

March 16, 1943.

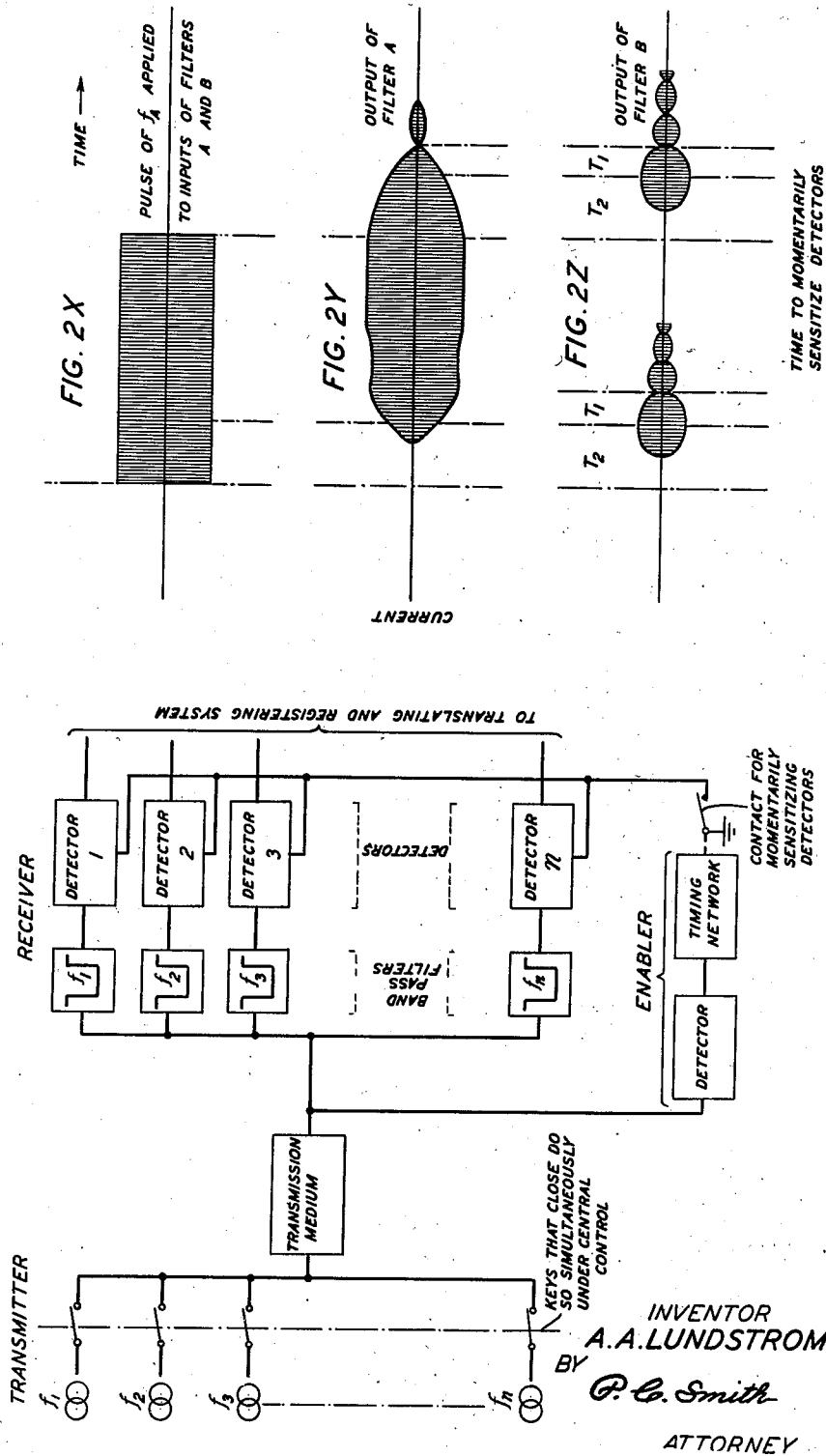
A. A. LUNDSTROM

2,314,229

SIGNALING SYSTEM

Filed Dec. 10, 1940

2 Sheets-Sheet 1



INVENTOR
A. A. LUNDSTROM

BY *P. C. Smith*

ATTORNEY

March 16, 1943.

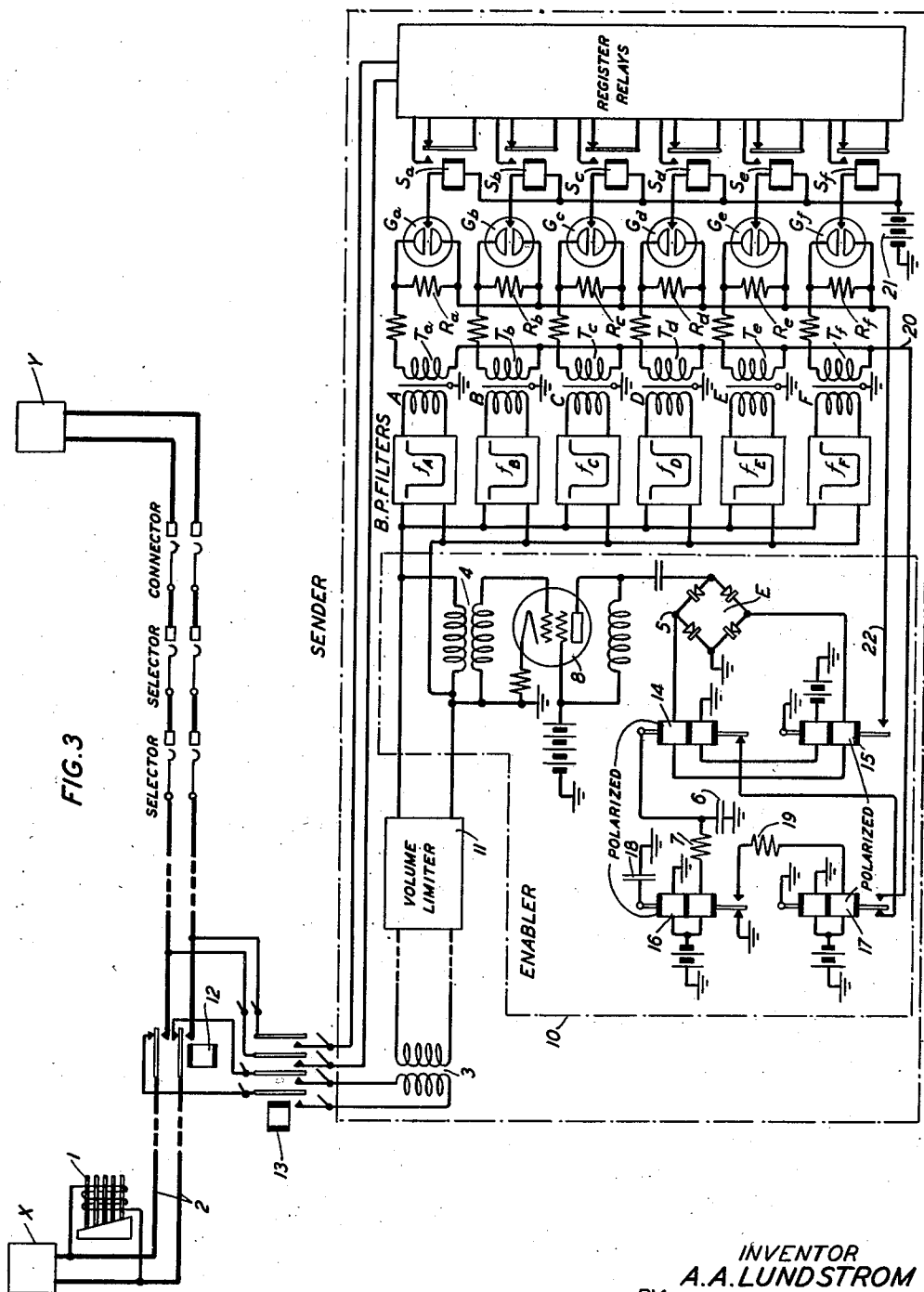
A. A. LUNDSTROM

2,314,229

SIGNALING SYSTEM

Filed Dec. 10, 1940

2 Sheets-Sheet 2



INVENTOR
A. A. LUNDSTROM
BY
P. C. Smith
ATTORNEY

UNITED STATES PATENT OFFICE

2,314,229

SIGNALING SYSTEM

Alexis A. Lundstrom, East Orange, N. J., assignor
to Bell Telephone Laboratories, Incorporated,
New York, N. Y., a corporation of New York

Application December 10, 1940, Serial No. 369,391

13 Claims. (Cl. 179—18)

This invention relates to signaling systems and particularly to the receiving equipment of a transmission medium over which alternating current signals, preferably within the voice frequency range, are transmitted. The received signals are then used for any desired purpose such as, for instance, the operation of controlling equipment for the selective positioning of telephone or telegraph switching apparatus or as vehicles of intelligence which is to be recorded or retransmitted to a more distant point.

In systems of this kind, the receiving circuit usually consists of a channel for each frequency in the signals and comprises a filter and a detecting device the latter of which is responsive to the signal energy that gets through the filter. A registering or recording device which is controlled by all the channels is then used for registering or recording the designation indicated by the frequencies in the signal.

As is well known, the impact and the cut-off of an alternating current impulse on the input side of a plurality of paralleled filters produce frequency spectra on their respective output sides which are of the greatest intensity for the filters adjoining either side of the one through which the current will pass and progressively diminishes in intensity with respect to the other filters more remotely located. If a detector such as a vacuum tube is connected to the output side of each of the filters, the detector connected to the filter which passes the current will, of course, operate. There is danger, however, that the detectors connected to the filters on either side of the one which responds to the current will also operate on the current produced by the transient disturbance set-up in the adjoining filters at the beginning and end of the pulse. To avoid this occurrence, it is the usual practice in carrier multiplex telegraph systems, for example, to reduce the intensity of unwanted transient by providing a shaping filter for each signal frequency at the transmitting station. Although with this arrangement a disturbance is, of course, produced in the band-pass filters of the receiving station at the beginning and end of the shaped signal current, this disturbance in the filters on either side of the filter which passes the incoming signal current is sufficiently attenuated by the particular shaping filter to prevent the false operation of the vacuum tube detectors associated with the adjoining filters.

The development of the gas-filled tube, which is a vessel containing one or more of the so-called inert gases at low pressure, is normally

non-conducting until a breakdown potential is applied to two of its electrodes, is thereafter conductive on a voltage less than breakdown voltage and can be only quenched thereafter by removing or momentarily reversing the positive potential connected to the anode, has made it possible to take advantage of certain electrical properties of band-pass filters by which substantial economies can be effected in signaling systems of the carrier multiplex type through the elimination of the shaping filters at their transmitting stations. Thus it is known that if a plurality of paralleled band-pass filters are connected to the receiving end of a transmission line, and these filters all have the same phase shift characteristics in their pass-bands, are adapted to pass equal steady band widths in cycles and are equally spaced in cycles within the entire available frequency range, a signal impulse of two or more frequencies applied simultaneously to the transmission line will cause the wanted frequencies out of the filters to reach a maximum intensity at the same time that the unwanted frequencies, produced by the transient spectrum in the adjoining filters, will reach a minimum. In the absence of shaping filters at the transmitting station this phenomenon will be present, of course, in the filter network of the receiving station since the filters thereof are ordinarily (though not necessarily) of equal sections and, therefore, of substantially identical phase characteristics and would be equally spaced within the frequency range. However, due to the use of the ordinary vacuum tube detector on the output side of each of the filters of the receiver, the detectors which are on either side of the filter which passes a signal frequency, would be subject to false operation on the transient spectrum at the beginning and end of the signal frequency pulse and this is avoided, as before stated, by using shaping filters at the transmitting station, which insure a minimum spectrum effect on the output side of the filters of the receiver.

However if, in a carrier multiplex receiver, the vacuum tube detectors thereof are replaced by gas-filled tube detectors and means are provided for controlling the time when these detectors are to be rendered conducting to respond to incoming signal frequencies and the length of time during which their conductivity is to be sustained, it is evident that the use of filters of identical phase characteristics equally spaced within the available frequency range at the receiving station will make it possible to avoid

altogether the use of filters at the transmitting station since the gas-filled detectors of the receiver can then be kept unresponsive to the unshaped incoming signal frequencies until the maximum intensity of the unwanted frequencies produced on the output side of the receiving filters consequent to the application of the signal frequencies to the input side of the filters, will have been reached and passed, subsequent to which the detectors can be kept conducting for a measured duration, cutting off such conductivity before the termination of the signal frequencies so as to again avoid false operation of the detectors by the unwanted frequencies produced by the transient spectrum at the termination of the signal frequencies. And since, if the receiving filters are of identical phase characteristics and are equally spaced within the available frequency range, the unwanted frequencies will all reach their maximum intensities at the same time regardless of which of the receiving filters are operated by the incoming signal frequencies, it follows that one common means may be utilized to control the time when the detectors shall be rendered conducting as well as the duration of such conductivity.

In accordance with a feature of this invention, therefore, each channel detector of a signaling system is provided with a filter network of equal sections and equal band width to all the others and means are provided whereby the incoming signal energy operates a circuit network herein called the "enabler" which is adapted to activate the channel detectors after a time interval subsequent to the arrival of the signal energy and which is of sufficient duration to permit the dissipation of the transient disturbance. This time interval is determined by the physical constants of the filter network and the width of the pass band which, being substantially the same for all filters, produces the same time interval in each of the channels.

This and other features of the invention will be more readily ascertained from the following detailed description of said invention, appended claims and attached drawings in which:

Fig. 1 is a conventional representation of the fundamental elements of the invention in its generalized form;

Fig. 2 shows certain graphic illustrations intended to show the character of the disturbance in the filter receiving the signal as well as in the filters receiving the transient disturbance induced thereby; while

Fig. 3 shows the application of the invention to an automatic telephone switching system wherein the transmitted signals are utilized to selectively position known switching selectors for the purpose of establishing a connection between the calling station and a called station.

Referring, now, to Fig. 1, the signaling system comprises a transmitting station provided with two or more sources of signal frequencies connected to one end of a transmission medium such as a telephone line, radio channel, carrier band, etc. and in which a commutator or keying mechanism is utilized to apply a plurality of frequencies simultaneously to the medium in one signal pulse, and a receiving station having as many channels as there are signal frequencies, each channel being provided with a band-pass filter device f_1-f_n having uniform phase shift characteristics, equal band widths in cycles of which the signal frequency constitutes the mid-band frequency, and a detector I—N for each

channel operatively connected, respectively, to each of the filters and responsive to the signal frequency passing to the output side of the filter. The receiving station is further augmented by a common untuned detector circuit or "enabler" which operates on the reception of the signal at the input to the band-pass filters. This operation initiates a relay timing chain which ultimately causes all the detectors associated with the filter outputs to be simultaneously sensitized after a particular time interval when the intensities of the wanted frequencies out of the filters are a maximum while the intensity of the unwanted transient spectrum frequencies out of adjoining filters are a minimum.

The operation of the enabler in avoiding the sensitization of the detectors until after the dissipation of the spectrum transient can best be explained by diagram, reference being had to Figs. 2X, 2Y and 2Z which represent the results of actual tests. For simplicity consider a two-frequency system using the frequencies f_A and f_B and a receiver equipped with band-pass filters A and B having the mid-band frequencies f_A and f_B . When a square pulse f_A appears at the input to these filters as shown by Fig. 2X, the output of filter A is roughly shown by the envelope indicated by Fig. 2Y as building up to a maximum value at a subsequent time T_2+T_1 . The unwanted current output of filter B (due to the transient disturbance set up by the impact of f_A on filter B) rises to a maximum value after an interval T_2 and then decays to a minimum value after interval T_2+T_1 as indicated by the left-hand graph on Fig. 2Z. Provided that the channel detectors are sensitized momentarily by the enabler at the time T_2+T_1 , the largest ratio between the wanted output of filter A and the unwanted output of filter B is achieved with a minimum in delay between the first appearance of currents out of the filters and the time that the filters are sensitized.

Referring again to Fig. 2Z, it is seen that the unwanted current after the first maximum decays in a succession of maximums and minimums while the end of the applied pulse sets up another transient current which is in the same order of magnitude as the initial transient and has the same envelope with a minimum occurring at the time (T_2+T_1) after the disappearance of the applied frequency f_A . It is obvious, therefore, that the sensitization of the detectors, while it must be rendered effective after a time T_2+T_1 from the appearance of the frequency f_A at the output of filter A in order to avoid the false operation of the detector connected to filter B, it must be equally rendered ineffective by the time that the decay of frequency f_A begins in order to avoid, at the end of the pulse, a false operation of the detector connected to filter B.

The time T_2 is the envelope delay through the filter and is due to the slope of the phase shift versus frequency characteristic of the filter pass band. This simply displaces the pulse along the time scale to the extent of time T_2 , and for any particular band-pass configuration with a fixed number of sections, it is inversely proportional to the frequency band width of the filter in cycles. From which it appears evident that, in order to obtain the same time T_2 in each of the channels, the filters therein will have to have substantially identical phase shift characteristics. The time T_1 is due to the restricted frequency pass band of one filter and is equal to the reciprocal of the band width in cycles. Whence it is further evi-

dent that, in order to obtain the same time T_1 in each of the channels, the filters therein will have to have the same band width in cycles. In order, therefore, to sensitize all the detectors in all the channels at the same time, the filter envelope delay due to the phase shift of the several filters plus the build-up time out of the filter due to the restricted pass band shall be the same for all the filters in the receiver.

Assuming a band of frequencies available for signaling it is necessary to "spot" the signaling frequencies over this range so that they will provide a maximum discrimination between the wanted (see Fig. 2Y) and the unwanted filter responses (see Fig. 2Z). The intensity of the transient response is, to a good approximation, proportional to the filter band width and inversely proportional to the difference in cycles between the filter mid-band frequency and the frequency applied outside of its band. In order to use the available band to best advantage, therefore, it is necessary to make the unwanted transient response in adjoining filters equal and a minimum, and this may be achieved by imposing the additional requirement that the signaling frequencies shall occupy the entire available frequency range and be equally separated in cycles.

Referring, now, to Fig. 3 which represents a practical application of the invention to an automatic telephone system, X represents a transmitting station equipped with a device 1 suitably arranged to produce one or more currents of different frequencies, preferably in the voice frequency range, in response to operations thereof for designating digits or other characters making up the signal to be transmitted; 2 represents a line extension between said station and a central point, which extension may be established by any suitable means such as, for instance, line extending switches and the like whence, for the purpose of switching control and the further extension of the transmitting station X to the receiving station Y in the event that said two stations are not connected by a direct line, the line extended from station X may be connected, through a selectable sender connector relay 13, to a switching control device herein called a sender. The sender comprises coupling transformers 3 and 4, volume limiter 11 (if one is necessary), the enabler circuit 10, and the six signal receiving channels A—F, it being assumed that there are six signal frequencies equally spaced in cycles over the entire band in cycles. Each channel comprises a band-pass filter such as f_A , a coupling transformer such as T_A , a three-element cold cathode gas-filled tube such as G_A one of whose control electrodes is connected to a terminal of the secondary winding of transformer T_A and the other (in parallel with corresponding electrodes of the remaining tubes) to a contact of relay 15, and a resistance such as R_A bridged across the control electrodes of the tube and likewise paralleled to the contact of relay 15. The volume limiter 11, the band-pass filters f_A — f_F , the gas-filled tubes G_A — G_F and other electrical and electromechanical units herein schematically indicated are commercially available pieces of apparatus which need no further description of their physical characteristics. The enabler 10 comprises the amplifier tube 8, the rectifier bridge 5 and the polarized relays 14, 15, 16 and 17 with their intermediate capacitor-resistance networks controlling the operating times of said relays in the manner described hereinafter. It will be

noted at this time, however, that relays 14 and 15 have a permanent series biasing circuit through their lower and upper windings respectively which causes their armatures to assume the positions shown in the drawing, while relays 16 and 17 have independent biasing circuits through their respective upper windings. In the case of relay 16, there is an operating circuit also normally established from battery through the lower winding of said relay, resistance 7, armatures and contacts of relays 14 and 17, respectively, to ground. The currents through both windings of relay 16 oppose each other, the position assumed by the armature of the relay as engaging the left contact being due to the fact that the current through the lower winding overpowers that flowing through the upper winding. The armature of relay 17, on the other hand, engages its left contact solely in response to the current flowing through its upper or biasing winding, the circuit path for the lower winding being open at the right contact of relay 16.

In the operation of the invention as applied to a signal system in which the connection between station X and station Y is to be established by means of switching selectors controlled by a sender responsive to the alternating currents transmitted from device 1 at station X, the transmission line 2 between station X and the sender may be established in any suitable manner, say through the medium of a relay 13, where a sender is available to a plurality of transmitting stations to each of which it may be connected by switching circuits well known in the automatic switching arts, relay 13 being merely representative of the connecting medium in such a circuit for connecting the line to the sender. Where the invention is adapted for use with carrier multiplex telegraph systems, for instance, the line may well terminate directly at the receiving station Y in which event the line conductors 2 are extended directly to the input side of transformer 3.

In transmitting the desired signals from station X, the sending device 1 may be operated to produce two or more of the frequencies which make up the signal to be transmitted, which frequencies are, of course, the same as those for which the channel detectors A—F are adapted for response.

The resulting current thus produced by the operation of device 1 is transmitted over a circuit which is traced from one side of the sending device 1, lower conductor of the looped pair 2, lower back contacts of relay 12, next to the inner contacts of relay 13, primary winding of transformer 3, inner contacts of relay 13, top back contacts of relay 12, upper conductor of looped pair 2, to the other side of the station sending device 1. The current, composed of the signal frequencies, is induced in the secondary winding of transformer 3 and fed into the input side of the volume limiter 11 whence a part of the energy is applied, through the secondary of transformer 4, to the grid of tube 8 for amplification therein while the remainder is applied through a suitable resistance pad (not shown) to the band-pass filters f_a — f_b .

The output of tube 8 is applied to the two horizontal terminals of rectifier bridge 5 from which, through the two vertical terminals of said bridge, it is further applied serially through the upper and lower windings of relays 14 and 15, respectively, whereupon the current flowing through these respective windings is sufficient to oppose that normally flowing through their re-

spective biasing windings and cause both relays to operate. Relay 15 applies solid ground to the lower control electrode of all the channel tubes G_a-G_r , to the upper control electrodes of said tubes via high resistance R_a-R_r and to one side of the secondary windings of the channel transformers T_a-T_r via the high resistances R_a-R_r and another low resistances in series with each of said high resistances.

When the armature of relay 14 breaks with its contact, a charging circuit is established for normally discharged condenser 6 which traces from ground through said condenser, resistance 7, lower winding of relay 16 to battery. Since, with the operation of relay 14, the circuit through the lower winding of relay 16 is opened and the charging circuit of condenser 6 is established through said lower winding, and since, with no current flowing through said lower winding, the armature of the relay would come into engagement with the right contact as a result of the current through the upper winding, the effect of the condenser charging current is to prolong the time during which the armature of relay 16 engages its left contact until the magnetic effects of the decaying charging current through the lower winding of relay 16 is no longer sufficiently powerful to overcome the effects of the normally existing biasing current through the upper winding of said relay, at which time the relay operates and the armature thereof moves into engagement with its right contact, thereby establishing the charging circuit of condenser 18 over a path which traces from ground through condenser 18, armature and right contact of relay 16, resistance 19, lower winding of relay 17 to battery. This charging current is in the direction to oppose the effect of the biasing current normally flowing through the upper winding of relay 17 as above described so that, during the condenser charging period the armature of relay 17 moves from its left contact into engagement with its right contact whereupon ground is connected to the upper control electrode of the channel tubes G_a-G_r via conductor 20, the secondary winding of each of the transformers T_a-T_r and each of their respective associated low resistances connected between the upper terminal of the secondary winding of each of said transformers and the upper control electrode of the associated tube. Since both control electrodes of each of the tubes are now connected to ground, that portion of the signal energy which passed through the band-pass filters f_a-f_r involved for the frequencies carrying the signal energy will now cause the potential of the signal to be applied to the two control electrodes of the particular channel tubes and cause the gap therebetween to break down and become conducting. Because of the partial ionization of the gaseous substance that results from the breakdown of the control gap within each of the tubes to which the signal voltage is applied, the potential required to break down the main gap between the anode and cathode electrodes is reduced to the amount required which is below the value that would be required if the gap between the control electrodes had not been first ionized. Upon the breaking down of the main gap, a circuit is established for each channel relay S_a-S_r for which the associated tube has become conducting through its control and main gaps, a typical one of said circuits being traced, for instance, from positive battery 21, winding of relay S_a , main gap electrode to lower control

electrode of tube G_a , conductor 22, to ground on the armature of relay 15. Relay S_a operates in said circuit and closes through one or more sets of contacts to a register circuit of any suitable design such as, for instance, the one disclosed in my Patent 2,237,742 issued on April 8, 1941, wherein, in combination with contact sets closed by other relays in the group of relays S_a-S_r responsive to associated tubes rendered conducting in the manner above described, register the digit or character represented by the particular combination of frequencies in the transmitted signal.

When condenser 18 is fully charged, the current through the lower winding of relay 17 ceases to flow and the armature of this relay now assumes its former position of engagement with the left contact under the influence of the current flowing through the upper or biasing winding. In so doing, ground is thereby removed from conductor 20 and, therethrough, from the upper control electrode of all the channel tubes G_a-G_r , thereby rendering further duration of the signal impulse impotent to influence any further operation. However, since the tubes which correspond to the frequencies in the signal have already operated and are maintained operated via their respective anode circuits and the contacts of relay 15 independent of the frequency composition of the signal impulse, the removal of the ground from the upper electrode of all tubes will have no other effect except the desirable one of preventing tubes which have not already operated from operating for any cause whatsoever.

When the signal impulse terminates, relays 14 and 15 release, condenser 6 immediately discharges to ground potential via the armature and left contact of relay 14 and left contact and armature of relay 17 to ground, while current is simultaneously reestablished through the lower winding of relay 16, causing the armature of this relay to assume its normal position of engagement with its left contact. Condenser 18 is discharged thereby. Relay 15, in releasing, opens the main gap circuit of the operated tubes causing the same to quench and release the corresponding channel relays, thereby placing all channel detectors in a condition of receptivity to the next incoming signal. The incoming signals which are successively registered in the register relays of the sender are then utilized to selectively position a train of switching selectors and connectors for extending the transmitting station X to the receiving station Y, after which the sender is disconnected from the line by the release of relay 13 and the two stations are connected together by the operation of relay 12, all in the manner described in my copending application above mentioned.

While I have described my invention and the means for utilizing the same in connection with its application to a particular kind of a transmission line, it is to be understood that various other applications and embodiments thereof may be made by those skilled in the art without departure from the spirit of the invention as defined within the scope of the appended claims. Thus if the invention were to be adapted for application to a carrier multiplex telegraph system, the signal receiving channels A-F might form an integral part of the transmission line itself thereby dispensing with the use of a sender, while the receiving station Y would comprise equipment responsive to the relays S_a-S_r which would be set in accordance with the frequencies

comprising each of the signals either for decoding and permanently recording the same or for registering them for retransmission to some other distant point, all in the manner well known to the telegraph art.

What is claimed is:

1. A receiving circuit for a signaling system adapted for the transmission of plural frequency signals thereover comprising a filter device for each signal frequency, said devices having substantially identical phase characteristics and substantially equal band-pass widths, gas-filled electronic means in circuit with each of said filter devices normally unresponsive to currents passed through said filter devices, and means responsive to a signal impulse for sensitizing all of said electronic means for response to said impulse.

2. A receiving circuit for a signaling system adapted for transmission of plural frequency signals thereover comprising a filter device for each signal frequency, said devices having substantially identical phase characteristics and substantially equal band-pass widths and being equally spaced within the entire signal frequency band, gas-filled electronic means in circuit with each of said filter devices normally unresponsive to currents passed through said filter devices, and means responsive to a signal impulse for sensitizing all of said electronic means for response to said signal impulse.

3. A receiving circuit for a signal system adapted for the transmission of plural frequency signals thereover comprising a filter device for each signal frequency, said devices having substantially identical phase characteristics and substantially equal band-pass widths and being equally spaced within the entire signal frequency band, gas-filled electronic means in circuit with each of said filter devices normally unresponsive to currents passed through said filter devices, and means responsive to a signal impulse for sensitizing all of said gas-filled electronic means for response to said signal impulse a predetermined interval subsequent to the application of said signal impulse to said filter devices.

4. A receiving circuit for a signal system adapted for the transmission of plural frequency signals thereover comprising a filter device for each signal frequency, said devices having substantially identical phase characteristics and substantially equal band-pass widths and being equally spaced within the entire signal frequency band, gas-filled electronic means in circuit with each of said filter devices normally unresponsive to currents passed through said filter devices, and means responsive to a signal impulse for sensitizing all of said gas-filled electronic means for a time duration measured between a predetermined interval subsequent to the application of said signal impulse to the input sides of said filter devices and a predetermined interval prior to the termination of said signal impulse at the output sides of said filter devices.

5. In a signaling system, the combination with a transmission medium, of a plurality of receiving means connected thereto for response to alternating current signal energy of plural frequencies transmitted thereover but held normally unresponsive to said alternating current signal energy, comprising a filter device for each of said receiving means, said devices having equal sections and equal band-pass widths and equally spaced from each other within the entire sig-

nal frequency band, and means responsive to said signal energy for activating all said receiving means for response to said signal energy a predetermined interval subsequent to said energy being available at the input sides of said filter devices.

6. In a signaling system, the combination with a transmission line of a plurality of receiving means connected thereto for response to plural frequency current signals transmitted thereover but held normally unresponsive to said signals, comprising filter devices of equal phase shift characteristics and equal frequency band widths for said receiving means, and means responsive to said signals for activating said receiving means an interval after each signal is applied to the input sides of said filter devices which is determined by the phase shift and band width properties of said filter devices.

7. In a signaling system, the combination with a transmission line of a plurality of receiving means connected thereto for response to plural frequency current signals transmitted thereover, each of said receiving means comprising a filter section of equal phase shift characteristics and equal band width in cycles to corresponding filter sections in each of the other of said receiving means, a gas-filled electronic device normally unresponsive to the current passed by said filter section, and means responsive to said signal for rendering each of said gas-filled electronic devices partially conductive a predetermined interval after a signal is applied to the input side of said filter devices, whereby the gas-filled electronic device in each of said receiving means through which a frequency of the signal has passed becomes wholly conductive in response thereto.

8. In a signaling system, the combination with a transmission line of a plurality of receiving means connected thereto for response to plural frequency current signals transmitted thereover, each of said receiving means comprising a filter section of equal phase shift characteristic and equal band widths in cycles to corresponding filter sections in each of the other of said receiving means, a gas-filled electronic device normally unresponsive to the current passed by said filter section, means responsive to said signal for rendering all of said gas-filled electronic devices partially conductive a predetermined interval subsequent to the application of said signal to the input sides of said filter devices, whereby the gas-filled electronic device in each of said receiving means through which a frequency of the signal has passed becomes wholly conductive in response thereto, and means for restoring those gas-filled electronic devices which have not been rendered wholly conductive.

9. In a signaling system, the combination with a transmission line of a plurality of receiving channels connected thereto for response to plural frequency current signals transmitted thereover, each of said receiving channels comprising a filter section of equal phase shift characteristic and equal band widths in cycles to corresponding filter sections in each of the other of said receiving channels, a gas-filled electronic device normally unresponsive to the current passed by said filter section, means responsive to a signal for rendering all of said gas-filled electronic devices partially conductive a predetermined interval subsequent to the application of said signal to the input sides of said filter devices, whereby the electronic device in each of

said receiving channels through which a component frequency of the signal has passed becomes wholly conductive in response thereto, and means for restoring partially conductive gas-filled electronic devices after a predetermined interval.

10. In a signaling system, the combination with a transmission line and plurality of channel detectors each comprising a filter section of equal phase shift characteristic and equal band width in cycles to corresponding filter sections in each of the other of said channel detectors and a gas-filled conductor device normally unresponsive to the current passed by said filter section, of means for rendering all of said gas-filled conductor devices partially conductive for response to a plural frequency current signal transmitted over said line a predetermined interval subsequent to the application of said signal to the input sides of said filter sections, said means comprising a first pair of polarized relays responsive to said signal for applying a potential to a control electrode of each of said gas-filled conductor devices, a second pair of polarized relays for applying a potential to another control electrode of each of said gas-filled conductor devices whereby all of said devices are rendered conducting between their respective pair of control electrodes, and capacitor-resistor networks interconnecting said first and said second pair of polarized relays for operating said second pair of polarized relays after a first predetermined interval and for keeping them operated for a second predetermined interval.

11. In a signaling system, the combination with a transmission line and a plurality of channel detectors each comprising a filter section of equal phase shift characteristic and equal band width in cycles to corresponding filter sections in each of the other of said channel detectors and a gas-filled conductor device normally unresponsive to the current passed by said filter section, of means for rendering all of said gas-filled con-

ductor devices partially conductive for response to a plural frequency current signal transmitted over said line a predetermined interval subsequent to the application of said signal to the input sides of said filter sections, said means comprising a first pair of polarized relays responsive to said signal for applying a potential to a control electrode of each of said gas-filled conductor devices, a second pair of polarized relays for applying a potential to another control electrode of each of said gas-filled conductor devices whereby all of said devices are rendered conductive between their respective pair of control electrodes, and capacitor-resistor networks interconnecting said first and said second pair of polarized relays for operating said second pair of polarized relays after a first predetermined interval measured by the duration of said peak disturbance and for keeping them operated for a second predetermined interval.

12. In a signal selective system, the combination with energy responsive means, of frequency discriminating means and time discriminating means for activating said energy responsive means a predetermined interval after a plural frequency signal is applied to said frequency discriminating means.

13. In a multifrequency synchronous signal transmission system comprising a selecting receiver channel for each frequency in a plural frequency signal, means for causing the wanted currents in each frequency of said selecting receiver channel to rise to a maximum at the same time that the unwanted transient currents in adjacent channels are a minimum, said means comprising band-pass filters of substantially equal band widths and phase characteristics equally spaced in frequency range, and means for connecting signal observing means at said time for a short interval.

ALEXIS A. LUNDSTROM.