

March 14, 1939.

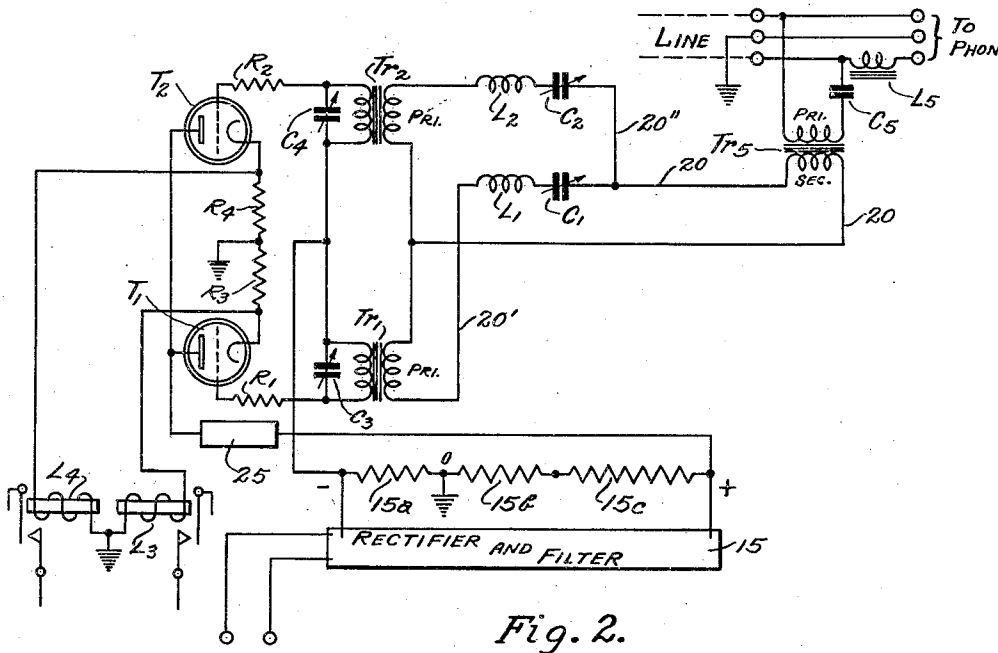
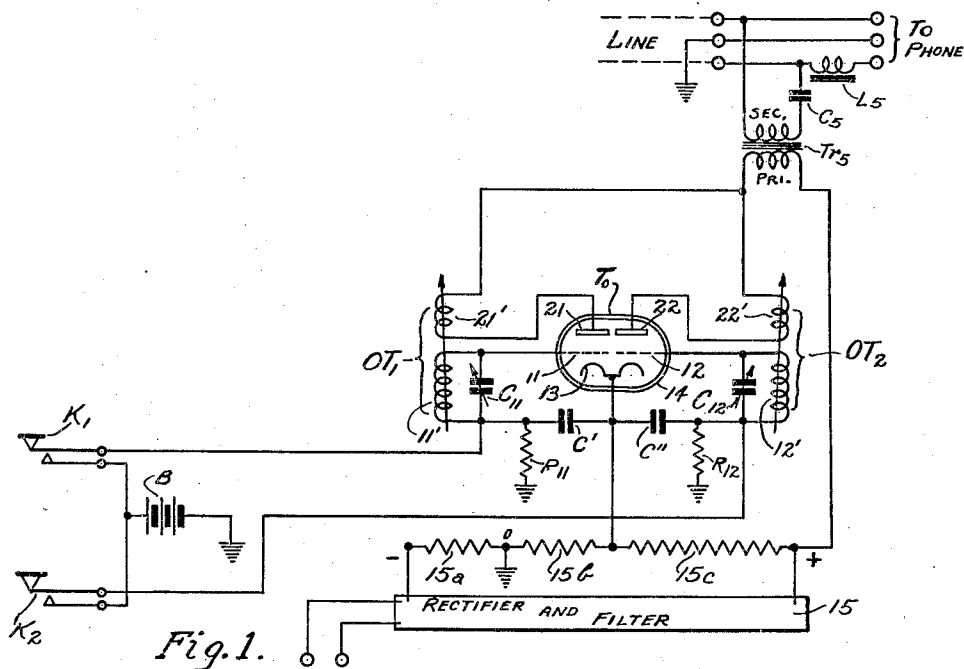
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2,150,241

COMMUNICATION SYSTEM

Filed Feb. 23, 1935

2 Sheets-Sheet 1



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COMMUNICATION SYSTEM

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2 Sheets-Sheet 2

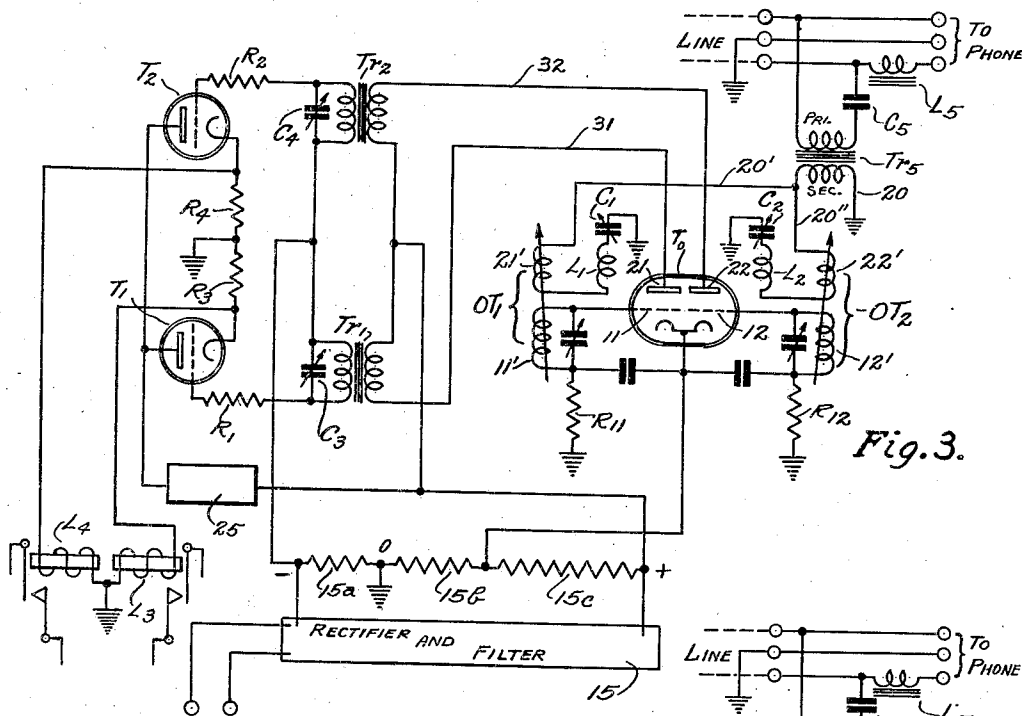


Fig. 3.

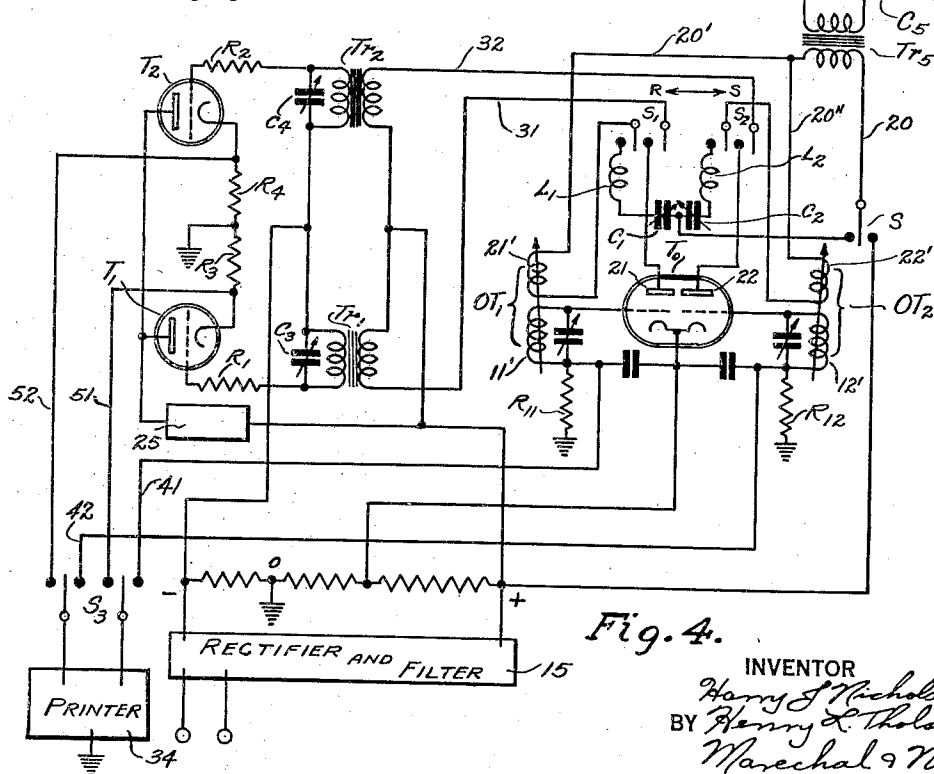


Fig. 4.

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## UNITED STATES PATENT OFFICE

2,150,241

## COMMUNICATION SYSTEM

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Application February 23, 1935, Serial No. 7,674

6 Claims. (Cl. 178—66)

This invention relates to communication systems, and particularly to carrier telegraph systems.

It is the principal object of the invention to provide a very satisfactory carrier communication system making use of simple and economical apparatus.

A further object is to provide a carrier system having a minimum of steps or links in the system.

A further object is to provide a carrier system particularly adapted to telegraph systems utilizing signals of uniform duration but of different characteristics.

A further object is to provide a carrier system in which frequencies are generated, amplified, and the like in groups, each group being handled in such manner as to obtain compensation of certain variations in the relations between the signals of the several frequencies.

A further object is to provide a carrier system particularly adapted to simultaneous telephonic and telegraphic communication over the same circuit.

Other objects and features will be in part obvious and in part hereafter pointed out in connection with the following description, the accompanying drawings, and the appended claims.

In the drawings:—

Fig. 1 shows in schematic representation a preferred form of sending circuit illustrating one aspect of the invention;

Fig. 2 shows one form of receiving circuit according to the invention;

Fig. 3 shows another form of receiving circuit according to the invention; and

Fig. 4 shows a combined sending and receiving arrangement embodying the circuits of Figs. 1 and 3.

In the several figures, like characters represent like parts.

Referring now to Fig. 1, oscillator tube  $T_0$  is preferably of the twin-triode vacuum tube type being provided with two grids 11 and 12, two anodes 21, 22, and a common thermionic cathode 13 all mounted in an evacuated envelope 14 in well known manner. Power for tube  $T_0$  and the other tubes employed in the various circuits is obtained from a rectifier and filter unit 15 as indicated, or from any other suitable source. The voltage divider of unit 15 is provided with the proper sections, as for example 15a, 15b, 15c, or is suitably tapped to provide the proper potentials to the various circuits of the arrangement. Oscillator tube  $T_0$  is provided with two tuned oscillator circuits of known type, one circuit designated by reference numeral 11' being associated with grid 11, while similar circuit 12' is associated with grid 12. Inductively coupled with these circuits are feed-back circuits 21', and 22', associated with anodes 21 and 22 respectively forming

oscillation transformers  $OT_1$  and  $OT_2$ , respectively. Oscillator circuit 11' is tuned to a particular frequency  $f_1$  while oscillator circuit 12' is tuned to a different frequency  $f_2$ . These are known as the channel frequencies, and in cases where simultaneous telephone and telegraph communication are to be provided over the same circuit, these frequencies are preferably chosen in the range just above the usual audible telephonic frequencies, as for example in the range between ten and twenty kilocycles. Where telephonic communication is not involved, the frequencies are advantageously chosen in the audible range since following well known laws, the lower frequencies are more efficiently transmitted over wire circuits. The invention is not, of course, restricted to any particular frequencies or frequency ranges, nor is it restricted to the provision of two channel frequencies and circuits, as more may be provided if desired.

Grids 11 and 12 are normally held at a negative bias by section 15b of the voltage divider, the bias being sufficient to prevent oscillation. The normal bias is applied through resistors  $R_{11}$ ,  $R_{12}$ , while by-pass capacitors  $C'$ ,  $C''$  offer a low impedance return of the oscillating grid currents to cathode.

The keying equipment is connected across the grid-cathode circuits of oscillator tube  $T_0$ . Thus, for example, the circuit including key  $K_1$ , resistor  $R_{11}$ , and battery B may be regarded as the sending loop of channel one, while the circuit including key  $K_2$ , resistor  $R_{12}$  and battery B may be regarded as the sending loop of channel two. Both oscillation circuits are coupled to the line by suitable means such as line transformer  $Tr_5$ . Blocking capacitor  $C_5$  is provided to prevent direct current from the line saturating transformer  $Tr_5$ , but is not essential on lines where stray currents are not likely to occur. The sending circuit, consisting of the secondary of  $Tr_5$  and  $C_5$  in series therewith is preferably bridged across the line head of telephone instruments when used. Suitable means, such as choke  $L_5$ , is preferably connected in series with the telephone instruments for the purpose of impeding the passage of carrier currents in that direction while permitting the passage of voice currents to the telephone instruments.

The operation of the circuit shown in Fig. 1 is as follows:—Normally oscillator tube  $T_0$  is prevented from oscillating by reason of the negative bias on its grids. Assume that the key  $K_1$  is closed, completing the sending loop circuit. Then current from battery B flows through  $K_1$  and  $R_{11}$  and return via the grounded frame, setting up a voltage across  $R_{11}$  opposing the bias voltage and raising the potential of grid 11 sufficiently to cause  $T_0$  to build up oscillations in the circuit 11' associated with grid 11. Oscillations of frequency

quency  $f_1$  are then transferred to the line via line transformer Tr5. As soon as the key is released the original bias on grid 11 is returned, and the oscillations are promptly stopped. Thus a train of waves of frequency  $f_1$  is transmitted over the line so long as key K<sub>1</sub> is held down, and such carrier signals represent the signal pulses in the sending loop as regards time and duration. Assuming key K<sub>2</sub> to be depressed, the action is similar except that the potential of grid 12 is raised positively and carrier signals of frequency  $f_2$  are transmitted to the line.

It should be observed that the arrangement herein shown eliminates the need for an amplifying tube, with a consequent saving in apparatus although such amplifying means as desired may be used. It also presents a novel method of "keying" carrier generating apparatus. Furthermore, since the same oscillator tube generates a plurality of frequencies, there is an inherent compensation of variations likely to occur were the frequencies generated by separate tubes. For example, a common cathode and a common atmosphere for the plural elements of the tube are conducive to uniformity of emission and space currents. As the tube ages, the constants of the tube circuits are affected in the same degree, hence the power ratio of the oscillating currents tends to remain balanced, thus maintaining a uniform ratio of the signals. The tuning and balancing of the circuits is facilitated by the uniformity of the characteristics of the plural tube circuits. There is also a saving in power, a saving in space and in associated parts.

Referring now to Fig. 2, representing one form of receiving arrangement, the receiving circuit 20 is coupled to the line by line transformer Tr5 in the same manner as in the previous figure or by other suitable means. Likewise, inductance L5 offers a high impedance to the carrier signals in the direction of the telephone instruments with relatively minor attenuation of the voice currents. The receiving circuit 20 is divided into two branches 20' and 20'' tuned to frequencies  $f_1$  and  $f_2$  by series combinations of capacity and inductance, C<sub>1</sub>, L<sub>1</sub> and C<sub>2</sub>, L<sub>2</sub>, respectively. The primaries of transformers Tr1 and Tr2 are included in branch circuits 20' and 20'', and the secondary circuits of these transformers are tuned to frequencies  $f_1$  and  $f_2$  by capacitors C<sub>3</sub> and C<sub>4</sub> respectively. Transformers Tr1 and Tr2 couple the tuned branch circuits to the grids of electronic relays T<sub>1</sub> and T<sub>2</sub> as shown. The L/C ratio or ratio of inductance to capacity of the tuned circuits including C<sub>3</sub> and C<sub>4</sub> should preferably be small in order that the full resonant response of the tuned circuits will be somewhat delayed. This counteracts the tendency of transient impulses to "trip" T<sub>1</sub> and T<sub>2</sub>.

Electronic signal translating devices comprising relays T<sub>1</sub> and T<sub>2</sub> are preferably of the well known triode gas-discharge tube type in which the grid "trips" or ionizes the tube permitting a comparatively large ionization current to flow in the anode-cathode circuit thereof. After ionization, the grid loses control and is ineffective to terminate the discharge until the anode potential is reduced substantially to zero. Hence deionizing or cut-off means additional to the grid are provided when direct current is used to supply the anode circuit. Any suitable means may be used, such means being indicated by reference numeral 25. For example, a cut-off relay

may be used in the position of 25 when the tubes are used alternately, to effect deionization of the tube or interruption of the circuit after a brief interval of operation, thus serving both tubes, or other known means may be used. Resistors R<sub>1</sub>, R<sub>2</sub> serve to limit the grid current upon ionization of their associated relays, while resistors R<sub>3</sub>, R<sub>4</sub> represent the load resistances of T<sub>1</sub> and T<sub>2</sub> respectively. Relays L<sub>3</sub>, L<sub>4</sub> may represent the receiving relays for two channels, two printer actuating magnets, or any other translating means by which the telegraphic signals are recorded or rendered intelligible. Relays T<sub>1</sub> and T<sub>2</sub> are conveniently supplied with energy by rectifier unit 15, or from any other suitable source.

The operation of the arrangement of Fig. 2 is as follows: Assume that a train of carrier waves of frequency  $f_1$  is received from the line. Owing to the tuned filter arrangement L<sub>1</sub>, C<sub>1</sub> in branch circuit 20', this branch offers a markedly lower impedance to the signal train than does branch 20''. Hence the voltage which appears across the secondary of Tr1 is considerably higher than that across the secondary of Tr2. Furthermore the secondary of Tr1 being tuned to frequency  $f_1$ , while the secondary of Tr2 is tuned to frequency  $f_2$ , a further frequency selective effect is obtained. For example, under suitable conditions, for signals of frequency  $f_1$  the voltage ratio of the potential applied to the grid of T<sub>1</sub> as compared to the potential applied to the grid of T<sub>2</sub> may be 10 to 1, while a like ratio favorable to T<sub>2</sub> may be obtained for signals of frequency  $f_2$ . Thus by suitable choice of the operating conditions for T<sub>1</sub> and T<sub>2</sub>, following well known practice, T<sub>1</sub> will be exclusively tripped by signals of frequency  $f_1$ , while T<sub>2</sub> will be exclusively tripped by signals of frequency  $f_2$ .

Assuming that T<sub>1</sub> has thus been tripped, a pulse of current flows (following the ordinary convention) from positive source via cut-off device 25 to the anode of T<sub>1</sub>, thence by space current to cathode, through resistor R<sub>3</sub> to frame and return to source. The current through resistor R<sub>3</sub> causes a potential drop across same, hence part current (in such amount as is desired) is diverted through the winding of relay L<sub>3</sub> energizing same. After an interval determined by cut-off device 25, the potential across the anode and cathode of T<sub>1</sub> is reduced substantially to zero, the potential being held down long enough to permit the grid of T<sub>1</sub> to regain control, thus effecting the de-ionization of T<sub>1</sub>.

In similar manner, upon the reception of a train of waves of frequency  $f_2$ , T<sub>2</sub> is ionized, relay L<sub>4</sub> is energized and cut-off device 25 causes the deionization of T<sub>2</sub> thus restoring the circuit to normal condition.

It should be noted that the cut-off device operates to effect deionization after a definite, predetermined interval, hence the translating devices are energized for the same duration by all signals of amplitude sufficient to ionize the electronic relays. The invention is thus particularly suitable to equal signal systems, and in such systems has the practical advantage of providing reliable operating impulses even though the received signals may be clipped or mutilated.

The arrangement here shown is very desirable in that among other advantages, it eliminates the need for a detector and/or amplifying tube, the electron relays which perform the usual function of a line relay being actuated directly by the incoming signals. It is characterized by its simplicity and advantageous use of electron

relays. In addition to the selective action of the tuned receiving circuits, further selective action is obtained by the novel method of selective tuning of the electron relay input circuits.

Referring now to Fig. 3 which shows another form of receiving arrangement in accordance with the invention, selection as to frequency is accomplished in steps, the first of which occurs in the coupling circuits of tube  $T_0$  which here functions as a signal amplifying tube. The arrangement shown is particularly suitable for use on lines where the attenuation is considerable and/or where the channel frequencies are narrowly spaced. The secondary circuit 20 of line transformer  $Tr_5$  has two branch circuits 20', 20'' including coupling coils 21', 22' of transformers  $OT_1$  and  $OT_2$ , these branch circuits being selectively tuned to frequencies  $f_1$  and  $f_2$  by suitable means such as filter arrangements  $S_1, L_1$  and  $C_2, L_2$ . The secondaries of  $OT_1$  and  $OT_2$  are also tuned to frequencies  $f_1$  and  $f_2$  respectively, and apply potential variations corresponding to the carrier signals to grids 11 and 12 of tube  $T_0$ . The primaries of transformers  $Tr_1$  and  $Tr_2$  are included in plate circuits 31 and 32 associated with plates 21 and 22 respectively. The remainder of the arrangement is as described in connection with Fig. 2.

The operation is as follows:—Carrier signals from the line are transferred by line transformer  $Tr_5$  to branch circuits 20' and 20'', but in unequal degree depending upon the carrier frequency, as for example signals of frequency  $f_1$  are offered a low impedance path by filter combination  $L_1, C_1$  and a high impedance path by filter combination  $L_2, C_2$ , hence the major portion of the energy flows in circuit 20'. For signals of frequency  $f_2$  the reverse holds. Further selective action occurs in tuned circuits 11' and 12' improving the voltage ratio of the potentials applied to grids 11 and 12. Tube  $T_0$  amplifies the signals, which are applied with augmented amplitude to the primaries of transformers  $Tr_1$  and  $Tr_2$ . With proper operating conditions,  $T_1$  will thus be tripped by  $f_1$  signals, and  $T_2$  by  $f_2$  signals, producing selective operation of translating devices  $L_3$  and  $L_4$ .

This arrangement is characterized by its high selection ratio, its ability to function reliably on weak signals, its economy of apparatus, and the inherent compensatory features of the twin amplifying tube employed.

It should be noted that amplifying tube  $T_0$  has the beneficial effect of increasing the selection margin. As is well known, electron relays such as  $T_1$  and  $T_2$  here employed are tripped by a certain critical value of potential. For example, let it be assumed that each tube can be tripped by a peak potential of twenty volts applied to the primaries of  $Tr_1$  and  $Tr_2$ . Let it further be assumed that the selection ratio due to tuned circuits  $L_1, C_1$ , and  $L_2, C_2$  and tuned transformers  $OT_1$  and  $OT_2$  is ten to one, and that the effective amplification factor of  $T_0$  is five. Then if the peak voltage on grid 11 due to a  $f_1$  signal is 10 volts, that on grid 12 will be one volt, giving a selection margin of nine volts. After amplification by tube  $T_0$ , these peak voltages become 50 volts and 5 volts respectively, giving a selection margin of 45 volts. This voltage difference, applied to  $T_1$  and  $T_2$  by transformers  $Tr_1$  and  $Tr_2$ , provides a substantial operating margin for selection purposes. It is to be understood that the voltage values cited in the example are for illustrative purposes, and in practice reliable selec-

tive action can be obtained with comparatively feeble carrier signals, and widely varying selective ratios.

Referring now to Fig. 4, a combined sending and receiving arrangement is shown which is particularly adapted to two way systems in which communication is held in one direction or the other, but not simultaneously in both directions. This arrangement represents a combination of those shown in Figs. 1 and 3.

Suitable switching means, designated by  $S, S_1, S_2, S_3$ , are provided to change the circuits at will from sending to receiving condition. The switches are shown at convenient places in the diagram, but in practice are conveniently grouped in a single multiple switch. It is assumed that when the switch tongues are moved to the right, the circuits are in sending condition and when moved to the left are in receiving condition. Assuming first that sending conditions are to be established, all switch tongues are to be considered as being to the right. Switch  $S$  then applies positive potential to plate 21 via lead 20, primary of  $Tr_5$ , branch 20' and coil 21', via switch  $S_1$ , and thence to plate 21; and to plate 22 through the circuit including the primary of  $Tr_5$ , thence through branch 20'' and coil 22', via switch  $S_2$  to plate 22. Switch  $S_3$  connects the sending device, such as printed 34, across grid resistor  $R_{11}$  via lead 41, and across grid resistor  $R_{12}$  via lead 42. A printer which has been found to give very satisfactory results is that disclosed in our copending application Serial No. 738,833, filed August 7, 1934.

The sending operation is the same as described in connection with Fig. 1, except that printer 34 functions in the same manner as but replaces the keying arrangement comprising  $K_1, K_2$ , and  $B$  of Fig. 1. Briefly, one portion of the printer circuits is associated with  $OT_1$  and the other portion with  $OT_2$ . When one of the printer keys is operated, the tube  $T_0$  is placed in oscillation at the selected frequency,  $f_1$  or  $f_2$ , and for the proper duration and at the proper time in accordance with the particular key operated, a corresponding signal being sent over the line.

Assuming next that receiving conditions are to be established, all switch tongues are moved to the left. Switch  $S$  connects lead 20 to the mid point between  $C_1, C_2$ ; switch  $S_1$  connects plate 21 to lead 31, and coil 21' to  $L_1$ ; while switch  $S_2$  connects plate 22 to lead 32 and coil 22' to  $L_2$ , thus completing the signal circuits as described above in connection with Fig. 3. Switch  $S_3$  connects printer 34 to leads 51 and 52 which are included in the output circuits of electron relays  $T_1$  and  $T_2$ .

The receiving operation is the same as that described in connection with Fig. 3, except that printer 34 functions in the same manner as but replaces the translating devices  $L_3, L_4$  of Fig. 3. Thus the signals, distinguished by their frequency, time, and/or duration, are caused to effect the selective operation of the printer and to cause operation of the printer keys corresponding to those at the sending station.

The arrangement is characterized by its dual utility, relative simplicity, and balancing and compensating features.

It will be apparent that the arrangements shown in Figs. 1 and 2 can be combined into a sending-receiving unit in the same general manner as the arrangements of Figs. 1 and 3 have been combined, and in some applications may be preferable to that shown in Fig. 4. The detailed

connections for such combination will readily be seen by those skilled in the art, hence further description is not required.

The advantages enumerated, and others un-  
5 mentioned, are attributable to the method of handling the channel frequencies in groups, to the use of a multiple tube with balanced elements, to the advantageous use of electron re-  
10 lays in combination with frequency selective circuits, and to the novel arrangements disclosed.

It will be apparent that the invention provides a carrier signalling system which is relatively simple, economical in the use of apparatus, efficient and reliable in action, and which meets in  
15 a highly satisfactory manner the manifold and exacting requirements for a system of this type.

While the methods herein described and the forms of apparatus for carrying these methods into effect constitute preferred embodiments of  
20 the invention, it is to be understood that the invention is not limited to these precise methods and forms of apparatus, and that changes may be made in either without departing from the scope of the invention which is defined in the  
25 appended claims.

What is claimed is:

1. In carrier signalling systems, a carrier frequency selective receiving arrangement comprising a plurality of frequency selective receiving  
30 circuits each tuned to a particular frequency, a plurality of electron discharge tubes each provided with a control grid and adapted to be substantially completely ionized upon the direct application of a signal having a critical value of  
35 potential to its control grid, magnetic coupling means for coupling said selective receiving circuits to the grids of said discharge tubes, said magnetic coupling means being provided with a tuned secondary circuit characterized by an L/C  
40 ratio adapted to retard the resonant response of said tuned circuit, a plurality of signal translating means each operatively associated with the discharge circuit of one of said discharge tubes,  
45 a source of direct current for applying operating potential to said discharge tubes, and discharge current terminating means associated with said discharge tubes adapted to produce deioniza-  
tion of said discharge tubes.

2. The arrangement specified in claim 1 in  
50 which the magnetic coupling means for coupling the selective tuned receiving circuits to the grids of the discharge tubes have the grid circuits tuned to the same frequency as the receiving circuits.

3. A carrier signaling system comprising, in  
55 combination, wave generating means including an electron tube having a plurality of grid and anode elements mounted in a common sealed envelope and including individual circuits connected to said elements adapted to generate  
60 oscillations of a plurality of predetermined frequencies, an energy source for said tube, individual oscillation circuits included in each of the circuits connected to the grid elements, means coupling the said oscillation circuits to the individual anode circuits, means included in the grid  
65 circuits for normally conditioning said tube to inhibit oscillations, keying means in the individual grid circuits, and means common to said keying means to nullify the said tube condition-  
70 ing means upon operation of any one of the keying means thereby conditioning the selected

grid circuits to provide for the generation of oscillations of a selected one of said predetermined frequencies as long as the selected keying means remains operated.

4. In a carrier telegraph system a two channel  
5 receiving arrangement including, in combination, two selective receiving circuits each tuned to an individual frequency, selective signal translating means, and selective signal amplifying means including an electronic amplifying tube pro-  
10 vided with twin control grids connected respectively in said selective receiving circuits and also having twin anodes, said grids and anodes being immersed in a common atmosphere and sealed in a common envelope, two electronic discharge  
15 tubes each provided with control grids and adapted to be ionized upon the application of a critical value of potential to their control grids, and individually tuned magnetic coupling means for coupling the anode circuits of said amplifying  
20 tube to the control grids of said discharge tubes, said tuned circuit of the magnetic coupling means being characterized by a controlled small L/C ratio adapted to retard the resonant response of said tuned circuit.

5. In carrier signal terminal apparatus adapted  
25 to function selectively for sending and receiving, in combination, an electronic discharge device having a plurality of grid and anode elements mounted in a common sealed envelope and in-  
30 cluding individual circuits connected to said elements, individual tuned circuits included in each of the grid circuits and including means for normally conditioning the device to prevent current flow in the anode circuits, individual keying  
35 means included in the said grid circuits and signal translating means controlled by the said anode circuits, positionable switching means to condition selectively the said device and said  
40 associated circuits whereby in one position the keying means are effective to initiate selectively carrier signals of predetermined frequencies and in another position condition the same said elements of the device and associated circuits to  
45 amplify selectively signals of the aforesaid predetermined frequencies on receiving thereby controlling selectively the operation of the said translating means.

6. In carrier signal terminal apparatus adapted  
50 to function selectively for sending and receiving, in combination, signal translating means, selectively tuned electronic relay means adapted to selectively actuate said signal translating means, an electronic discharge device having a plurality  
55 of grid and anode elements mounted in a common sealed envelope and including individual circuits connected to said elements, individual tuned circuits and individual keying means included in each of the grid circuits, and position-  
60 able switching means to condition selectively the said device and associated element circuits whereby in one position selective operation of the keying means are effective to initiate selectively  
65 carrier signals of predetermined frequencies, and in another position condition the same said elements of the device and associated circuits to amplify selectively signals of the aforesaid predetermined frequencies thereby controlling selectively the operation of the said electronic relay means and associated translating means.

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