Feb. 18, 1930. G. D. GILLETT 1,747,236

AUTOMATIC SELECTION OF RECEIVING CHANNELS

Original Filed Dec. 11, 1928

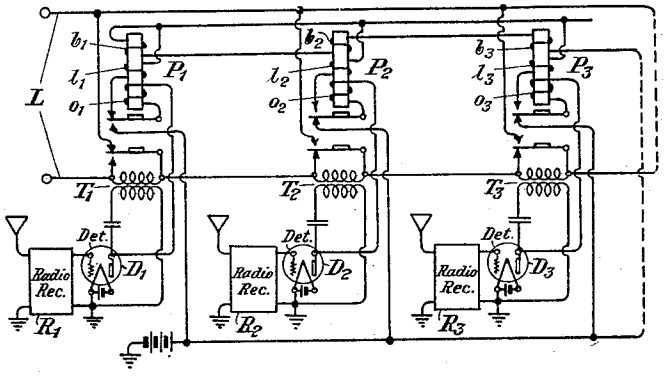

Fig. 1

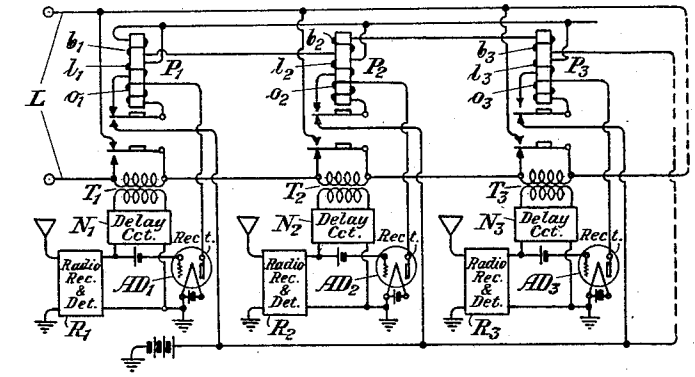

Fig. 2

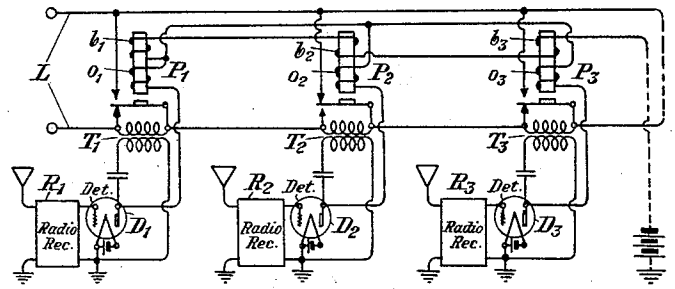

Fig. 3

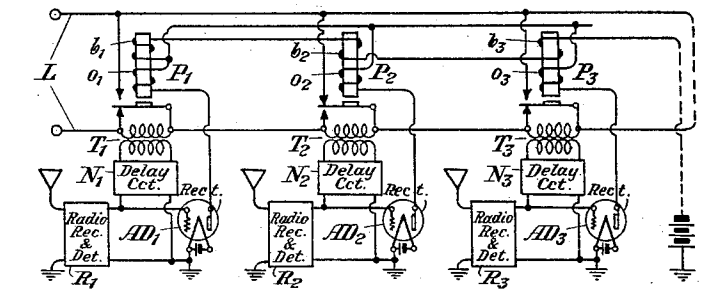

Fig. 4

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1,747,236

UNITED STATES PATENT OFFICE

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AUTOMATIC SELECTION OF RECEIVING CHANNELS

Application filed December 11, 1928, Serial No. 325,164. Renewed September 28, 1929.

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 face 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 wave length 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.

In an application filed by Ralph Bown, Serial No. 325,149, upon December 11, 1928, a system is disclosed for automatically selecting a desired receiver which involves the selection of the first receiver in the selective order whose output exceeds a predetermined minimum even though other receivers may have greater outputs. This system depends upon the fact that the selecting relays are all biased for the same definite marginal operation. In the invention herein disclosed the relays are not arranged with a fixed bias and hence are not operated upon a fixed margin but are so arranged as to be self-biasing. The circuit organization is such that any selecting relay may operate to take control of the circuit when the output of its corresponding receiver exceeds that of the receiver then having control of the circuit by a predetermined amount. This may be accomplished by causing the relays to be biased by an amount which is a function of the signal strength of the receiver the output of which is at the moment being used, or by an amount which is proportional to the average output of some or all of the receivers.

By means of the present invention the simplicity of the circuit of the Bown application above referred to is to a large extent retained while the advantageous result is attained of a selecting operation by which the receiver whose output is selected will be that receiver whose output is substantially the largest of all the receivers.

The invention may now be more fully un-

derstood from the following description when read in connection with the accompanying drawing, Figures 1, 2, 3 and 4 of which illustrate four different embodiments of the invention.

Fig. 1 illustrates a circuit arrangement for selecting a receiver in which the selecting relays are controlled by the received carrier wave and in which the bias which must be overcome before any given relay can be operated to select is determined by the strength of the carrier signal received by the particular receiver which is at that time connected to the receiving terminal. By this arrangement the relay circuit will select a new receiver whenever the carrier signal strength in the new receiver becomes greater by any given ratio than the receiver which was previously selected.

For purposes of illustration three receivers are illustrated, although it will be understood that the system may be extended to any number desired. These receivers comprise radio receiving apparatus indicated symbolically at R_1, R_2 and R_3 and detectors indicated at D_1, D_2 and D_3. The detectors function to detect from the received radio waves the voice or other signal waves in accordance with which the carrier waves were modulated at the distant sending station. The radio apparatus symbolically represented at R_1, R_2 and R_3 may be any known radio apparatus necessary or desirable in the reception of signals over and above the final detectors represented at D_1, D_2 and D_3.

The output circuit of each detector is associated with the receiving circuit L through a transformer, the transformers corresponding to the several receivers being indicated at T_1, T_2 and T_3. Selecting relays are associated with each receiver, these selecting relays being indicated at P_1, P_2 and P_3. Each relay has a lower contact which normally short-circuits the secondary winding of the transformers previously referred to. Each relay is also provided with three windings:—an operating winding connected to the plate circuit of the detector of the receiver so as to be operated by the direct current glowing therein, a locking winding and a biasing winding. The operating winding of the relay P_1 is designated o_1, the locking winding l_1 and the biasing winding b_1. The corresponding windings of the other relays are designated by the same letters with subscripts corresponding to the particular station with which the relay is associated. The biasing windings b_1, b_2 and b_3 of the three relays are connected in series, and the energizing current for the operating winding of any relay which has been operated flows in series through the biasing windings of all the relays.

Further details of the circuit arrangement will be clear from a brief description of the operation, which is as follows: Assume that all of the relays are in a normal nonoperated condition and that a carrier wave is received simultaneously by the several receivers R_1, R_2 and R_3. As a result of this carrier wave a direct current is caused to flow in the plate circuit of each detector, this direct current being proportional to the amplitude of the carrier, and as the carrier arriving at the several stations may be subjected to different degrees of fading the direct currents flowing in the plate circuits of the detectors of the several receivers will not have the same value. When the received carrier is accompanied by side bands, as will be the case when signals are being received, the direct current in the plate circuit of the detector of each receiver will still be substantially determined by the amplitude of the received carrier for the reason that the carrier wave is so much greater in energy than the side band that the latter has substantially no effect in determining the amplitude of the direct current in the plate circuit of the detector.

With all of the relays in a non-operated condition the direct current generated in the plate circuit of the detector D_1 flows from the plate through the winding o_1 over the back contact of the upper armature of relay P_1 to the B battery, which supplies the plate circuits of all the detectors. As no biasing current is at this time flowing through the biasing windings b_1, b_2 and b_3, this plate current through the winding o_1 causes the relay P_1 to pull up its armatures. At its lower armature relay P_1 removes the short-circuit normally existing about the secondary winding of the transformer T_1 and closes a connection across the line L to short-circuit the transformers T_2 and T_3. At its upper front contact relay P_1 closes a new operating circuit from the plate of the detector D_1 through the winding o_1, over the front contact of the upper armature, through the locking winding l_1, thence serially through the biasing winding b_1, b_2 and b_3 of all the relays, and thence back to the B battery. Obviously, the bias which must now be overcome by any other relay in order to operate is determined by a current which is proportional to the carrier received by the receiver R_1. The relay P_1 remains operated notwithstanding the bias due to the current flowing through the winding b_1 because the current flow in both the operating winding o_1 and in the locking winding l_1 is in such a direction as to tend to hold the armatures against their front contacts.

Suppose, now, the carrier wave received by some other receiver, for example receiver R_2, becomes sufficiently stronger than that received by the receiver R_1 so that it bears a predetermined ratio to the carrier wave received by the receiver R_1. The direct current which is determined by the received carrier will flow from the plate of detector D_2 through the operating winding o_2 of the

relay P_2, over the back contact of the upper armature of relay P_2 to the B battery. The ratio of the turns on windings o_2 and b_2 are such that when this operating current bears a predetermined ratio to the biasing current which is caused to flow through the biasing winding b_2 by the previously selected receiver R_1, the relay P_2 will operate to open the short-circuit about the secondary of transformer T_2 and bridge a short-circuit across the line to short out the transformer T_3. The receiver R_2 is not yet operatively connected to the line L, however, as the relay P_1 has not yet released its lower armature. Relay P_2 upon pulling up its upper armature completes a circuit from the plate of the detector D_2 through the winding o_2, over the front contact of the upper armature, through the locking winding l_2 and thence in series through the biasing windings b_1, b_2 and b_3 to battery. Relay P_2 is now locked up, but the biasing current through the winding b_1 of the relay P_1 is now the sum of the currents determined by the receivers R_1 and R_2 so that the resultant biasing current is sufficient to overcome the energizing action of the current supplied by the receiver R_1 through its operating and locking windings, and hence the relay P_1 is released. At the moment before the release of relay P_1 the total biasing current through the winding b_1 is insufficient to prevent maintaining the relay P_2 energized by the current supplied through its opearting and locking windings, since this current was larger by a predetermined ratio than the current supplied by the receiver R_1 to the windings of the relay P_1. As soon as the relay P_1 releases, however, the direct current from the plate circuit of the detector D_1 no longer flows through the biasing windings b_1, b_2 and b_3, and the bias on the several relays is now determined solely by the selected receiver R_2 which is connected to the circuit L to the exclusion of the other receivers.

In order that the relay circuits above described will be enabled to select a new receiver whenever the carrier signal strength in the new receiver exceeds that in the preselected receiver by a given predetermined ratio, the number of turns on the operating, locking and biasing windings of each relay must bear a definite ratio to each other. The ratio r of the number of turns of any biasing winding b to its corresponding operating winding o may have any value greater than unity. Then, if it is desired to have comparable forces operating the new selecting relay and causing the release of the previously operated selecting relay at the moment of reselection, the ratio of the number of turns in the locking winding l to the number of turns in the operating winding o should be the square of the ratio r.

In order to more clearly understand the theory upon which the relays operate, let us suppose a current I_1 flowing through o_1 causes relay P_1 to operate. Then current I_1 flows through each of the windings o_1, l_1, b_1, b_2 and b_3.

Let f_1 represent the force acting on the armature of P_1 due to current I_1 flowing through o_1. Then, if r be the ratio of turns on b_1 to those on o_1, and r^2 be the corresponding ratio between l_1 and o_1, the force acting on the armature of P_1 due to the current in winding b_1 will be $-rf_1$ and the corresponding force for winding l_1 will be r^2f_2. The total force F acting on the armature of relay P_1 will then be

$$F_1=f_1+r^2f_1-rf_1$$

Now, with current I_1 flowing through winding b_2 of relay P_2 the biasing force on the armature of relay P_2 will also be $-rf_1$. In order to operate relay P_2 the current I_2 in winding o_2 must produce a force f_2 on the armature which is at least equal and opposite to the biasing force $-rf_1$. Hence,

$$f_2=rf_1$$

When relay P_2 operates the current I_2 flows through windings o_2, l_2, b_1, b_2 and b_3, being added to the current I_1 in the windings b_1, b_2 and b_3. The force acting on the armature of P_1 due to winding l_2 will now be

$$r^2f_2=r^3f_1$$

Now the force acting on the armature of P_2 due to the current I_2 flowing through winding b_2 will be

$$-rf_2=-r^2f_1$$

The total pull on the armature of P_2 due to winding b_2 will be equal to the sum of the forces produced by currents I_1 and I_2 flowing through said winding and hence equal to $-(r+r^2)f_1$. Obviously, the same force will act upon the armature of P_1 due to currents I_1 and I_2 flowing through the winding b_1. Hence, at the instant P_2 operates and before P_1 releases the total force acting upon the armature of P_2 will be

$$F''_2=rf_1+r^3f_1-(r+r^2)f_1=r^3f_1-r^2f_1$$

This force is positive as $r^3f_1>r^2f_1$ and hence tends to hold the armature of P_2 attracted.

Under the same conditions the total force acting on the armature of P_1 will be

$$F'_1=f_1+r^2f_1-(r+r^2)f_1=(1-r)f_1$$

Sinve $r>1$ this force is negative and causes the armature of P_1 to be released.

It will be noted that the ratio of the forces acting upon the armatures of P_1 and P_2 at the moment of release is

$$\frac{F''_2}{F'_1}=\frac{r^2(r-1)f_1}{(1-r)f_1}=-r^2$$

Hence as r approaches unity the forces act-

ing upon the two armatures, while opposite in direction, will be substantially equal.

After P_1 releases the current I_1 no longer flows through b_1, b_2 and b_3 so that the total force acting on the armature P_1 will be

$$F_2 = rf_1 + r^3f_1 - r^2f_1 = f_2 + r^2f_2 - rf_2$$

which is r times as great as the force F_1 previously acting on the armature of relay P_1.

The biasing force which must now be overcome before any relay other than P_2 can take control of the circuit is

$$-rf_2 = -r^2f_1$$

which is r times as great as the biasing force previously acting on relay P_1.

Fig. 2 shows a circuit similar to Fig. 1 so far as the operation of the selecting relays is concerned but differing therefrom in that the selecting relays are operated by a direct current determined by the detected received signal instead of the received carrier. This involves causing a re-selection after every pause in the signal such as might take place between words or even syllables, whereas in the arrangement of Fig. 1 re-selection only took place whenever there occurred a readjustment between the relative values of the carriers received by the different receivers, and this re-selection took place regardless of whether a detected signal was received or not. In Fig. 2 the receivers conventionally indicated at R_1, R_2 and R_3 now include all apparatus necessary to translate the received waves into detected signal currents capable of transmission to the listener. In other words, the detector which was separately represented in Fig. 1 is now a part of the apparatus conventionally indicated at R_1, for example. The detected voice signal is passed through a delay circuit or network, indicated conventionally at N_1, N_2 and N_3, and through a transformer, such as T_1, T_2 and T_3, to the line L. The circuits of the transformers are controlled by the selecting relays exactly as in Fig. 1.

In order to operate the relays, however, a rectifier AD_1 is connected across the output of the radio receiver R_1, and similar rectifiers AD_2 and AD_3 are connected across the outputs of the receivers R_2 and R_3. The plate circuit of each rectifier is connected to the operating winding of the corresponding relay. Each rectifier serves to pick off from the output circuit of the corresponding receiver some of the detected voice energy and produce therefrom a rectified direct current component for operating the corresponding selecting relay, and this direct current component will be proportional to the amplitude of the final detected signal and not necessarily to the amplitude of the carrier wave received by the receiver.

Whenever, therefore, a detected current corresponding to a vocal word or syllable is received, the selecting relays operate upon the same principles as described in connection with Fig. 1. In other words, at the beginning of the signal any or all of the relays may momentarily operate due to the fact that there is no biasing current through the biasing windings. The relay corresponding to the receiver producing the largest detected signal in its output finally obtains control of the circuit provided its signal exceeds by a predetermined ratio the signal produced by any other receiver corresponding to a relay then operated. The purpose of the delay network is to enable any successive operation of the relays which may be necessary to bring about this result to take place before the voice current from the receiver which is ultimately selected is transmitted to the line, as otherwise we might have a condition where momentarily more than one receiver would be operatively connected. If during the continuance of a syllable or word the signal from the selected receiver should fade, and the signal be received at another receiver with a value exceeding that of the previously selected receiver by the predetermined ratio, the new receiver will be switched to the circuit L in place of the one previously selected.

Where it is found that circuit arrangements such as shown in Figs. 1 and 2 cause too much swapping or changing from receiver to receiver, it is possible to use a simpler circuit, such as is shown in Fig. 3. In the arrangement shown in this figure, instead of choosing the receiver with the strongest signal, the arrangement is such as to select merely the first receiver whose level is above the average of the group by a given amount. In this figure the circuit arrangements of the several receivers and their connections to the receiving line L are identical with those previously described in connection with Fig. 1. The relays P_1, P_2 and P_3, however, have no holding windings and the direct current supplied by the plate of any detector to its operating winding flows through all of the biasing windings in series regardless of whether the relay is operated or not. The result is that the direct current components in the plate circuits of the detectors of the several receivers (which direct current components will be substantially proportional to the amplitudes of the received carrier waves of the several receivers) will be superposed and flow through all of the biasing windings. Therefore, in order for a reselection to take place the newly selected receiver must have an output direct current in its plate circuit which is greater than the average plate current supplied by the several receivers.

In this circuit arrangement, if all of the relays are normally released and a carrier wave is received by all of the receivers, the operating currents flowing through the operating windings of all the relays simultaneous-

ly combine and flow through all of the biasing windings in series. In order for any relay to operate, therefore, its operating current must exceed the average operating current of the three receivers. Obviously, the operating currents of all three receivers cannot do this. If, however, the operating currents from two receivers should exceed the average as, for example, the receivers R_1 and R_3, then both relays P_1 and P_3 would be operated. Relay P_1, however, would have exclusive control of the circuit as its armature would open the short-circuit normally existing about the secondary of the transformer T_1 and its front contact would short-circuit all of the transformers to the right thereof.

If thereafter the operating current from receiver R_1 should fall below the average relay P_1 would be released and receiver R_3 would be exclusively connected to the line L unless it should happen that at the same time the operating current from the receiver R_2 also exceeded the average, in which case the relay P_2 would be energized and thereby connect the receiver R_2 to the line L exclusively by virtue of the fact that the transformer T_3 would be short-circuited at the front contact of the relay P_2.

For operation, when the received carrier signal is just greater than the average the ratio of the turns in the operating winding to the turns in the biasing winding should be equal numerically to the number of receivers in the group. If, however, operation is desired only when the level of the received carrier wave is greater than the average by a given amount such that the received carrier will bear a ratio k to the average, the ratio of the number of turns on the operating winding to the number of turns on the biasing winding should be equal numerically to $\frac{n}{k}$.

That these design principles hold true will be clear from the following considerations.

Suppose currents $I_1, I_2 \ldots\ldots I_n$ are supplied from the receivers through the various operating windings and that these currents combined flow through all of the biasing windings. The average current from the receivers then becomes

$$\frac{I_1 + I_2 + \ldots\ldots + I_n}{n} = I$$

where n is the number of receivers. If t_b represents the number of turns on each biasing winding the pull produced by a given biasing winding upon its armature will be proportional to the product of the current nI flowing through the winding and the number of turns t_b of the winding, or nIt_b. For a given relay to operate against this bias in response to a current through its operating winding having a value equal to or just greater than the average I, the relation

$$It_o = nIt_b$$

must hold where t_o is the number of turns on the operating winding and It_o is proportional to the pull exerted upon the armature by the operating winding. Hence the ratio of the number of turns on the operating winding to the number of turns on the biasing winding becomes

$$\frac{t_o}{t_b} = n$$

Where it is desired that the relay shall only respond to an operating current I′ sufficiently greater than the average I so that the ratio of operating current to the average current is

$$\frac{I_1}{I} = k$$

the pull exerted upon the armature by the operating current will be proportional to kIt_o, and as this pull must at least equal the pull due to the biasing winding, the following relation holds:

$$kIt_o = nIt_b$$

Therefore, the ratio of the number of turns of the operating winding to the number of turns of the biasing winding becomes

$$\frac{t_o}{t_b} = \frac{n}{k}$$

Fig. 4 shows a modified arrangement similar to Fig. 3 but differing therefrom in that the selecting relays are operated not by the received carriers but by the received detected signal currents. In order to accomplish this result the receiving circuits are similar to those shown in Fig. 2 and are similarly connected through delay circuits and transformers to the line L. Likewise, rectifiers such as AD_1, AD_2 and AD_3 are bridged across the outputs of the several receivers and the plate circuits of the rectifiers are connected to the operating windings of the relays P_1, P_2 and P_3. The rectifiers produce in these operating windings direct current components proportional to the amplitude of the detected signals. Consequently, selection takes place only when signals are being received.

In the case of Fig. 3 the selection is based on the principle that, instead of choosing the receiver with the strongest detected signal, the first receiver in the order of selection the level of whose signal exceeds the average by any given amount is actually selected. In order to give time for this selection to take place by the operation of the necessary relay or relays upon the receipt of a detected signal wave corresponding to a word or syllable following a pause, the delay circuits such as N_1, N_2 and N_3 are provided. By means of these

delay circuits the detected signal is prevented from being transmitted to the line L until one of the relays obtains exclusive control of the line for its associated receiver.

The ratios of the windings of the selecting relays in Fig. 4 will be the same as described in connection with Fig. 3.

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, normally disabled connections along said receiving circuit for associating said receivers with said receiving circuit, selecting relays corresponding to each receiver each arranged to render its corresponding connection operable and to independently disable connections in order beyond it, and means to bias said relays to determine their operating margins in accordance with the strength of the signal received by the receiver controlling another selecting relay.

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, normally disabled connections along said receiving circuit for associating said receivers with said receiving circuit, selecting relays corresponding to each receiver each arranged to render its corresponding connection operable and to independently disabled connections in order beyond it, and means to bias said relays to determine their operating margins in accordance with the strength of the signal received by a receiver whose selecting relay is operated.

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, normally disabled connections along said receiving circuit for associating said receivers with said receiving circuit, selecting relays corresponding to each receiver each arranged to render its corresponding connection operable and to independently disabled connections in order beyond it, and means whereby the operating current of one relay determines the bias of another relay and thereby determines the margin of operation of said other relay.

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, normally disabled connections along said receiving circuit for associating said receivers with said receiving circuit, selecting relays corresponding to each receiver each arranged to render its corresponding connection operable and to independently disable connections in order beyond it, and means whereby the operating current of an operated relay determines the bias of an unoperated relay and thereby determines the margin of operation of the latter.

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 and the received signals vary differently at the several receivers with variations in transmission conditions, a receiving circuit, normally disabled connections along said receiving circuit for associating said receivers with said receiving circuit, selecting relays corresponding to each receiver each arranged to render its corresponding connection operable and to independently disable connections in order beyond it, and means whereby the operating current of one relay determines the bias of the other relays and thereby determines their margins of operation.

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, normally disabled connections along said receiving circuit for associating said receivers with said receiving circuit, selecting relays corresponding to each receiver each arranged to render its corresponding connection operable and to independently disable connections in order beyond it, and means whereby the operating current of an operated relay determines the bias of unoperated relays and thereby determines their margin of operation.

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, normally disabled connections along said receiving circuit for associating said receivers with said receiving circuit, selecting relays corresponding to each receiver each arranged to render its corresponding connection operable and to inde-

pendently disable connections in order beyond it, said selecting relays each having operating windings and biasing windings, and means whereby the operating current of one relay flows through the biasing winding of other relays.

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, normally disabled connections along said receiving circuit for associating said receivers with said receiving circuit, selecting relays corresponding to each receiver each arranged to render its corresponding connection operable and to independently disable connections in order beyond it, said selecting relays each having operating windings and biasing windings, and means whereby the current through the operating winding of an operated relay flows through the biasing windings of unoperated relays.

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, and means associated with said receiving circuit to at all times automatically select the receiver having maximum output.

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, means associated with said receiving circuit to automatically select the receiver having maximum output, and means to cause reselection of a receiver whenever the output of another receiver exceeds that of one previously selected.

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, normally disabled connections along said receiving circuit for associating said receivers with said receiving circuit, selecting devices corresponding to each receiver each arranged to render its corresponding connection operable and to independently disable connections in order beyond it, and means to bias said selecting devices to determine their operating margins in accordance with the strength of the signal received by the receiver controlling another selecting device.

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, normally disabled connections along said receiving circuit for associating said receivers with said receiving circuit, selecting devices corresponding to each receiver each arranged to render its corresponding connection operable and to independently disable connections in order beyond it, and means to bias said selecting devices to determine their operating margins in accordance with the strength of the signal received by a receiver whose selecting device is operated.

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, normally disabled connections along said receiving circuit for associating said receivers with said receivng circuit, selecting devices corresponding to each receiver each arranged to render its corresponding connection operable and to independently disable connections in order beyond it, and means whereby the operating current of one selecting device determines the bias of another selecting device and thereby determins the margin of operation of said other selecting device.

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, normally disabled connections along said receiving circuit for associating said receivers with said receiving circuit, selecting devices corresponding to each receiver each arranged to render its sorresponding connection operable and to independently disable connections in order beyond it, and means whereby the operating current of an operated selecting device determines the bias of an unoperated selecting device and thereby determines the margin of opeartion of the latter.

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, normally disabled connections along said receiving circuit for associating said receivers with said receiving circuit, selecting devices corresponding to each receiver each arranged to render its corresponding connection operable and to independently

disable connections in order beyond it, and means whereby the operating current of one selecting device determines the bias of the other selecting devices and thereby determines their margins of operation.

16. 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, normally disabled connections along said receiving circuit for associating said receivers with said receiving circuit, selecting devices correspondng to each receiver each arranged to render its corresponding connection operable and to independently disable connections in order beyond it, and means whereby the operating current of an operated selecting device determines the bias of unoperated selecting devices and thereby determines their margins of operation.

In testimony whereof, I have signed my name to this specification this 10th day of December 1928.

GLENN D. GILLETT.