Feb. 13, 1930. W. C. BOHN 1,747,218

AUTOMATIC SELECTION OF RECEIVING CHANNELS

Filed Dec. 11, 1928 2 Sheets-Sheet 1

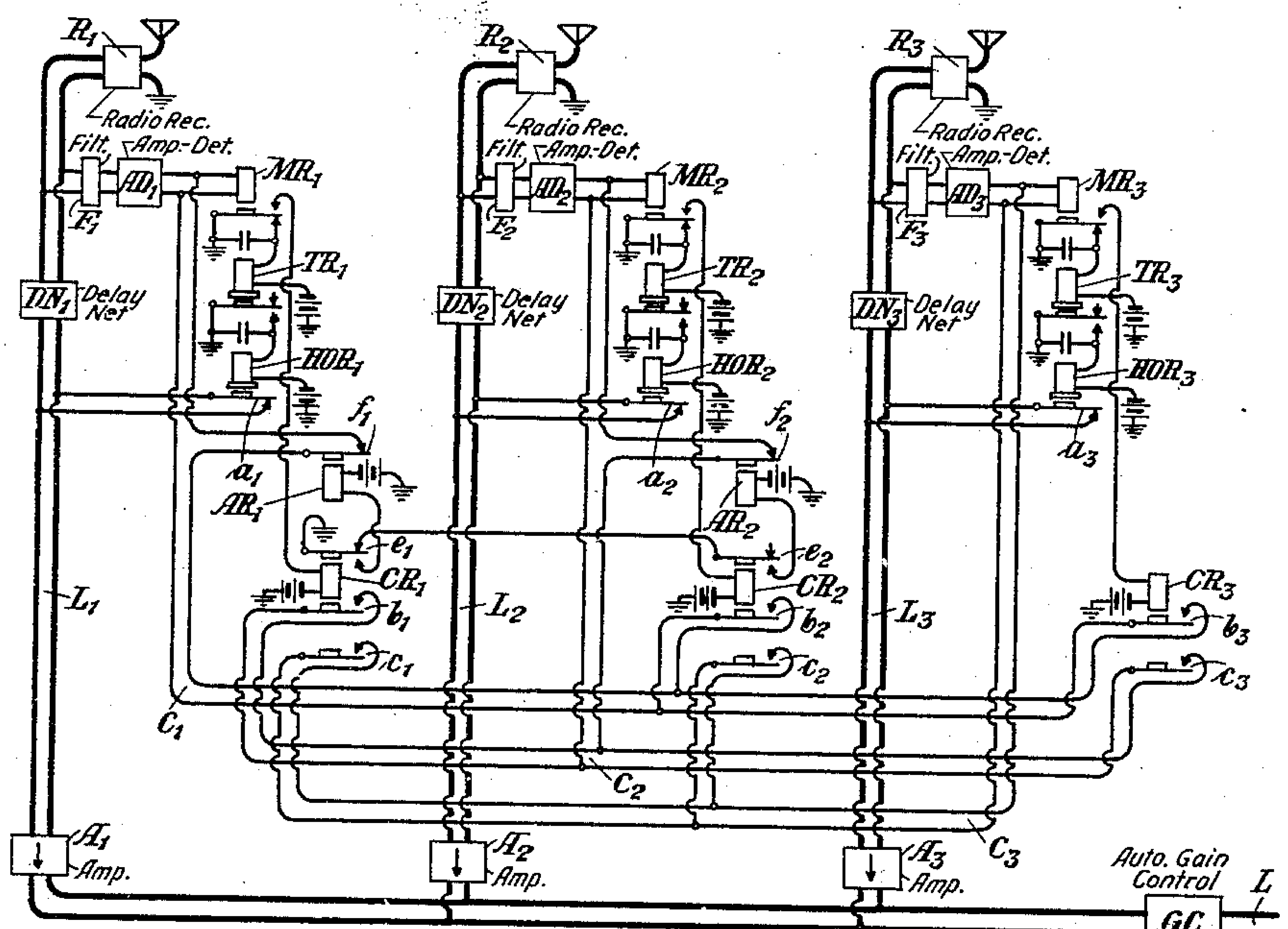

Fig. 1

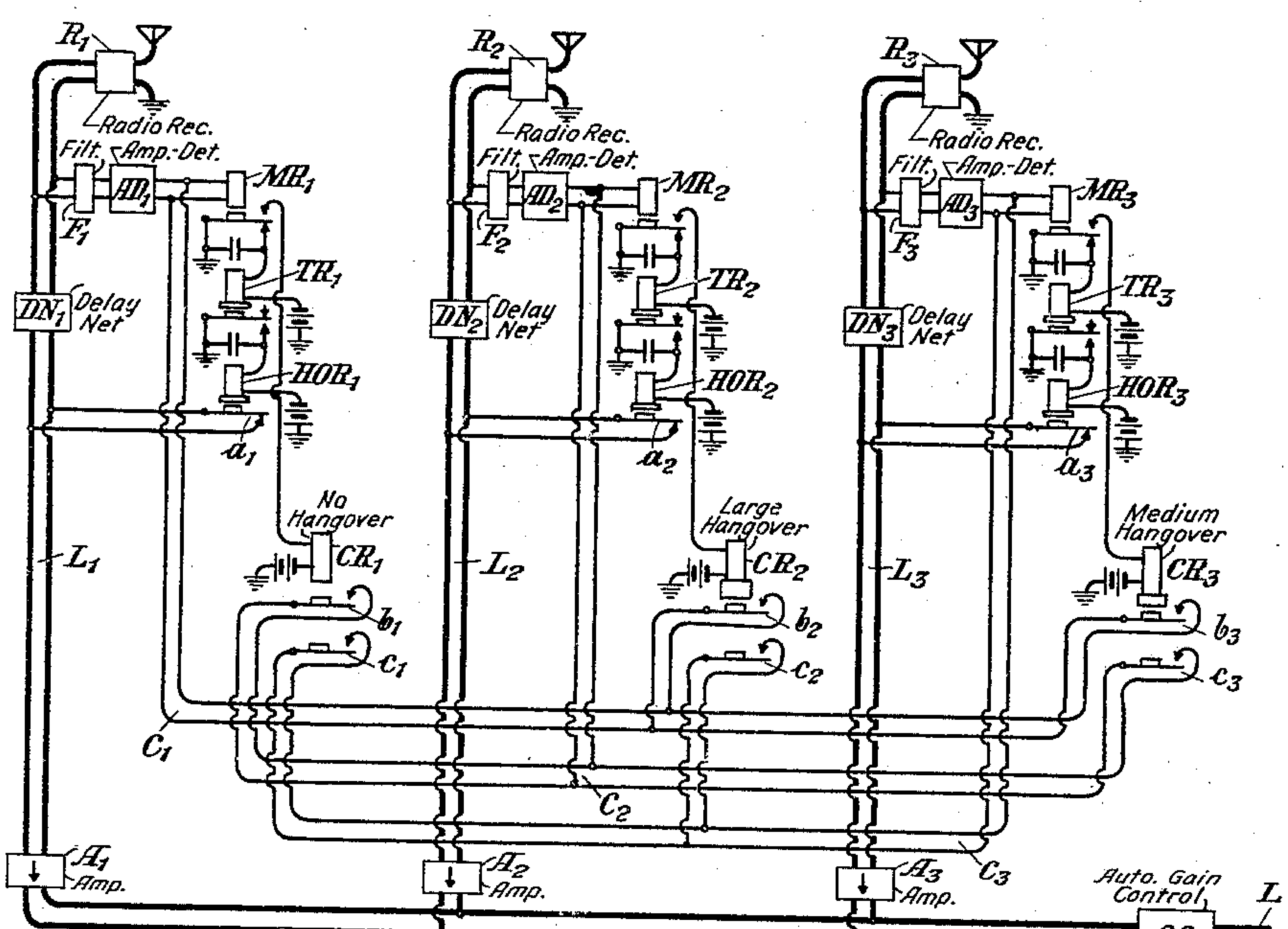

Fig. 2

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AUTOMATIC SELECTION OF RECEIVING CHANNELS

Filed Dec. 11, 1928 2 Sheets-Sheet 2

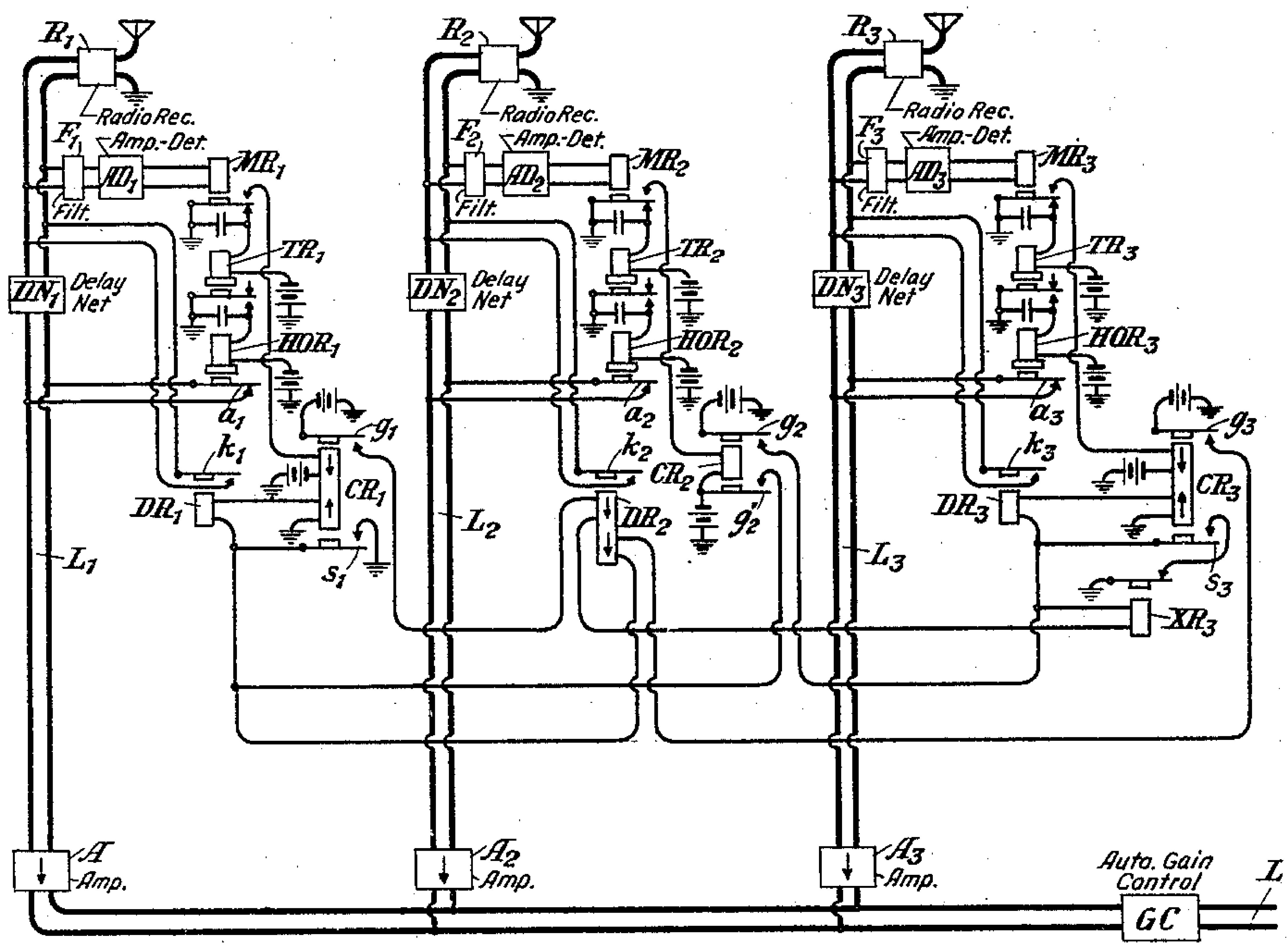

Fig. 3

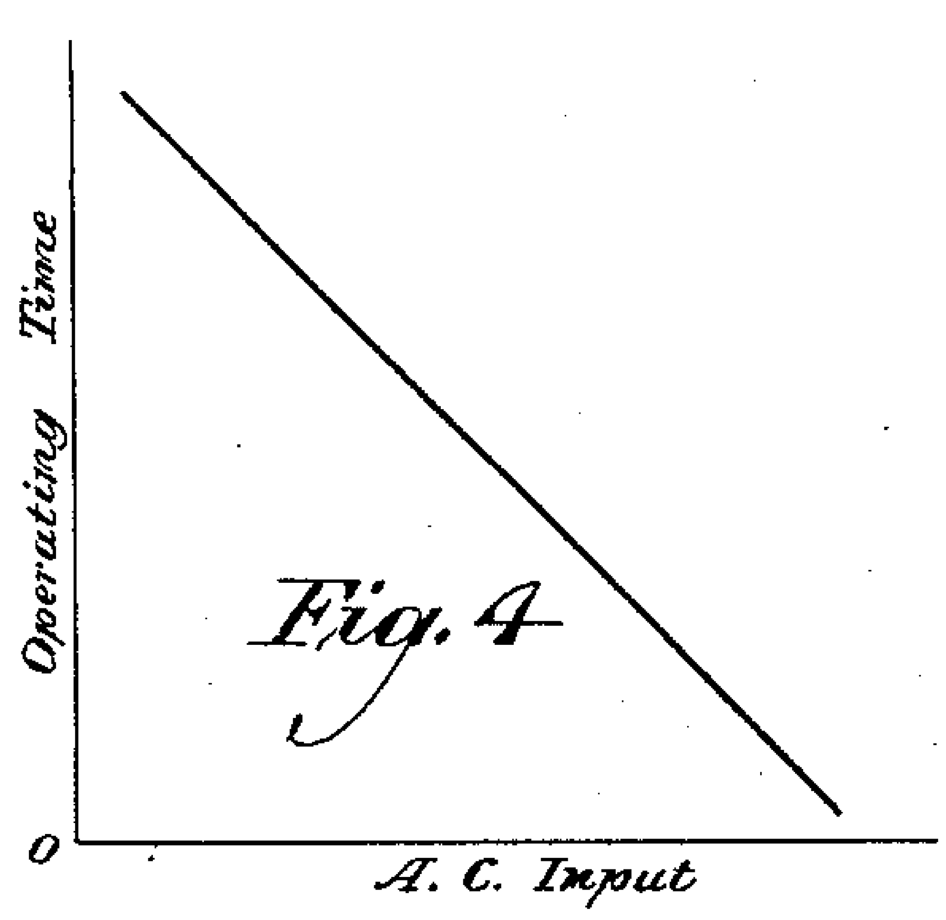

Fig. 4

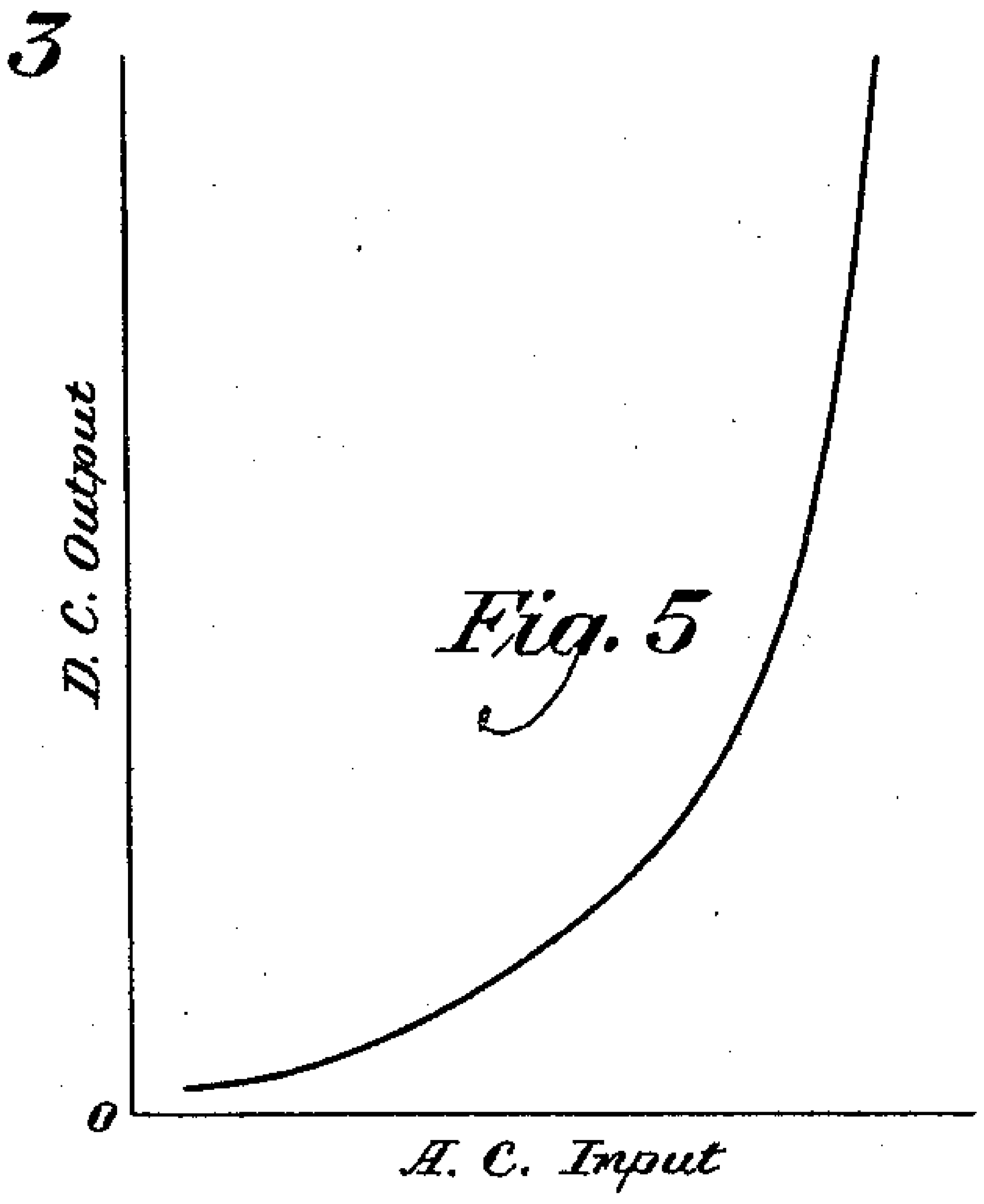

Fig. 5

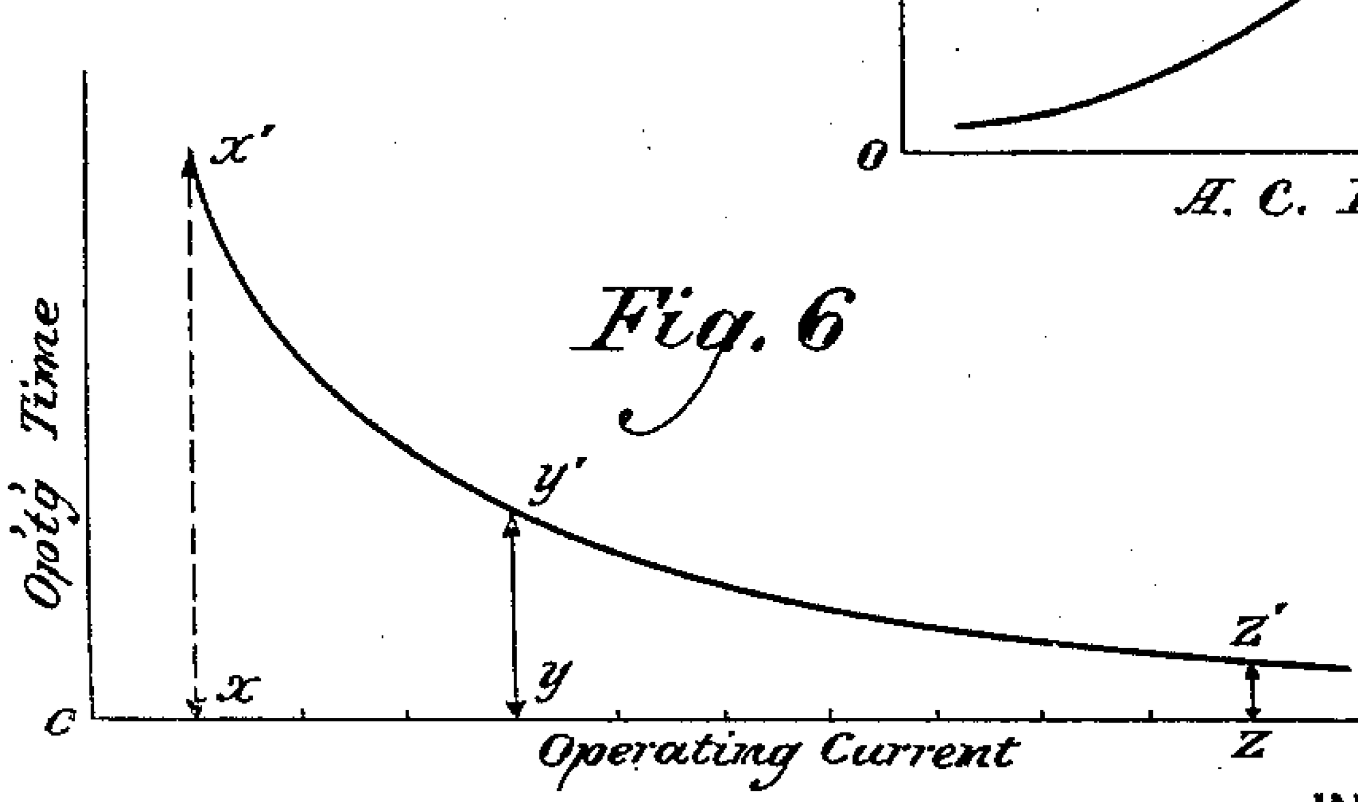

Fig. 6

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Patented Feb. 18, 1930 **1,747,218**

UNITED STATES PATENT OFFICE

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AUTOMATIC SELECTION OF RECEIVING CHANNELS

Application filed December 11, 1928. Serial No. 325,197.

This invention relates to methods and means for limiting the extent which any received signal may vary in intensity.

One source of signal variation is that due to changes in the strength of the signal as received from the signal medium. In the case of radio reception such variations are generally known as fading. Fading is particularly severe when receiving short wave lengths, and the method generally employed for maintaining a more or less constant demodulated signal has been to provide an automatic gain control or regulator. This method of regulation has certain limitations, however, and becomes inadequate, for example, when the signal drops below the limiting noise level. The present invention has as one of its objects the provision of a system which will be free from these limitations and may be used either independently or supplementary to automatic gain regulation for maintaining a constant output level at all times.

The invention is based on the fact that if a number of receiving stations properly located and sufficiently far apart are used to pick up a transmitted signal, the signal does not fade similarly at each of the receiving stations. Observations made on various wave lengths have shown that the receiving antennæ need only be separated from each other by a distance of the order of a few wave lengths or so in order to get this effect. The possibility of the signal fading out equally at all of the receiving stations at the same time is, therefore, reduced with increase in the number of receiving stations.

It has been heretofore proposed to use more than one receiver to pick up the radio signal and to choose for use the receiver giving the best results. In the past this was accomplished by cutting over manually from a receiver giving a signal of low volume to another which at the moment was giving a signal of larger volume, and again switching back to the first receiver or some other receiver as the signal again became low in volume. Obviously, such a method of operation was limited to cases where the changes in the signal occurred slowly enough to permit the operator to select the best receiver or receiver output.

Where the signal intensity changes quite rapidly, as is often the case with short wave reception, a system capable at all times of rapidly cutting in the best of the available received signals is desirable. It is therefore proposed to use a number of receiving stations, properly located, and to continuously and automatically select the receiver or output of the receiver giving the most useful signal, minimizing in this way the effect of rapid changes in the amplitude of the received current and reducing the possibility of the signal entirely fading out.

A system to accomplish these results should be capable of automatically, and more or less continuously, selecting for reception purposes the receiver output which is the best of those available, or at least one which is above a predetermined minimum. Where two or more receiver outputs are of equal strength, only one of them should be connected through for reception at any one time. Finally, if while one receiver output is connected through for one reception, another receiver, or receivers, furnish more desirable signals, the system should operate without undue delay to automatically select the signal from one of the more desirable receivers, cutting off at the same time the receiver from which the signal had previously been obtained.

Although various methods for accomplishing the foregoing results may be devised, the systems herein disclosed are so organized that they will depend for their operation upon the amplitude of the demodulated signal currents and will, therefore, have the advantage of being independent of the kind of transmission employed at the transmitter, so that the transmission may consist either of a single side band, carrier and one side band, or of a carrier and two side bands. At the same time the system may, if it is preferred, be operated by changes in the amplitude of the carrier itself.

The invention will now be more fully understood from the following description, when read in connection with the accompanying drawings, in which Figures 1, 2 and 3 are schematic circuit diagrams embodying three different forms of the invention, while Figs. 4, 5 and 6 are curves illustrating the operation of certain features of the apparatus.

Fig. 1 shows a system for automatically and recurrently selecting the largest or substantially the largest output of one of a series of radio receivers R_1, R_2, R_3 for connection to a main receiving line L. Although only three receivers are shown, the system may be applied to any number of receivers, with slight modification in the relay circuits. In general, the largest output to be selected may be either voice or carrier frequency, the design of the delay circuits and of the amplifier-detector system employed depending upon which type of signal is to be selected.

In Fig. 1 the output is shown as adapted for voice frequency operation. It will be observed that the output of each receiver, such as R_1, is connected to a delay device, such as the delay network DN_1. These delay networks are of known construction and have the effect of delaying the speech currents in a manner similar to that of a long wire line circuit. In the present instance, the delay circuits are used to delay the speech currents long enough to permit all of the associated control relays to function before the speech currents arrive at the short-circuiting contact, such as a_1, which controls the connection of each receiver to the line L. In order to control the connection of the receiver R_1 to the line L, a filter F_1 is provided for selecting some of the voice energy from the output of the receiver R_1. (In case the automatic control is to be exercised from the fading of the carrier, the filter F_1 would be designed to select the carrier frequency.) On the output side of the filter F_1 is an amplifier-detector unit AD_1 of well-known construction, for amplifying and rectifying the selected energy to produce a direct current whose instantaneous amplitude is determined by the amplitude of the signal received from the receiver R_1. This rectified current is used to control the relay switching arrangements to be described hereinafter.

These switching arrangements are primarily controlled by a master relay MR_1 in the output of the amplifier-detector AD_1. When a signal current is received from the output of the receiver R_1 of sufficient volume to operate the master relay MR_1, the armature of said relay is attracted to release the slow release relay TR_1, which in turn completes the circuit of the hangover HOR_1. The latter relay, by opening the short-circuiting contact a_1, removes the short-circuit from the output side of the delay network DN_1, thereby establishing a connection through the receiver R_1 to the line L and permitting the speech currents which have been delayed by the network DN_1 to pass to the receiving line. The hangover relay HOR_1 is a slow release relay and thereby introduces a sufficient hang-over operation to enable any currents which are just entering the delay network at the end of the signal, to pass through the network to the receiving line under the control of master relay MR_1.

As will be pointed out later in connection with the circuit arrangements whereby one of the receivers is selected to the exclusion of the others, conditions may arise which will permit a momentary operation of the master relay under conditions such that some other receiver is ultimately to be selected. While in general such momentary operation may not produce any harmful effect, since the hangover relay will have released before the pulse of signaling current producing the momentary operation of the master relay MR_1 will have passed through the delay network DN_1, the relay circuit arrangement of Fig. 1 is so arranged as to prevent any opening of the short-circuit contact a_1 in response to a momentary operation of the master relay MR_1. This is due to the fact that the intermediate relay TR_1 is slow to release and when the contact of the master relay MR_1 is only attracted momentarily, the armature of the intermediate relay TR_1 is not released to close the circuit of the hangover relay HOR_1 to in turn open the contact a_1.

In order to properly control the various selecting relays and circuits whereby a particular receiver is selected in such a manner that the receiver having the largest output will be selected in preference to a receiver having a lesser output but sufficient to operate its master relay, the master relay, such as MR_1, associated with receiver R_1, should operate more quickly in response to a large rectified current than in response to a smaller rectified current. Since the ordinary relay responds more quickly to larger currents than small currents, this requirement does not call for any special design of the master relay MR_1. Fig. 6 shows a typical curve illustrating the relation between operating current and operating time for a master relay. $o—x$ represents the minimum current necessary to operate the master relay. Until the received signal from a particular receiver is of sufficient strength to produce a rectified current of this value, the master relay will not operate and hence the receiver cannot be connected to the receiving line L. With the rectified current of the value $o—x$, however, an operating time $x—x'$ will be required to operate the master relay. If a greater operating current, such as $o—y$, is received, the relay will only require the length of time $y—y'$ to operate. If the operating current should have the value $o—z$, the time required to operate the relay would be that represented by $z—z'$.

In order to have the best operation of the system so that the discrimination between different receivers, with respect to the time of the operation of the master relays, may be more exact, it might be desirable to have an amplifier-detector arrangement of such character that a linear relation would exist between the input signal current and the operating time as illustrated by the curve of Fig. 4. If it is considered desirable to maintain this strict proportionality between the operating time and the input signal current, the detector, in the amplifier-detector such as AD_1 may be similar to the well-known design employed in connection with volume indicators, such as are used in broadcasting stations. The characteristic of such a detector will be similar to that indicated by the curve of Fig. 5. In actual practice, however, the relation between the relay operating time and the signal input current shown in Fig. 4 need not necessarily be linear so long as the operating time decreases with increase of the input current. The ordinary amplifier-detector such as is used in connection with echo suppressors will be satisfactory for the purpose of the present invention, and in the following description it is assumed that the amplifier-detector units, such illustrated at AD_1, are the echo suppressor type.

The apparatus so far described is similar for each receiver and hence the corresponding apparatus associated with the receivers R_2 and R_3 is not described in detail.

In order that the proper receiver may be selected at any given time, it is necessary that a master relay, such as MR_1, operate certain dependent relays for controlling the selection. For example, if the transmitted signal is received simultaneously by the three receivers illustrated and each has approximately the same sensitivity, and each is connected to a similar antenna, then if the antennæ are sufficiently far apart, the three received signals will in general not fade simultaneously. At any instant, therefore, the signal may be maximum on receiver R_1 or on receiver R_2 or on receiver R_3; or, again, the amplitudes may be the same on the receivers R_1 and R_2, or R_1 and R_3, or R_2 and R_3, but greater than the amplitude of the third receiver; or the signals received on the three receivers may be of the same amplitude. In order to effect a proper selection under any of the above conditions, relays CR_1, CR_2 and CR_3 are associated with the several receivers, each of these relays being operated whenever the corresponding master relay attracts its armature to its front contact. Each of the relays, such as CR_1, is designed to be quick in its response so that its selecting functions may be performed without delay.

Each of the master relays may be disabled by means of short-circuit connections, such as C_1, C_2 and C_3. The relay CR_1 has two contacts b_1 and c_1, the former of which closes the short-circuited C_2 for the master relay MR_2 and the latter of which closes the short-circuit C_3 for the master relay MR_3. Said relay also has a third contact e_1 which, when operated, energizes an auxiliary relay AR_1 for opening the short-circuit C_1 of its master relay FR_1 at f_1 and also for controlling the circuit of the corresponding auxiliary relay AR_2 of the receiver R_2 to give priority to the receiver R_1 when both receivers have the same output, as will be described later.

Similarly, the relay CR_2 associated with the receiver R_2, by means of its contacts b_2 and c_2 controls the short-circuiting connections for the master relays MR_1 and MR_3, respectively. Likewise, by means of its contact e_2, the relay CR_2 controls the circuit of the auxiliary relay AR_2 to disable the short-circuit C_2 of its own master relay MR_2 by means of the contact f_2. The relay CR_3, by means of its contacts b_2 and c_2, controls the short-circuit C_1 and C_2, respectively, for disabling the master relays MR_1 and MR_2. Said relay CR_3, however, is provided with no auxiliary relay and hence cannot open the short-circuit C_3 associated with its own master relay. Consequently, as will be described later, if the receiver R_3 and any other receiver are receiving signals of the same strength simultaneously, the other receiver will be given preference.

The selecting arrangement above described is so designed that, when it selects, it selects the maximum signal for connection to the main receiving line L at all times to the exclusion of signals from any of the other receivers. If two or more receivers yield approximately the same maximum signal, only one is connected through for reception. Advantage is taken of the fact that the time required for a master relay to operate depends upon the amplitude of the operating current. The operating time of the master relays employed will therefore depend upon the rectified current supplied to them by the amplifier-detectors which, in turn, depends upon the output speech levels of the receivers across which the amplifier-detectors are bridged. While, as already stated, this relation between the output speech level and the operating time may be made prcatically linear, if desired, a non-linear speech level versus relay operating time characteristic is in practice sufficient to enable the selective system to readily select between signals which are above a predetermined minimum intensity. It will not, however, select the maximum signal at all times since the differential between two or more very strong signals from different receivers will not be as fine as between weaker signals furnishing detector currents which are just above the minimum operating current necessary to cause operation of the master relay. A receiving system employing such non-linear selecting arrangement will, however, effect a considerable improvement over the conventional method of receiving signals since signals of usable intensity will be continually selected, and the possibility of the signal fading out will be greatly reduced.

The nature of the selecting arrangement is also such that whenever the signal from a particular selected receiver falls below the value necessary to cause operation of its master relay—in other words, whenever the signal from that receiver fades below a given value, the selection effected under the control of its master relay will no longer be effective, and a new selection will be started. Also, a new selection will occur whenever a momentary interruption occurs in the signal, such as the pause between sentences and, in fact, the system may be so designed as to re-select whenever a pause takes place such as would occur between successive words. Therefore, while a receiver once selected will remain selected so long as its output is above the minimum requirement, even though another receiver may a moment later have a greater output, re-selection due to pauses will occur with such frequency that in general the signal from a particular selected receiver will not have time to fade materially.

In any event, the volume of the signals connected to the main receiving line can be kept substantially constant by means of an automatic gain control such as is indicated schematically at GC in Fig. 1. This gain control arrangement may be of any type well known in the art arranged to respond to the received voice range as distinguished from the carrier. Such a gain control arrangement is illustrated, for example, in the patent to Espenschied and Bown, No. 1,447,773, of March 6, 1923. Automatic gain controls have heretofore been used with some success for accommodating the gain or sensitivity of a receiver to the signals received. However, when the signals fade down into the noise levels and are brought up by the introduction of more gain by the automatic gain control, the noise is brought up by the same amount so that the signal may still be unintelligible. This disadvantage may be overcome, however, if maximum signals are selected from a plurality of receivers, as above described, and the volume is controlled in the main receiving line, as indicated in Fig. 1. Since the volume of the signals from the different receivers determine which receiver shall be cut through to the receiving line, the range in volume which the automatic gain control in the receiving line must care for will be comparatively small.

Operation of Figure 1

Further details of the apparatus of Fig. 1 will be clear from the description of its operation, which is as follows:

Useful signal from one receiver only

Let us assume that the largest signal output is being received from receiver R_1 and that the signal outputs from the receivers R_2 and R_3 are not sufficient to cause the operation of the corresponding master relays MR_2 and MR_3. The signal of the receiver R_1 then passes to the delay circuit DN_1, and through the filter F_1, to the amplifier-detector AD_1, thereby causing the operation of the master relay MR_1. Upon attracting its armature, the master relay opens the circuit of the intermediate relay TR_1 and closes the circuit of the control relay CR_1. Relay TR_1 after an instant releases its armature to energize the relay HOR_1 which removes the short-circuit from the output of delay circuit DN_1 at a_1. This action takes place just before the signal is passed through the delay network and the receiver R_1 is now cut through to the line L. The relay CR_1 at its upper front contact e_1 completes the circuit of the auxiliary relay AR_1, which at f_1 opens the short-circuit connection c_1, which might be established across the master relay MR_1 by the relays CR_2 and CR_3 in case they should be operated. At the same time the relay CR_1 closes its contacts b_1 and c_1, the former closing the short-circuit connection C_2 about the master relay MR_2, associated with the receiver R_2, and the latter closing the short-circuit C_3 about the master relay MR_3 associated with the receiver R_3.

The output of the receiver R_1 is now connected to the line L exclusive of the other receivers, and should the volume of the output of either of the other receivers increase to such an extent as to be able to operate corresponding master relays, such operation would be prevented and the receiver R_1 would remain exclusively connected to the line L until such time as the master relay MR_1 is released, due to the fading of the signal from the receiver R_1, or due to an interruption in the signal between successive words or sentences (or, in the case of telegraph transmission, between successive telegraph impulses), of sufficient duration to enable MR_1 to release the hangover relay HOR_1 and again short-circuit the connection L_1 between the receiver R_1 and the line L.

If either receiver R_2 or receiver R_3 should be the only receiver whose output was of sufficient magnitude to operate the corresponding relay, the operation of connecting such receiver to the line L, to the exclusion of other receivers, would be similar to that just described.

Maximum signals from one receiver only

Where more than one receiver supplies an output of sufficient volume to operate its corresponding master relay, but the output of one is substantially greater than that of any other, the receiver having the larger output will be selected and connected with the line L. For example, if the signals from receivers R_1 and R_3 are strong enough to operate the master relays MR_1 and MR_2 but the signals from receiver R_2 are stronger, master relay MR_2 will operate first. The operation of this relay sets into operation a train of relays, including hangover relay HOR_2, to remove the short-circuit from the line L_2 at contact a_2. As soon as the master relay MR_2 is operated, it also actuates relay CR_2 to short-circuit the master relays MR_1 and MR_3 by means of its contacts b_2 and c_2, respectively. By the actuation of the contact e_2, relay CR_2 completes the circuit of relay AR_2 to disable the possible short-circuiting connection of the master relay MR_2 at f_2.

In the meatime, if the master relay MR_3 should be operated momentarily before the short-circuit at C_3 is applied thereto by means of the contact c_2, such momentary opertion will not enable signals entering the delay network DN_3 to get to the line L, as the intermediate relay TR_3 prevents the release of the hangover relay HOR_3 in response to a momentary actuation of the master relay, as has already been described. Similarly, a momentary actuation of the master relay MR_1 before the short-circuit C_1 is applied by the contact b_2, would not result in the operation of the hangover relay HOR_1 to cut the receiver R_1 through to the line L.

On the other hand, if the signal from the receiver R_1 is such that the relay MR_1, while operated an instant later than the relay MR_2, is operated so nearly simultaneously therewith that the relay CR_1 has time to pull up and open the contact e_1 before the contact at e_2 can effectively establish the circuit of the relay AR_2, the relay AR_2 will be prevented from operating to open the possible short-circuit connection for the relay MR_2 at f_2. The radio receiver R_1 may now again control the circuit by reason of the fact that relay CR_1 energizes relay AR_1 to open the possible short-circuit of the relay MR_1 at f_1. Contacts b_1 and c_1 in the meantime short-circuit the master relays MR_2 and MR_3 so that the relay MR_2 will fall off and release the relay CR_2. While the receiver R_1 is now connected exclusively to the circuit notwithstanding that the amplitude of the signal from the receiver R_2 is slightly greater, this action is only possible where the margin of difference between the amplitudes of the two signals is relatively small, with a consequent small difference in time discrimination between the operation of the two master relays. The improper selection above described could not take place where the operation of the relay MR_1 was sufficiently later than that of the relay MR_2 to enable the latter to establish the short-circuit at b_2 across the relay MR_1 before it had been actuated sufficiently to energize the relay CR_1. No particular harm would be caused by such improper selection for the time margin of operation of the two relays would depend upon a marginal difference between outputs of the two receivers of such relatively small magnitude that it would not really be important to select the largest signal. In any event the fact that a signal of slightly smaller volume than the maximum had been selected, would be adequately compensated by the action of the auto-gain control apparatus GC.

Signals from two receivers equal to and stronger than those from the third

Suppose the signals received from receivers R_1 and R_2 are of equal strength and greater than the signal from receiver R_3. Under these conditions the master relays MR_1 and MR_2 operate simultaneously. Relay MR_1 completes the circuit of relay CR_1 so that contacts b_1 and c_1 short-circuit the master relays MR_2 and MR_3. Relay MR_2 also completes the circuit of relay CR_2 but the closing of the contact b^2 by the latter, which would normally put a short-circuit on the master relay MR_1, is prevented by the fact that the relay CR_1 is actuated to complete at e_1 the circuit of the relay AR_1 and open the possible circuit of the relay AR_2 which might be closed by the relay CR_2. The relay AR_1 opens at f_1 the short-circuit which would otherwise be established by the contact b_2. The relay AR_2 cannot operate while the relay CR_1 is operated. Hence while the contact b_1 disables the relay MR_2 associated with the receiver R_2, the contact c_2 cannot disable relay MR_1 associated with receiver R_1, due to the operation of relay AR_1 with the consequent opening of the contact f_1. Therefore, only the signal from the receiver R_1 is connected through to the line L by the opening of the contact a_1 on the part of the hangover relay HOR_1.

In general, whenever the signal received from the receiver R_1 is equal to the maximum signal from any other receiver, as in the case just described, the signal from the receiver R_1 is given preference, due to the action of the relay AR_1 and its contact f_1, which prevents disabling of its relay system while permitting the operation of its own relay system to disable the operation of the relay system associated with the other receiver. Therefore, when maximum and equal signals are received on the receivers R_1 and R_2, or the receivers R_1 and R_3, the signal from the receiver R_1 is preferred in the selection and cut through to the receiving line. The same holds true when the signals from all three receivers are equal.

When the signals received from the receivers R_2 and R_3 are maximum and substantially equal, the master relays MR_2 and MR_3 will operate simultaneously. The relays

CR_2 and CR_3 will also operate simultaneously, the former to short-circuit MR_3 at the contact c_2 and the latter to short-circuit MR_2 at the contact b_3. The relay CR_2, however, completes the circuit of relay AR_2 at the contact e_2, thereby causing the opening by the contact f_2 of short-circuit C_2 which was closed by contact c_3 under the control of the relay MR_3. As there is nothing to open the short-circuit C_3 established about the master relay MR_3, the latter is de-energized after its momentary operation. While the receiver R_2 is exclusively cut through to the line L under the control of the master relay MR_2, the momentary operation of the relay MR_3 does not cause the opening of the contact a_3, due to the slow release of the intermediate relay TR_3, as already described. The relay MR_1, associated with the receiver R_1, is of course held inoperative by the closing of the contact b_2.

Re-selection

It will, of course, be obvious that when one of the receivers has been selected and connected to the line L, it will remain so connected to the exclusion of other receivers, even though its output may thereafter become less than that of some other receiver, until the master relay associated with the particular receiver is released. This will, of course, take place whenever the signal fades to an amplitude lower than necessary to operate the master relay. It will also take place whenever an interruption occurs in the signal, such as might result from the pause between two sentences or the pause between successive words of a sentence. In the case of telegraph operation, such release of the master relay might take place between successive signal impulses. As soon as the relay releases, the master relays of the other receivers become operated again so that the most desirable signal can again be selected. If the output of a different receiver is selected at this time, the a-contact of the hangover relay associated with the receiver previously used will be closed to disable the receiver just before the signals from the newly selected receiver have had time to pass through their delay circuit.

The rate of re-selection of course depends upon the time of operation and release of the various mechanical relays. With relays of the type available, which will operate in from .003 to .005 of a second or even less, the operation of the chain of two or three secondary relays, which depends upon the operation of the master relay, would not require a total operating time of much more than .01 of a second and perhaps even less. Under these circumstances new signals could be selected as often as one hundred times per second without interrupting the signal to the line L.

The sensitivity to which the voice-operated devices can be adjusted will depend, as in the case of all devices of this kind, upon the prevailing noise or static, for if the device is too sensitive, noise may cause false operation. This limitation, however, does not detract in any appreciable degree from the utility of the selecting system above described, especially when it is used for short wave reception where static is usually of the "steady" type and well below the signal level. Signals nearer the steady noise level would in most cases be uncommercial even if they could be selected, and one of the chief advantages of multiple reception and selection lines, of course, in the fact that a means of avoiding such signals, as much as possible, is afforded.

Obviously, provision may be made for keeping the receiving line L connected through to the "air" by way of another receiver at all times when the receiving line is not so connected through one of the three selective receivers shown. The use of such a stand-by receiver would not, in general, be necessary, as the several selective receivers provided will ordinarily be sufficient to insure that some one of them will practically always afford an output of sufficient amplitude to actuate its master relay and thereby connect it to the line.

Operation of Figure 2

With the system shown in Fig. 2, results similar to those obtained with the system just described are capable of attainment. The circuits from the receiver outputs to the main receiving line L are identical with those shown in Fig. 1, and the voice operated devices may be made to function in a like manner. The essential difference lies in the method of giving preference to only one of two or more receivers when the outputs thereto have the same maximum amplitude. In order to obtain preference under such conditions, the dependent control relays CR_1, CR_2 and CR_3, which are controlled by the master relay, are given different hangover periods. These hangover periods need not be of long duration, the essential requirement being that they be different.

The operation of the circuit under conditions when the output of only one receiver is of sufficient amplitude to operate a master relay, is the same as described in connection with Fig. 1 and need not be discussed further. Also, the operation will be as previously described when more than one receiver supplies an output sufficient to operate the corresponding master relay, but the output of one receiver substantially exceeds that of the other receiver.

When signals from receivers R_1 and R_2 are maximum and equal

We will now consider the operation of the system when the signals received from receivers R_1 and R_2 are maximum and equal, and hence the master relays MR_1 and MR_2 associated with these receivers operate simultaneously. Relay CR_1 is operated by master relay MR_1, and at its contact b_1 places the short-circuit across master relay MR_2. Master relay MR_2 has, however, in the meantime completed the circuit for relay CR_2 which at its contact b_2 places a short-circuit across the relay MR_1. As the relay CR_1 has no hangover, or substantially no hangover, it is immediately de-energized following the short-circuit placed upon the master relay MR_1, so that the contact b_1 is opened and the short-circuit is removed from the master relay MR_2, permitting the latter to be acted upon by the incoming signals once more. Relay CR_2, having a considerable hangover period, does not open its contact b_2 in response to the momentary short-circuit applied to the master relay MR_2, and hence the short circuit established across the relay MR_1 remains, with the result that the receiver R_2 is connected through to the line L by removing the short-circuit at a_2 just before the signal passes through the delay network DN_2. The receiver R_1, on the other hand, is not connected through to the line L, as the momentary actuation of the master relay MR_1 does not cause the hangover relay HOR_1 to operate.

The time required to free the master relay MR_2 so that it can again be acted upon by means of the signals, is equal to the release time of the relay CR_1, which would be about .003 seconds or less. The hangover time of the relay CR_2, therefore, ought to be slightly longer than that in order that the master relay MR_1 be kept short-circuited until the signal currents have had time to operate the master relay MR_2 again. The delay device DN_2 must, of course, delay the signals until all of the foregoing operations are completed. The total time required for this entire operation can be made of the order of .01 second or less when fast mechanical relays are employed.

As in the case of Fig. 1, the hangover relays HOR_1, etc., should be so controlled by the master relays that they will not be operated by a short pulse through the master relay. The initial pulse which operates both the relays MR_1 and MR_2 will therefore be of too short duration to make the hangover relay HOR_1 operate and hang over to falsely connect signals from receiver R_1 through to the receiving line after they have passed through the delay device DN_1. By this circuit arrangement it is possible in all cases to prevent the signal from more than one receiver being connected to the receiving line L at any one time. Hence, when the relay MR_2 is operated the secoond time and the contact b_1 can no longer interfere with the continued operation of the relay MR_2 by speech signals (due to the hangover of relay CR_2), the hangover relay HOR_2 becomes operated and connects the signal through, while contacts b_2 and c_2 disable the master relays associated with the receivers R_1 and R_3. The hangover period of the hangover relays, such as HOR_1, HOR_2, etc., must, of course, be of sufficient duration to permit all of the delayed speech currents to get through to the receiving line after the cessation of speech or other signals.

Re-selection

Let us now suppose that the selected signal being received through the receiver R_2 ceases for a period long enough to permit the relay CR_2 to release. The shorter the hangover period of the relay CR_2, the shorter will this period be. The moment this relay releases, the system is again ready for re-selecting signals. The re-selection may take place before the hangover relay HOR_2 releases, provided, of course, it releases just before the same signal from some other delay circuit associated with a re-selected receiver is connected to the receiving line L.

When receivers R_2 and R_3 receive equal maximum signals

The operation under this condition will be similar to that described for the condition when equal maximum signals are received from receivers R_1 and R_2. The relay CR_2 is given a somewhat larger hangover than the relay CR_3, with the result that relay CR_2 hangs over during the brief period that the relay CR_3 is energized and applies a short circuit to the master relay MR_2 at c_3. Relay CR_2, therefore, maintains the short circuit applied to the master relay MR_3 at contact c_2, thus giving the signal from the receiver R_2 the right of way.

When signals from all three receivers are equal and of sufficient strength to operate the master relays

Under these conditions, all three master relays are simultaneously operated. Relays MR_1 and MR_3, however, are only operated momentarily and the corresponding control relays CR_1 and CR_3, therefore, maintain the short-circuit across the master relay MR_2, which is controlled by the contacts b_1 and c_3, until both of these control relays release. As the control relay CR_3 has a slightly longer hangover than the control relay CR_1, the latter releases first, thereby removing the short-circuits applied to master relays MR_2 and MR_3 at b_1 and c_1. A moment afterwards the relay CR_3 releases and removes the short-circuits applied to relays MR_1 and MR_2 at contacts b_3 and c_3. No short-circuit is now applied to the relay MR_2, and as the relay CR_2 has a slightly longer hangover than relay CR_3, it does not release, due to the temporary application of the short-circuit to the relay MR_2, but maintains the short-circuit applied at contacts b_2 and c_2 to short-circuit the master relays MR_1 and MR_3. Consequently, signals will be received and applied to the line L only from the recevier R_2.

It will, of course, be obvious from the foregoing that if equal maximum signals are received from receivers R_2 and R_3 and a signal of materially less volume is received from receiver R_1, both receivers R_2 and R_3 will be given preference to R_1, due to the fact that their master and control relays will be energized to short-circuit the master relay MR_1 before the latter will have had an opportunity to energize the control relay CR_1. As between receivers R_2 and R_3 from which signals of the same volume are being received, receiver R_2 is arbitrarily given preference, due to the longer hangover of its control relay CR_2.

Operation of Figure 3

As in the case of the systems previously described, the arrangement shown in Fig. 3 may be designed either (1) simply to select one of a number of signals which may be above a certain predetermined minimum intensity or (2) to select the signal having the maximum intensity. Whether the system will operate the one way or the other depends upon the characteristic of the amplifier-detector units employed. If these units have an operating characteristic such that the time they will require to operate will depend inversely upon the strength of the signal impressed upon them, the circuit is such that the receiver giving the strongest signal will be selected by virtue of the fact that the master relay actuated by the strongest signal will operate faster than the master relays actuated by the weaker signals. The range and nature of this relation of relay operating time versus actuating signal which would be required, depend upon the range over which the signals to be selected may vary in intensity (due to fading, etc.) and upon how closely the apparatus shall be required to differentiate between signals of nearly the same amplitude.

If, on the other hand, the apparatus is designed simply to select signals above a predetermined minimum intensity, not necessarily the maximum of the received signals, the operating time versus operating signaling intensity characteristic is of less importance so long as the sensitivity of the voice-operated device is adjusted, so that it will positively operate on signals above the predetermined minimum intensity.

The apparatus of Fig. 3 is in general similar to that of Figs. 1 and 2 except in so far as the circuit arrangements for determining preference as between different receivers are concerned. As these structural and circuit differences will be evident from the description of the operation which follows, no detailed description of the apparatus and circuits will now be given.

Useful signals from one receiver only

Let us assume that the receiver R_1 only is furnishing a signal strong enough to operate a master relay and that the master relay MR_1 is operated thereby. Relay MR_1 through relay TR_1 and hangover relay HOR_1 operates the contact a_1 in a manner previously described in connection with the other figures to connect the signals from the receiver R_1 to the receiving line L through the delay network DN_1. The master relay also completes a circuit through the upper winding of relay CR_1. This relay is provided with a lower biasing winding and is constructed in a manner well known in the art so that current through the upper or operating winding tends to attract its armature and thereby close the contacts g^1 and s^1 controlled thereby while current through the lower or biasing winding tends to repel the armature and thereby open the contacts. This is indicated by the two arrows applied to the relay.

When current flows through the upper winding of relay CR_1, due to the action of the master relay MR_1, contacts g_1 and s_1 are closed. Contact g_1 connects battery through the upper winding of the disabling relay DR_2 associated with the receiver R_2, through the winding of an auxiliary relay XR_3, through the winding of the disabling relay DR_3, and through the lower or biasing winding of the relay CR_3 associated with the receiver R_3. Relay DR_2 is also provided with a second winding whose circuit may be closed over the contact g_3 of the control relay CR_3. This second winding produces the same effect upon the armature of the relay as the upper winding, this fact being indicated by the arrows in the figure pointing in the same direction. The current flow through the upper winding of relay DR_2 causes contact k_2 to close and short-circuit the receiver R_2. Likewise the current flow through relay DR_3 causes contact k_3 to close and short-circuit the receiver R_3. The energization of the auxiliary relay XR_3 and the current through the biasing winding of relay CR_3 are without use or effect at this time. As a result of the foregoing actions, master relays MR_2 and MR_3 are prevented from subsequent operation on peak values of speech or other signals, and signals from the receiver R_1 only are connected through to the line L for reception.

Returning to relay CR_1, the closing of the contact s_1 at this time is of no importance as the function of this contact only comes into play usefully when signals from receivers R_2 and R_3 are strong enough to operate relays MR_2 and MR_3 before the disabling relays DR_2 and DR_3 have had time to short-circuit the master relays through contacts k_2 and k_3, respectively. Since we are here considering only the simplest case where signals from receiver R_1 alone are strong enough to operate master relay MR_1, master relays MR_2 and MR_3 are not positively operated, and hence the function of the contact s_1, which is the short-circuit to thereby prevent the operation of relay DR_1, need not be present.

Obviously, the operation is similar to that above described when any one of the other receivers alone receives signals strong enough to operate its master relay.

Maximum signals from one receiver only

When signals from receivers R_2 and R_3 are strong enough to operate master relays MR_2 and MR_3 but the signals from receiver R_1 are stronger, master relay MR_1 will operate before either master relay MR_2 or MR_3, due to the characteristics of the amplifier-detector units and the master relays as illustrated in Figs. 5 and 6. Relay MR_1 causes the current to flow through the upper winding of relay CR_1, thereby closing contacts s_1 and g_1 before either relay CR_2 or CR_3 has had time to operate. Contact s_1 short-circuits relay DR_1 and the biasing winding of relay CR_1 so that the subsequent operations of relay CR_2 or CR_3 cannot cause the closing of contact k_1 (which would short-circuit the master relay MR_1) or permit the bias to interfere with the actuation of relay CR_1. The closing of contact g_1 in the meantime operates relay DR_2 through its upper winding and also operates relays XR_3 and DR_3, thereby short-circuiting at k_2 and k_3 the master relays MR_2 and MR_3. Also, the hangover relay HOR_1 which had been positively operated by the master relay MR_1, cuts the signals from the receiver R_1 (which are the stronger) through for reception.

It might be here pointed out that as in the case of Figs. 1 and 2, the contacts a_1, a_2 and a_3 are so controlled that they will not be operated by a very short impulse through the master relays MR_1, MR_2 and MR_3. For example, such a pulse might be given relays MR_2 and MR_3 before the contacts k_2 and k_3 have been closed in response to the actuation of control relay CR_1, as above described. Therefore, if the master relays MR_2 and MR_3 are momentarily operated, no harm is done from the standpoint of the possibility of the signal being simultaneously received from two receivers. No signal would be received from receivers R_2 and R_3 in this case since the delay networks are arranged to delay the signals long enough for all relays to complete their operations before the signals have had time to pass through the delay network.

Only the stronger signals from the receiver R_1, therefore, get to the receiving line, the weaker signals from the receivers R_2 and R_3 having been excluded. The operation will, of course, be similar if at the time of the selection, signals from the receiver R_2 are definitely stronger than those from receivers R_1 and R_3, and the same holds true in the case where the signals from the receiver R_3 are definitely stronger than those from the other receivers.

Re-selection

So long as the signals from the selected receivers are stronger than the signals from other receivers, the selected receiver will continue to be connected to the receiving line L. When the continuity of the selected signals is interrupted, as, for example, by the normal keying of telegraph signals, or momentary cessation of speech, or by the fading of the received signal, the master relays and dependent relays at once release so that reselection of signals is possible. The interval of interruption required to permit re-selection to take place will depend upon the release time of the master relays. If these relays release rapidly, a short interruption, something like .005 second will permit reselection. At telegraphic signaling speeds of 100 words per minute, the average interval between dot-dash characters making a single Morse letter is about .012 second or about four times longer than would be required to cause the master relays to release. Re-selection could, therefore, easily take place in the interval between any dot or dash in the transmission. On speech modulation, intervals of the required order continually occur between sentences and words and oftentimes on weak syllables.

If, therefore, the selected signal is at any time lower in amplitude than some other signal, the signal of higher amplitude will almost immediately be selected. The hangover relays, such as HOR_1, are adjusted to maintain their contacts, such as a_1, closed until the last element of the disconnected signal has been passed through the delay network. Should the selected signal suddenly fade before the selecting system has had an interruption on which to re-select, the master relay would release as soon as the signal dropped to less than the required minimum, permitting a new receiver with a maximum signal to be selected. In this event the automatic gain control arrangement GC would come into play to bring the falling signal up to standard. The occurrence of rapid fading, as was pointed out previously, is less in evidence when signals are strong, so that by selection of the strongest signals we inherently reduce the possibility of such fading.

When signals from two receivers are equal and stronger than those from the third

Let us now consider the operation of the system when the signals from receivers R_1 and R_2 are the stronger and are of equal amplitudes. Under these conditions master relays MR_1 and MR_2 operate simultaneously, causing control relays CR_1 and CR_2 to operate simultaneously, with the consequent simultaneous closing of contacts g_1, s_1, g_2, and g_2'. Contact s_1 prevents battery over contact g_2' from energizing relay DR_1 and the biased winding of relay CR_1. Contact g_1, however, closes the circuit through the upper winding of relay DR_2 and through the windings of relays XR_3 and DR_3 and also through the biasing winding of CR_3. Contacts k_2 and k_3 are therefore closed to disable receivers R_2 and R_3. In the meantime contact a_1 which has been closed by the hangover relay HOR_1 in response to relay MR_1, cuts the signals from the receiver R_1 through to the receiving line L while the signals from the remaining receivers will continue to be shorted out. During the momentary operation of contact g_2 simultaneously with the operation of contact g_1 (and before contact g_1 caused the contact k_2 to cut the operating signal from the amplifier-detector AD_2), contact a_2 would not be operated and would not hang over, due to the provision of the slow release intermediate relay TR_2 between the master relay and the hangover relay, as previously described.

The operation is similar when signals from receivers R_2 and R_3 are equal, the signal from receiver R_3 being chosen in preference to signal from the receiver R_2 in that case, by reason of the fact that the contact s_3 is provided in connection with the control relay CR_3, thereby short-circuiting relay DR_3 and preventing its energization in response to the energization of the relay CR_2. The relay CR_2 has no corresponding protecting contact for its corresponding disabling relay DR_2. It might also be mentioned that the auxiliary relay XR_3 is not operated over the upper contact g_2 of relay CR_2, since the circuit does not pass through relay XR_3 as it does in the case of the corresponding contact g_1, associated with the receiver R_1.

When signals from two receivers are above the required minimum but not equal

Let us now consider the operation for the case in which the signals from receivers R_1 and R_2 are of sufficient strength to operate corresponding master relays but the signal from the receiver R_2 is the stronger. In this case relay CR_2 will be operated before the relay CR_1 and hence disables the selective apparatus associated with the receiver R_1 so that only signals from the receiver R_2 can be connected through for reception by the line L. Contact g_2' of relay CR_2 puts battery through the winding of the relay DR_1 and through the biasing winding of relay CR_1. Relay DR_1 is energized and by means of contact k_1 short-circuits the receiver R_1 and thereby disables the apparatus associated therewith, including the master relay MR_1. The current flowing through the biasing winding of the relay relay CR_1 acts as a strong restoring force to reverse the direction of travel of the armatures g_1 and s_1 should they be traveling toward their front contacts at the time contact g_2' of relay CR_2 is closed. In other words, if contact g_2' closes first, due to stronger signals from the receiver R_2, operation of contact g_1 and s_1 may, due to the bias, be prevented from operating falsely immediately after.

Other and perhaps more effective means might be designed to prevent such false operation, but as will be clearly apparent, little harm is done if contacts s_1 and g_1 should close just after the contact g_2'.

Let us consider the case, for example, where the armatures s_1 and g_1 are too near their front contacts for a good strong biasing force to succeed in preventing them from contacting, after the contact g_2' (or g_3) has placed battery on the biasing winding of the relay CR_1. Contact s_1 would remove battery from relay DR_1 and the biasing winding of the relay CR_1, while contact g_1 would, through relays DR_2 and DR_3 disable receivers R_2 and R_3. Under these conditions the signal from receiver R_1 would be selected instead of that from receiver R_2. In such case, however, the signals from the two receivers would be of so nearly the same amplitude that it would make substantially no difference which of the two were selected.

In the case just assumed, a momentary actuation of relay DR_1 might cause the contact k_1 to be closed and thereby momentarily disable the receiver R_1. In order to prevent the contact k_1 from disabling the receiver R_1 (and hence, the relay MR_1) momentarily, relay DR_1 may be made just sluggish enough so as not to operate on pulses which are not sufficiently strong to enable the bias to prevent the armatures s_1 and g_1 from contacting after g_2' (or g_3). With the hangover relay, such as HOR_1, adjusted to release the moment the last element of the signal has passed through the associated delay network, the corresponding disabling relay, such as DR_1, need not be depended upon to cut the signal off the line L the moment another signal has been selected.

The operation is similar if the signals from the receivers R_2 and R_3 are maximum and the signals from receiver R_2 are the stronger. Here the control relay CR_2 operates before the control relay CR_3 and through its contact g_2 connects battery through the winding of disabling relay DR_3 and the biasing winding of the relay CR_3. If the signal from receiver R_2 is sufficiently strong so that the circuit through the biasing winding is established with sufficient rapidity as to cause the bias to repel the armatures s_3 and g_3, the receiver R_2 will be selected. If the signal from the receiver R_2 is only slightly stronger and almost equal to that from receiver R_3 the signal from the latter may be selected in preference by a method analogous to that just described in connection with receiver R_1.

Let us next consider the process of selection, first, when signals from the receivers R_1 and R_3 are equal, and second, when the signals are nearly equal. When signals from R_1 and R_3 are equal, relays CR_1 and CR_3 are operated simultaneously and hence the contacts g_1 and s_1, and g_3 and s_3 are closed simultaneously. Contact s_1 prevents the energization of the relay DR_1 in the biasing winding of relay CR_1. Contact g_1 operates relay DR_2 through its upper winding and closes the contact k_2, thereby short-circuiting the receiver R_2. With the contact s_3 closed, the winding of relay DR_3 and the biasing winding of relay CR_3 are short-circuited and the battery connection over the contact g_1 through the upper winding of relay DR_2 passes through the winding of the auxiliary relay XR_3 and thence over the contact s_3 and the back contact of relay XR_3 to ground. This causes the operation of the auxiliary relay XR_3 without operating relay DR_3 and the biasing winding of relay CR_3. The operation of the auxiliary relay XR_3 opens by means of its armature the short circuit which previously existed across the winding of the relay DR_3 and the biasing winding of the relay CR_3, due to the closing of the contact s_3. Relay XR_3, however, continues to be operated in series with the winding of the relay DR_3 and the biasing winding of the relay CR_3. The energization of relay DR_3 with resultant closing of contact k_3 short-circuits the receiver R_3, thereby disabling it and giving preference to the signal from the receiver R_1.

Consider now the case when the signals from receivers R_1 and R_3 are not quite equal, and assuming that the signal from receiver R_3 is but slightly stronger than that from receiver R_1 so that the contacts g_1 and s_1 cannot be prevented by the biasing action of the lower winding of relay CR_1 from closing just after contact g_3 has been closed by the relay CR_3. In this case the contact g_1 will operate the relay DR_2 and the auxiliary relay XR_3 so that the latter removes the short-circuit placed by contact s_3 across the winding of the relay DR_3 and biasing winding of relay CR_3. Consequently, relay DR_3 will be energized and by closing contact k_3 will short-circuit the receiver R_3 and give the signal from receiver R_1 the right of way. This case is analogous to that just described for signals from receivers R_1 and R_2, which are not quite equal, and the reasons for justifying the selection of the slightly weaker signal hold true here.

Operation when all signals are equal

When the signals from all three receivers are equal, all three master relays will be operated simultaneously, and hence, the control relays CR_1, CR_2, and CR_3 will be operated simultaneously. Contact g_1 operates DR_2, XR_3, DR_3 and the biasing winding of relay CR_3. Relay DR_2 at contact k_2 short-circuits receiver R_2. Auxiliary relay XR_3 opens the short-circuit across relay DR_3 and the biasing winding of relay CR_3, which would otherwise be closed at contact s_3 of relay CR_3. Relay DR_3, being energized, short-circuits the receiver R_3 at contact k_3. At receiver R_1 the closing of the contact s_1 of the relay CR_1 short-circuits the relay DR_1 and the biasing winding of relay CR_1, and therefore prevents the receiver R_1 from being disabled. As soon as the hangover relay HOR_1 operates, the signal through the receiver R_1 passes from the delay network DN_1 to the line L, and receiver R_1 is exclusively selected.

When the signals from the three receivers are not exactly equal but have so nearly the same amplitudes that the currents in the biasing windings of relays CR_1 and CR_3 cannot prevent the contacts of said relays from being closed, the signal from the receiver R_1 is always chosen. This follows from the fact that the moment contacts g_1 and s_1 are operated, whether before or after the operation of contacts g_2 and g_2', and g_3 and s_3, the contact g_1 causes the short-circuiting of the receivers R_2 and R_3 in the manner previously described, while the contact s_1 by protecting the relay DR_1 and the biasing winding of relay CR_1 gives the signals from the receivers R_1 the right of way. Here, again, it will be noted that even though the signal from receiver R_2 or R_3 might be slightly greater than that from receiver R_1, the three signals will have so nearly the same amplitude, that it will be a matter of no moment which is chosen.

It will be obvious that the general principles herein disclosed may be embodied in many other organizations widely different from those illustrated, without departing from the spirit of the invention as defined in the following claims.

What is claimed is:

1. In a signaling system subject to variable transmission conditions, a plurality of receivers each receiving the same signal and so related to each other that the received signals vary differently at the several receivers with variations in transmission conditions, a receiving circuit, and means associated with said circuit to automatically select a receiver whose signal output exceeds a preassigned minimum.

2. In a signaling system subject to variable transmission conditions, a plurality of receivers each receiving the same signal and so related to each other that the received signals vary differently at the several receivers with variations in transmission conditions, a receiving circuit, means associated with said circuit to automatically select a receiver whose signal output exceeds a preassigned

minimum, and means to cause a re-selection of a receiver whenever the signal output of the previously selected receiver falls below said minimum.

3. In a signaling system subject to variable transmission conditions, a plurality of receivers each receiving the same signal and so related to each other that the received signals vary differently at the several receivers with variations in transmission conditions, a receiving circuit, means associated with said circuit to automatically select a receiver whose signal output exceeds a preassigned minimum, means to cause a re-selection of a receiver whenever the signal output of the previously selected receiver falls below said minimum, and means to cause a re-selection of a receiver after an interruption longer than a preassigned minimum of the signal from a previously selected receiver.

4. In a signaling system subject to variable transmission conditions, a plurality of receivers each receiving the same signal and so related to each other that the received signals vary differently at the several receivers with variations in transmission conditions, a receiving circuit, and means associated with said circuit to automatically select the receiver having the maximum signal output.

5. In a signaling system subject to variable transmission conditions, a plurality of receivers each receiving the same signal and so related to each other that the received signals vary differently at the several receivers with variations in transmission conditions, a receiving circuit, means associated with said circuit to automatically select the receiver having the maximum signal output, and means to cause a re-selection of a receiver whenever the signal output of the previously selected receiver falls below a preassigned minimum.

6. In a signaling system subject to variable transmission conditions, a plurality of receivers each receiving the same signal and so related to each other that the received signals vary differently at the several receivers with variations in transmission conditions, a receiving circuit, means associated with said circuit to automatically select the receiver having the maximum signal output, means to cause a re-selection of a receiver whenever the signal output of the previously selected receiver falls below a preassigned minimum, and means to cause a re-selection of a receiver after an interruption longer than a preassigned minimum of the signal from a previously selected receiver.

7. In a signaling system subject to variable transmission conditions, a plurality of receivers each receiving the same signal and so related to each other that the received signals vary differently at the several receivers with variations in transmission conditions, a receiving circuit, means associated with said circuit to automatically select a receiver whose signal output exceeds a preassigned minimum, and means operating, when more than one of the receivers have substantially the same signal output above said preassigned minimum, to select one of said receivers to the exclusion of the others.

8. In a signaling system subject to variable transmission conditions, a plurality of receivers each receiving the same signal and so related to each other that the received signals vary differently at the several receivers with variations in transmission conditions, a receiving circuit, means associated with said circuit to automatically select the receiver having the maximum signal output, and means operating, when more than one of the receivers have substantially the same maximum signal output, to select one of said receivers to the exclusion of the others.

9. In a signaling system subject to variable transmission conditions, a plurality of receivers each receiving the same signal and so related to each other that the received signals vary differently at the several receivers with variations in transmission conditions, a receiving circuit, signal-responsive means associated with each receiver and responsive to signals above a preassigned minimum to establish a transmission connection from said receiver to said receiving circuit, and means operating, when more than one receiver has a signal output above said minimum, to enable the responsive means associated with one receiver to defeat the establishment of transmission connections from the other receivers.

10. In a signaling system subject to variable transmission conditions, a plurality of receivers each receiving the same signal and so related to each other that the received signals vary differently at the several receivers with variations in transmission conditions, a receiving circuit, signal-responsive means associated with each receiver and responsive to signals above a preassigned minimum to establish a transmission connection from said receiver to said receiving circuit, means operating, when more than one receiver has a signal output above said minimum, to enable the responsive means associated with one receiver to defeat the establishment of transmission connections from the other receivers, and means to cause a re-selection of a receiver whenever the signal output of a receiver previously effectively connected to said receiving circuit falls below said minimum.

11. In a signaling system subject to variable transmission conditions, a plurality of receivers each receiving the same signal and so related to each other that the received signals vary differently at the several receivers with variations in transmission conditions, a receiving circuit, signal-responsive

means associated with each receiver and responsive to signals above a preassigned minimum to establish a transmission connection from said receiver to said receiving circuit, and means operating when more than one receiver has a signal output above said minimum, to enable the receiver having the largest signal output to defeat the establishment of transmission connections from other receivers.

12. In a signaling system subject to variable transmission conditions, a plurality of receivers each receiving the same signal and so related to each other that the received signals vary differently at the several receivers with variations in transmission conditions, a receiving circuit, signal-responsive means associated with each receiver and responsive to signals above a preassigned minimum to establish a transmission connection from said receiver to said receiving circuit, means operating, when more than one receiver has a signal output above said minimum, to enable the receiver having the largest signal output to defeat the establishment of transmission connections from other receivers, and means to cause a re-selection of a receiver whenever the signal output of a receiver previously effectively connected to said receiving circuit falls below said minimum.

13. In a signaling system subject to variable transmission conditions, a plurality of receivers each receiving the same signal and so related to each other that the received signals vary differently at the several receivers with variations in transmission conditions, a receiving circuit, signal-responsive means associated with each receiver and responsive to signals above a predetermined minimum to establish a transmission connection from said receiver to said receiving circuit, and means operating, when more than one receiver has substantially the same maximum signal output greater than said preassigned minimum, to enable one of the receivers having such maximum output to defeat the establishment of transmission connection from all other receivers.

14. In a signaling system subject to variable transmission conditions, a plurality of receivers each receiving the same signal and so related to each other that the received signals vary differently at the several receivers with variations in transmission conditions, a receiving circuit, signal-responsive means associated with each receiver and responsive to signals above a predetermined minimum to establish a transmission connection from said receiver to said receiving circuit, means operating, when more than one receiver has substantially the same maximum signal output greater than said preassigned minimum, to enable one of the receivers having such maximum output to defeat the establishment of transmission connection from all other receivers, and means to cause a re-selection of a receiver whenever the signal output of a receiver previously effectively connected to said receiving circuit falls below said minimum.

15. In a signaling system subject to variable transmission conditions, a plurality of receivers each receiving the same signal and so related to each other that the received signals vary differently at the several receivers with variations in transmission conditions, a receiving circuit, and means associated with said circuit to automatically select a receiver whose signal output conforms to a desired requirement.

In testimony whereof, I have signed my name to this specification this 7th day of December, 1928.

WILLIAM C. BOHN.

DISCLAIMER

1,747,218.—*William C. Bohn*, Wyoming, N. J. AUTOMATIC SELECTION OF RECEIVING CHANNELS. Patent dated February 18, 1930. Disclaimer filed March 6, 1934, by the assignee, *American Telephone and Telegraph Company*.

Hereby enters this disclaimer to claims 4 and 15 of said Letters Patent, to wit:

"4. In a signaling system subject to variable transmission conditions, a plurality of receivers each receiving the same signal and so related to each other that the received signals vary differently at the several receivers with variations in transmission conditions, a receiving circuit, and means associated with said circuit to automatically select the receiver having the maximum signal output."

"15. In a signaling system subject to variable transmission conditions, a plurality of receivers each receiving the same signal and so related to each other that the received signals vary differently at the several receivers with variations in transmission conditions, a receiving circuit, and means associated with said circuit to automatically select a receiver whose signal output conforms to a desired requirement."

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