8 contacts to the secondary winding S of relay KP1 and to condenser KPC in the same way as the channel relays Ra, Rb, Rc, Rd, and Re when and if they, or any of them, operate on an alternating current impulse prior to the appearance of the timed "KP" impulse of frequency f . This ground causes relay KP1 to release and condenser KPC to discharge as above described, but the release of this relay does not interfere with the operation of relays KP2 and KP3 since these relays are now locked to ground on the No. 5 contacts of relay KP2. The purpose of this arrangement is to make sure that the timing circuit, comprising relay KP1 and condenser KPC, is normal and ready to give a complete timing cycle on the next call. A sequence adjustment of the No. 5 contacts of relay KP2 insures that these contacts close ahead of the No. 8 front contacts which release relay KP1.

As already stated, the alternating current signal code impulses consist of various combinations of two frequencies $a . . . f$ sent simultaneously according to the code previously given.

In the receiving circuit, a part of the signal voltage of these frequencies is applied through the network N4—N5 to the filters of the signal channels, while a portion of the voltage is available across resistor N1 and applied to the primary of transformer SPT and, by induction, to the control grid of signal present tube S. The cathode-anode current through the circuit of this tube is now reduced, causing relay SPR to operate over its primary winding P and apply ground on conductor 5, thence through the No. 9 contacts of relay KP2, conductor J and thence as traced to conductor L1, resistor CH1 and the primary windings P of the channel relays Ra . . . Rg, completing the circuit to battery through retard coil FLT1. Although current now flows through the primary winding P of each of the channel relays, none of these relays will operate until current through their respective secondary windings S is diminished by the application of signal potential to the control grids of their respective channel tubes.

With current thus established through the primary windings P of all the channel relays, the application of a signal potential to the control grids of any two of the channel tubes Ta . . . Tj in accordance with the impulse received will cause their respective associated channel relays to operate. After the operation of relays KP2 and KP3 by the "KP" impulse signal which, as above noted, is transmitted ahead of the digital impulse codes, the operation of one or more of relays Ra . . . Rf, as above set forth, causes ground to be applied to the corresponding conductors A . . . F, which connect with the settable registers (Fig. 4) or the translating relays associated therewith (Fig. 5), causes ground to be removed from the corresponding resistors A2 . . . F2 to reduce the voltage on the screen grids of the associated vacuum tubes, causes the operated channel relays to lock in consequence thereof as already described and, further, allows current to flow through the primary windings P of relays CK1, CK2 and CK3 in an amount almost directly proportional to the number of relays Ra . . . Rf which are operated. It will be noted that, prior to the reception of the "KP" signal, relays CK1, CK2, CK3, cannot function because they are, in effect short-circuited by the grounds applied to leads 6, 8, 10, 14, 15 and 19 from the back contacts of relays KP2 and KP3.

Relays CK1, CK2 and CK3 are all polarized relays. The operate current through the respective primary windings P and the bias currents through the respective secondary windings S are so proportioned that none of them will operate when a single channel relay Ra . . . Rf is operated. Relays CK1 and CK2 will operate, however, when two of said channel relays operate because of the increase in current through the primary winding P, and relays CK1, CK2 and CK3 will operate when three or more of said channel relays operate because of a still higher increase in the current through their respective primary windings P. Thus, for example, if, after the transmission of the "KP" signal and, therefore, after the operation and locking of relays KP2 and KP3, the operator were to depress the digit key 1 to put forth upon the trunk an impulse consisting of frequencies a and d , said impulse would cause the operation of relays Ra and Rd, in consequence

of which ground would be removed from the screen grid electrodes of channel tubes Ta and Td and, also, from conductors 19 and 10. Now while the current flowing through the secondary windings S of relays CK1, CK2 and CK3 is fixed and determined by the ohmic resistance of each of said windings and the ohmic resistance of resistors CKR1 and CKR3, the current that will now flow through the primary windings P of these relays is determined by the ohmic resistance of said separate windings and by the number of parallel paths to battery BAT1 which will be formed through resistors A2, A3 . . . F2, F3 by the operation of the number of channel relays. In the case assumed, relays Ra and Rd are operated; consequently, the current that flows through the primary windings P of relays CK1, CK2 and CK3 is determined by resistors A2 and D2 and A3 . . . F3, the actual path tracing from ground, serially through the primary windings P of relays CK1, CK2 and CK3, with resistors B3, C3, E3 and F3 in shunt therewith, resistors A3 and A2 to battery BAT1 and, in parallel therewith, through resistors D3 and D2 to battery BAT1. The quantity of current flowing through this circuit will produce sufficient magnetic flux in the relays to overcome the flux due to the current flowing through the secondary windings S of relays CK1 and CK2 and will cause said relays to operate, but this current will not produce sufficient flux to overcome the current through the secondary winding S of relay CK3 which, on this account, remains unaffected. Relays CK1 and CK2 will remain operated until ground is reapplied to conductors 19 and 10 on the release of relays Ra and Rd, which will be described later.

Should there be three frequencies in a digital impulse, say frequencies a, d and c, then relay Tc will operate along with relays Ta and Td, and ground will be removed from one side of resistors C2, C3 whereupon the circuit of relays CK1, CK2 and CK3 will take on an additional parallel branch through resistors C2, C3 to battery BAT1, resistor C3 being removed as a shunt around relays CK1 . . . CK3, and the current flowing through the primary windings P of relays CK1, CK2 and CK3 will be increased so that, this time, the flux will be sufficient to overcome the flux due to the current flowing through the secondary winding S of relay CK3, which will now operate along with relays CK1 and CK2. Relays CK1, CK2 and CK3, therefore, serve to check each of the incoming signals and, as will be shown, will advise the sender whether or not it should register these signals.

Considering the operation of the receiver in connection with the settable registers of Fig. 5 (and Y wiring in Fig. 3), the operation of relay CK2 removes ground from conductor M and applies it to conductor J in parallel with the ground applied to this conductor by relay SPR. Relay CK1, when operated, removes a short-circuit around resistance CH2 and effectively adds this resistance in series with the primary windings P of the channel relays Ra . . . Rf, by inserting this resistance between conductor Li and conductor L, the latter joining conductor J at the contacts of relay PT. With the primary windings P of relays Ra . . . Rf connected through resistance CH1 to ground, the circuit has its full sensitivity, but after relay CK1 operates and resistance CH2 is inserted in series with resistance CH1, the sensitivity is somewhat reduced. The reason for this slight decrease in sensitivity is to increase the protection against false operations

on transients and cross-modulations which may appear in the unoperated channels. Relay CK1 also applies ground from relays SPR and/or CK2 via conductors J and L, as traced above, to conductor H, in consequence of which a circuit is completed for relay TG over its No. 2 normally made continuity contacts, causing said relay to operate and lock over its No. 2 front contacts to ground on conductor J. Relay TG performs a function which will be shortly described.

As previously indicated, the path between conductor J and conductor L is closed in the sender at the start of each digit and remains closed until the sender opens it, after the registration of each digit, by the operation of relay PT, as hereinafter described, whereupon the channel relays are released by virtue of the fact that the circuit of the primary windings P of the channel relays is opened at the contacts of relay PT. Once this has occurred, the path to the primary windings P of the channel relays remains open and the channel relays remain released until relays SPR and CK2 both release and remove ground from conductor J, since, until this occurs, relay TG remains locked to prevent the release of relay PT. It will be noted, however, that, although the path to the primary windings P is opened at the contacts of relay PT, the operation of relay KP3 has applied ground over its No. 7 contacts to conductor 18 which is connected serially to the tertiary winding T of the channel relays, the circuit thereof being completed to battery through retard coil FLT. Now the tertiary winding T of each channel relay is connected so that the current flowing through it as a result of the circuit closed by the operation of relay KP3, is in a direction to release the relay; that is, the current is in a direction to aid the bias or secondary S winding and to oppose the current flowing through the primary P winding. Consequently, when the primary circuit is opened at the contacts of relay PT, the operated channel relays will release, either in consequence of the current flowing through their respective tertiary windings T if the signal impulse is not terminated, or in consequence of the resultant effect of the current flowing through their respective tertiary windings T and the current flowing through their respective secondary windings S if the signal impulse is terminated. Although current will, of course, flow through the tertiary windings T of the channel relays when current is also flowing through their primary windings P, the combined effect of the reduced current in the secondary winding S of the relays affected by a signal frequency and the current flowing through their respective tertiary windings T, will not be sufficient to overcome the current flowing through their respective primary windings P, in consequence of which said relays will remain operated until the primary circuit is opened at the contacts of relay PT. Those channel relays which do not have a signal voltage applied to the grid of their associated and respective channel tubes will have full current flowing through their respective secondary windings S so that these relays will remain in a released condition. Prior to the operation of relay PT as described hereinafter, the ground applied to conductor J over the upper contacts of relay CK2 insures that the digit will be registered correctly on short pulses. The reason for this is the fact that relay CK2 is held up by the locking circuit of relays Ra . . . Rf, as previously described, while the ground through the upper contacts of relay

SPR insures that there is no double registration in case the incoming signal persists for a longer time than actually required for the registration; that is, for a longer time than it takes relay PT to operate.

The registration in the sender of the succession of signal impulses transmitted from the transmitting station by the depression thereof of the appropriate sequence of digit keys of the key-set KS subsequent to the depression of key KP, depends upon the construction of the sender, the character of the settable registers therein and the manner in which these registers are to be set in response to the operation of the register relays in the combination of twos required by the frequency pulse code. Fig. 5 schematically shows the portion of a sender which, for instance, may be located in office X for the completion of a connection to a local station C, or to a telephone station B, the latter being located in office Y. If these stations are also to be reached for a call originating in office X through an operator's position provided with facilities for keying a series of direct current pulses representative of the called station designation, then the sender must be provided with corresponding facilities to register alternating current pulses when the call originates from an alternating current key-pulsing station, and to register direct current impulses when the call originates at a direct current key-pulsing station. The register for a sender adapted to handle both types of calls is illustrated in Fig. 5 and will be considered hereinafter. Fig. 4, on the other hand, shows schematically the portion of a sender which, for instance, might be used at office X for completing calls to a subscriber in that office only, such as subscriber C, when it is not necessary to accept calls from operators equipped with direct current key-sets or to complete calls to other offices, such as office Y. One of the characteristics of this register circuit, as compared with that of Fig. 5, is that it must always be supplied with a full complement of digit signals and that, having received them, it tells the sender to proceed with the call without awaiting for an ST or "start" signal to be transmitted or registered. Since such a signal may be received inadvertently, however, the register has been arranged to ignore it unless it should appear before the full quota of digit signals has been received, in which case a "reorder" indication will be given. These and other differences permit certain simplifications to be made in this case, which will be apparent from the more complete descriptions of the two arrangements that follow.

Considering first the registers of Fig. 4 (X wiring in Fig. 3) and assuming the same to be incorporated in a sender adapted to register only alternating current impulses of the character described (in which event relay SW will not be provided and conductors T₁, R₁ will be connected directly to the input terminals of pad AP), the seizure of the sender at the sender selector switch SS and the connection of the sender with the trunk will initiate circuit operations among which are, as said before, the connection of battery to conductors BAT₁ and BAT₂, and the operation of the steering relays TR₁ and TRA by the momentary application of ground to conductor 20, whereupon both relays lock serially to ground on the left contacts of relay TRA while relay TR₁ is furnished with a supplementary holding path over its No. 6 front contacts and conductor H to ground on the upper contacts of relay CK₁ when

the latter operates on the regular digit pulse. At the same time the other pairs of steering relays TRB and TR₂, TRC and TR₃, etc. up to the final pair TRN and CI, of which only relays TRB, TR₂, TRN and CI are shown, for the second and succeeding registers, are operated and locked up. With the operation of relay TR₁, the five signaling conductors A . . . E (conductor F has a different connection in a settable register of the kind shown in Fig. 4) are connected, respectively, to the operating windings of the five relays 1 . . . 5 constituting the register for the first digit and, after relays KP₂ and KP₃ have been operated by a "KP" signal, obvious circuits are completed from ground on the upper contacts of the channel relays Ra . . . Re operated in combinations of two according to the code given, over the appropriate two of the five conductors A . . . E, two armatures and right front contacts of relay TR₁ to the lower windings of the two corresponding relays of the five register relays 1 . . . 5 of the first digit register. When the first digit is registered and relay CK₁ is released, relay TR₁ is released and the signaling conductors A . . . E are advanced over back contacts of relay TR₁ and front contacts of relay TR₂ to the operating windings of the relays 1 . . . 5 of the second digit register. At the same time, the operated relays in the first digit register are locked up to off-normal ground on the No. 7 normally made contacts of relay TR₁, and conductor H is extended to relays TR₂ and TRB. Similarly, when the second digit is registered and relay CK₁ is released, relay TR₂ releases and the five signaling conductors A . . . E and conductor H are extended to the third group of steering and register relays, and so on until the last digit is registered, whereupon relay CI releases and opens conductor L to stop the reception of any further digit indications, thus preventing the reception of the ST signal, as previously indicated. If this signal should appear before the last digit is registered, however, it will cause the application of ground to conductors E and F, and since conductor F is connected to the reorder circuit, further registration will be stopped and a reorder signal will be sent back to the transmitting station as an indication of an error which must be corrected by retransmitting the whole number.

With this register arrangement, the registration of each digit is indicated by the operation of two relays in a particular register and it is possible to give a definite indication that the registration is completed, which may be done by means of polarized marginal relay TO which operates over its primary winding P as soon as two register relays of the connected register close their locking circuit, as shown hereinafter, but which will not operate when only one relay of said register operates.

Thus when a digit signal comes in, say the signal of digit 9 the pulse code of which is frequencies *a* and *e*, relay SPR operates to supply operating ground to the operate windings P of the channel relays Ra . . . R_f, as above described. Relays Ra and Re operate and lock in response to the frequencies in the signal, and relays CK₁ and CK₂ also operate for the reasons already given. Ground applied to conductor H by relay CK₁ short-circuits relay TRA which releases and thereby removes the ground it was supplying to the winding of relay TR₁, but the latter remains locked to ground on conductor H over its No. 6 front contacts until relay CK₁ releases. Circuits

are now closed for register relays 1 and 5 of the first digit register, the circuit of the former being traced from ground on the upper contacts of relay Ra, conductor 21, No. 6 front contacts of relay KP3, conductor A, No. 1 front contacts of relay TR1, lower winding of relay 1 to battery; the circuit of relay 5 being traced from ground on the upper contacts of relay Re, conductor 7, No. 4 front contacts of relay KP2, conductor E, No. 5 front contacts of relay TR1, lower winding of relay 5 to battery. Relays 1 and 5, upon operating, close a path from battery through their respective upper windings and locking contacts, No. 7 front contacts of relay TR1, right contacts of relay TRA, winding P of relay TO, contacts of relay CKA, conductor K, lower contacts of relay CK3, which is normal since only two frequencies are present in the signal, to ground. Relay TO operates, disconnects the resistance ground being supplied over conductor J from resistance CH2 via the front contacts of relay SPR and/or relay CK2, to the operate windings P of the channel relays, and locks itself to said ground on conductor J via its armature and front contacts, secondary windings S to battery via contacts No. 2 of relay CI. (Since both the P and the S windings of relay TO cause said relay to operate, a biasing spring or other suitable means must be provided to release it.) If the signal is short and relay SPR releases before registration is completed, relays Ra and Re are, nevertheless, held operated by the ground supplied to conductor J through resistance CH2 and the upper contact of relay CK2 until relay TO operates to signify that the registration of the digit has taken place. If the signal remains on longer than the time required for the register relays and relay TO to operate, the channel relays Ra and Re release but relay TO, which has been locked up as previously described, remains operated until relay SPR releases at the end of the signal pulse.

When the channel relays Ra and Re release, relays CK1 and CK2 release also, the former disconnecting ground from conductor H to cause the release of relay TR1, which, in consequence, advances the signaling conductors A . . . E over its No. 1 . . . 5 back contacts, respectively, to the armatures of the No. 1 . . . 5 contacts, respectively, of the next transfer relay TR2 from which they are extended via the front contacts of that relay to the register relays of the second digit register. The release of relay TR1 also advances conductor H over its No. 6 back contacts and the No. 6 front contacts of relay TR2 to the winding of that relay as well as relay TRB. Relay TR1, at its No. 7 contacts, also opens the connection from the winding P of relay TO to the first digit register and provides a ground for locking the two operated register relays 1 and 5 in that register. The register circuit is now ready for the second digit signal, after the reception of which it advances to the third digit register and so on until all of the digits have been registered. When ground is removed from conductor H at the end of the final digit signal, relay CI is released, and since it opens lead L at its No. 1 contacts and, therefore, lead L1, the further operation of relays Ra . . . Rf in the receiving circuit is prevented. Relay CI, through its No. 2 contacts, also opens the locking battery for relay TO and by means of contacts not shown causes the sender to advance the call.

Should only one channel relay operate due to the presence of only one frequency in the impulse produced, say, by some abnormal condi-

tion, the corresponding register relay would operate also, but the latter would not lock up since, with relay CK1 released, no ground would be applied to conductor H and relay TRA would not release in consequence thereof and no locking circuit for the register relay would be available through the primary winding P of relay TO. Should more than two channel relays operate, then relay CK3 would operate in addition to relays CK1 and CK2 for the reason already advanced and relay CK3, upon operating, would apply ground to conductor RO, completing thereby a circuit to a suitable "reorder" circuit which would function to cause a reorder signal to be sent back to the transmitting station the meaning of which, to the operator thereat, would be to retransmit the entire number. Relay CK3, by breaking its lower contact, disconnects ground from conductor K to prevent relay TO from operating.

Relay CKA, which is of the slow-release type, is normally operated by ground on conductor M applied thereto through the back contacts of relay CK2. It is released when relay CK2 operates, and serves to delay the closing of the register locking circuit and hence the operation of relay TO for a short interval in order to allow ample time for relay CK3 to function in case one or more interfering frequencies should cause the operation of more than two channel relays which would be operated by a normal digit impulse.

Fig. 5 schematically shows the registering elements of a sender in which each of the digit registers comprises four relays instead of five. A sender of this type is available not only to the trunked connection from the distant transmitting station where alternating current keying is used, but also to a local operator at office X whose position is equipped for direct current keying of impulses by which to obtain the number of the called station as, for instance, the position typified by the cord CD equipped with a key-set DA, and the local trunk designated by the jack LJ. The impulses produced by the key-set DA are direct current impulses which are registered in what is essentially a four-unit code as compared with the direct five-unit code of the alternating current signals for the registers of Fig. 4 and, for a sender which must handle digits transmitted into it by either code, either a different set of registers must be provided for each code or one set of registers may be provided for both coupled with a translating arrangement by which one code is changed into the other. For practical reasons the latter, or translating arrangement, is shown, and since the direct current pulse code is the basic one, the alternating current signal indications are converted into equivalent direct current pulse indications, the digit registers taking the direct current pulse code setting for the same digit regardless of whether the digit is transmitted by direct current pulses from the key-set DA or by alternating current pulses from the key-set KS.

The translator comprises the six relays TA . . . TF shown in the lower part of Fig. 5 but only a portion of their respective contact equipment and interconnecting wiring is shown. The six translator relays TA . . . TF are operated by the channel relays Ra . . . Rf over conductors A . . . F, respectively, when the latter relays operate after the "KP" signal has been received and relays KP2 and KP3 have been operated in consequence thereof, relay TA being operated by relay Ra, relay TB by relay Rb and

so on up to and including relay TF which is operated by relay R/.

In order to simplify the understanding of the operation of the translator, the table below is furnished to show, for each digit, what combination of translator relays is operated in accordance with the alternating current signal code and what register relay or combination of relays is operated thereby, these register relays being the same for signals in accordance with the direct current pulse code, which cause their operation by means of suitable indications placed on conductors TP, TM, RP and RM by the direct current key-pulsing circuit DCP.

Digit	Translator relays	Digit register relays	Leads grounded for direct current operation
1.	TA, TD	1	TM
2.	TB, TD	2	TP
3.	TD, TE	1, 2	TM, TP
4.	TB, TE	4	RP
5.	TC, TD	5	RM
6.	TA, TC	1, 5	TM, RM
7.	TB, TC	2, 5	TP, RM
8.	TC, TE	1, 2, 5	TM, TP, RM
9.	TA, TE	4, 5	RP, RM
0.	TA, TB	None	None
ST.	TE, TF	1, 4	TM, RP

It will thus be seen from the above table that, with the four-relay digit register, the number of relays operated to indicate the different digits varies from none for the digit "0" to three for the digit "8" when relays 1, 2 and 5 are operated. If the relays are given appropriate numerical designations, this system has the advantage that the digit itself may be identified by adding up the designations of the operated register relays. It lacks, however, the positive indication that the registration of a digit has been completed, which is obtained with the five-relay digit register of Fig. 4 wherein two relays, and only two, are always operated per digit and a relay TO is made to respond to this operation. As a consequence, it is not possible to use a marginal relay TO, as in the register of Fig. 4, to indicate that the register is satisfied, but a timing circuit must be used to insure that the channel relay circuits to the several register relays are maintained long enough for the slowest relay of the register to operate. The timing interval is obtained from polarized relay PT which is made slow-operate by means of the condenser PTC and resistance PTR associated with the right winding R of the relay, to the joint terminal of both windings of which battery is connected, through the left contacts of relay ACP which, along with relay ON, is operated in any suitable manner when the sender is seized for use on calls using alternating current key pulsing. As long as ground is supplied to the right winding R over conductor M via the No. 1 contacts of relay TG from the lower contacts of relay CK2, relay PT is held in the released position by the current flowing through said right winding R, during which time condenser PTC is, of course, short-circuited. But when ground is removed from conductor M by the operation of relay CK2, a charging circuit for condenser PTC is established from ground through resistance PTR, condenser PTC, right winding R of relay PT to battery on the left contacts of relay ACP. The charging current of the condenser is in the same direction as the current produced by the circuit completed by ground on conductor M so that, during the time that the flux produced by the charging current pre-

dominates over that of the current flowing through the left or operate winding O of the relay, the armature of said relay remains engaged to its contact to maintain ground to the operate windings of the channel relays via conductor L1, resistance CH2, conductor L, contacts of relay PT, conductor J to ground on the upper contacts of relay SPR and/or the upper contacts of relay CK2. When, however, the resulting flux drops below that due to the current flowing through the left winding O of relay PT, said relay operates to disconnect ground from the operate winding P of the channel relays with consequences already noted in connection with the register shown in Fig. 4.

The relays 1, 2, 4 and 5 of the individual digit registers are operated by grounds on conductors TM, TP, RP and RM, respectively, while the steering relays AC and AL, corresponding, respectively, to the relays TR1 and TRA of the register of Fig. 4 are controlled by ground on conductor TS. Relays AL and AC are operated in series by ground momentarily applied to conductor 20' and locked up to ground over the left contact of relay AL, and at the same time the other pairs of steering relays (not shown) between AL and AC and the steering relays NL and NC for the final register are operated, one from the other in succession, until they are all operated and locked up. With relay AC operated the conductors TM, TP, RP and RM are connected to the operate windings of the relays in the first digit register.

When direct current pulsing is involved as, for instance, in establishing a call from a subscriber in office X via a local position thereat to another subscriber either in the same office or another office, in such cases the sender is connected to the local trunk terminating in jack LJ in response to the operator having seized said trunk by plugging cord CD therein. Cord CD has the usual facilities for connecting the key-set DA across the tip and ring of the trunk, for initiating the operation of circuits, by which the selected sender is connected to the trunk LJ via the cross-points LSS1 and LSS2 at the sender selector switch SS through conductors TT and RR. Since, in this case, relay SW is normal, the trunk conductors, instead of being connected to the alternating current pulse receiver are connected to a direct current key-pulsing circuit DCP which responds to the key pulses and, in response to the operation of each digit key, causes ground to be applied to conductors TM, TP, RP and RM in accordance with the digit keyed. The grounds on these leads then complete circuits to relays 1, 2, 4 and 5 of one of the digit registers (which one depending upon the number of pairs of steering relays which have been released as the call has progressed) causing the operation of said relays in accordance with the code given, said relays locking over their upper windings and contacts to ground on relay ON which is operated at this time. Since this part of the sender equipment and its operation form no part of this invention, no further description of its operation is considered necessary.

As before indicated, relays TA . . . TF operate on the two-at-a-time basis in accordance with the alternating current pulse code, and the connections through their contacts are such that each pair that corresponds to a digit code will set up a path to the proper conductors TM, TP, RM and RP. For simplicity, only the path for

the translation and registration of the digit 1 in the first digit register is shown, concerning which, when relays TA and TD operate in response to the alternating current signal pulse of the digit 1, a circuit is completed for relay 1 of the first digit register, extending from battery through the lower winding of said relay, No. 1 front contacts of relay AC, conductor TM, No. 5 contacts of relay TD, No. 4 contacts of relay TA, to ground. Digit relay 1 operates over its lower winding and then locks over its upper winding and upper contacts to off-normal ground on relay ON.

Relays TA . . . TF, when operated in groups of twos according to the alternating current impulse code above given, also connect ground to the steering conductor TS, the path being traced from the right contacts of relay ACP, through a set of operated contacts on each of the two operated relays and a set of normal contacts on the unoperated relays of the translator. Ground on conductor TS short-circuits relay AL which releases, but it holds relay AC operated until the two operated relays of the translator release in response to the release of their associated channel relays, at which time relay AC will release and advance conductors TS, TM, TP, RM and RP to the next set of steering relays (not shown). In addition, and over obvious paths, the relays of the translator apply ground to the "reorder circuit" whenever relay TF operates with any of the other relays except relay TE. The purpose of this is to operate the "reorder circuit" and hence to cause a reorder signal to be sent back to the operator at the transmitting station under these circumstances, since the combination of frequency f with any other frequency except e (after the KP signal) is not an assigned code, and the reception of such a signal is therefore an error, which can be rectified only by retransmitting the whole number. The combination of relays TE and TF is the code of the "start" signal which is accepted in the same way as the digit signals. It is transmitted from the transmitting station by the depression of key ST thereat after all the digits are sent and, in the consequent operation of relays TE and TF, circuits are completed through the contacts of said relays to operate digit register relays 1 and 4, which in turn provide a signal for the sender to proceed with the setting up of the connection.

The circuit is made inoperative to the operation of a single translator relay by arranging the connection in such a manner that two translator relays must be operated in order to apply ground to conductors TS, TP, TM, RP and RM, and also by preventing the operation of relay PT, which is held released by ground supplied to its right winding R through normal contacts on relay CK2 and relay TG, neither of which will operate unless two channels have been energized (relay TG being under the control of relay CK1, which also requires that two channels be energized).

Considering, now, the operation of the register shown in Fig. 5, relay SPR, the channel relays Ra . . . Rf and relays CK1 and CK2 operate in the same manner as with the register of Fig. 4. In addition, the corresponding translator relays TA . . . TE operate as previously described and, when two relays are up, close ground to the proper conductors TP, TM, TS, RP and RM of the digit register relays, causing the release of relay AL and the operation of the required relay, or relays, in the first digit register while holding relay AC operated. At the same time, relay TG

operates over the following path: ground through the make contacts of relay SPR and/or relay CK2, conductor J, normal contacts of relay PT, conductor L, make contacts of relay CK1, conductor H, No. 2 normally made contacts and winding of relay TG to battery. When operated, relay TG locks through its No. 2 front contacts to ground on conductor J from relay SPR and/or CK2, and through its No. 1 contacts opens the path between the winding R of relay PT and conductor M, from which ground has already been removed by the operation of relay CK2. Removing ground from conductor M starts the timing cycle for the operation of relay PT which, operating after condenser PTC is charged, breaks the connection between conductors J and L. If relay SP has already released, the two channel relays in the group of relays Ra . . . Rf, which were operated by the incoming signal release and cause the release of all other above-mentioned relays except the register relays locked to ground on the contacts of relay ON. If relay SP is held up by a long incoming signal, all of the relays release except relays TG and PT, which wait until relay SP releases, due to the locking of relay TG to conductor J as described above. When relay AC releases, following the removal of ground from conductor TS, conductors TM, TP, RM, RP, and TS are transferred from the first digit register and steering relays to the second, and when the second and succeeding digits are received, the registration continues in a similar manner until the incoming "start" signal transmitted from the transmitting station by the depression of key ST thereat indicates that the last digit has been transmitted. The "ST" signal operates translator relays TE and TF, in turn operating relays 1 and 4 of a register succeeding the register which has taken the registration of the last digit transmitted (the number of digits which may be transmitted may vary depending upon the route and the called office) and a circuit closed through a pair of operated contacts on relays 1 to 4 of any register will operate a "start" circuit (not shown) which advises the sender that no more digits will be forthcoming and that, therefore, it may proceed with the necessary steps to complete the connection.

With either type of register sender, the registration of the required number of digits therein indicative of the route of the call (as for example, the name or number of the terminating exchange and/or the called number), causes the sender to become connected to a control circuit known as a "marker" in which, over contacts not shown on the digit registers, the necessary digits registration is transferred therein. In response to this registration, the marker then operates over certain control circuits to cause the selected trunk to become connected with another trunk to the terminating office or to the called line, whereupon the marker then disconnects and the sender proceeds to complete the connection at the terminating office or drops off if its work has been completed. Since these operations form no part of my invention, the same being well-known marker operations, they are not described herein.

While I have described my invention in connection with its specific application to one specific type of alternating current pulse receiver especially adapted to receive telephone designations to be used for establishing automatic telephone connections, it is to be understood that various other applications and embodiments thereof may be made by those skilled in the art without depart-

ing from the spirit of the invention as defined within the scope of the appended claims.

What is claimed is:

1. In an alternating current signal receiver, the combination with a channel for each signal frequency of means responsive to an initial unlocking frequency for controlling the response of said channels to their respective signal frequencies, and means responsive to said initial unlocking frequency when concurrently applied with another frequency for preventing said first-mentioned means from rendering said channels responsive to their respective signal frequencies, said means comprising a signal device and a network for attenuating the potential at said initial unlocking frequency, whereby the intensity of said potential is reduced relative to the potential of some other frequency concurrently applied therewith, and whereby said signal device responds to the attenuated potential of said initial unlocking frequency when applied alone and does not respond when concurrently applied with the unattenuated potential of said other frequency.

2. In an alternating current signal receiver, the combination with a line and a signal channel for each signal frequency connected to said line, of another channel connected to said line which is responsive to an initial unlocking frequency for rendering said signal channels responsive to their respective signal frequencies, and means responsive to said initial unlocking frequency when concurrently applied with another frequency for preventing said other channel from rendering said signal channels responsive to their respective signal frequencies, said means comprising a frequency discriminating network for said initial unlocking frequency connected across said line, a signal device in said other channel, and means associated with said signal device for rendering it responsive to said initial unlocking frequency when applied to said line and rendering it unresponsive when said initial unlocking frequency is applied to said line concurrently with another frequency.

3. In an alternating current signal receiver, the combination with a line and a signal channel connected to said line for each signal frequency of a frequency discriminating network connected across said line for reducing the potential of an applied initial unlocking frequency and of another channel connected to said line which is responsive to said initial unlocking frequency for rendering said signal channels responsive to their own respective signal frequencies, said other channel comprising a signal device inductively coupled to said line, means responsive to the operation of said signal device for activating said signal receivers, and a network resonant at said initial unlocking frequency for rendering said signal device responsive to said initial unlocking frequency when applied to said line and rendering it unresponsive when said initial unlocking frequency is concurrently applied to said other channel with some other frequency, said attenuating network reducing the potential of said start frequency to enhance the effect upon said signal device of the unattenuated potential of said other frequency.

4. In an alternating current signal receiver, the combination with a signal channel for each signal frequency of another channel to control the response of said signal channels to their respective signal frequencies, said other channel being responsive to an initial unlocking frequency

when applied singly to said receiver and unresponsive when said initial unlocking frequency is applied concurrently with another frequency.

5. In an alternating current signal receiver, the combination with a signal channel for each signal frequency of a device to control the response of said signal channels to their respective signal frequencies, which device is responsive to an applied initial unlocking frequency and unresponsive to the combination of said initial unlocking frequency and another frequency concurrently applied therewith, and means for increasing the intensity of the applied other frequency relative to the intensity of the applied initial unlocking frequency.

6. In an alternating current signal receiver, the combination with a signal channel for each signal frequency, a plurality of settable registers and means for connecting said registers to said signal channels, of means responsive to an initial unlocking frequency applied for a predetermined interval for operating said connecting means, said means being unresponsive to said initial unlocking frequency when concurrently applied with another frequency and responsive to signal frequencies through said connecting means when operated to effect the operation of said registers in response to the operation of said signal channels when appropriate signal frequencies are applied thereto.

7. In an alternating current signal receiver, the combination with a line and a signal channel for each signal frequency connected to said line of another channel connected to said line for controlling the response of said signal channels to their respective signal frequencies, which other channel comprises a vacuum tube inductively coupled to said line, a polarized relay having a first and second winding of which the first winding is energized, a cathode-anode circuit for said tube including the second winding of said polarized relay differentially connected with respect to said first winding, the control element of said tube being positively biased to effect a maximum current flow in said cathode-anode circuit whereby said current, in flowing through the second winding of said relay, overbalances the current flowing through the first winding to cause said relay to assume an unoperated position, and a network resonant to an initial unlocking frequency interposed between the cathode of the tube and the second winding of said relay, whereby the application to said line of a potential oscillating at said initial unlocking frequency causes the impedance of said resonant network to be increased and the current through the second winding of said relay to be reduced in consequence thereof, whereby said relay is then energized on the current flowing through its first winding to effect the control of said channels, and whereby the application to said line of a potential at the initial unlocking frequency and of another potential but of different frequency concurrently applied therewith causes the impedance of said resonant network to be reduced to maintain overbalancing current through the second winding of said relay, said relay then remaining in its unoperated position.

8. In an alternating current signal receiver, the combination with a line, a signal channel for each signal frequency connected to said line, and a shunt network connected across said line which is resonant at an initial unlocking frequency, of another channel to control the re-

sponse of said signal channels to their respective signal frequencies, said other channel comprising a vacuum tube, a step-up inductive coupling connecting the control element of said tube with said line, a cathode-anode circuit, a polarized relay having a first and second winding, a network resonant to said initial unlocking frequency, means controlled from the contacts of said relay to control the effective operation of said signal channels, a cathode-anode circuit for said tube including said resonant network and the second winding of said relay, the first winding of said relay having an independent circuit for causing current to flow therethrough in opposition to current through said second winding, means applicable through said coupling for maintaining a positive potential at said control element which effects a maximum current flow through the second winding of said relay which overbalances the current through said first winding to cause said relay to maintain an unoper-

ated position, whereby the application to said line of an attenuated potential oscillating at said initial unlocking frequency causes an increase of potential to be applied to the control element of said tube in consequence of which the impedance of said resonant network is increased to reduce the current through the second winding of said relay which operates on the current through its first winding to control the operation of said channel control means, and whereby the concurrent application to said line of a potential at said initial unlocking frequency reduced by said shunt network and the unreduced potential of another frequency causes a relatively increased potential to be applied to the control element of said tube in consequence of which the impedance of said resonant network is reduced to maintain the current through the second winding of said relay, said relay remaining in unoperated position.

ALEXIS A. LUNDSTROM.