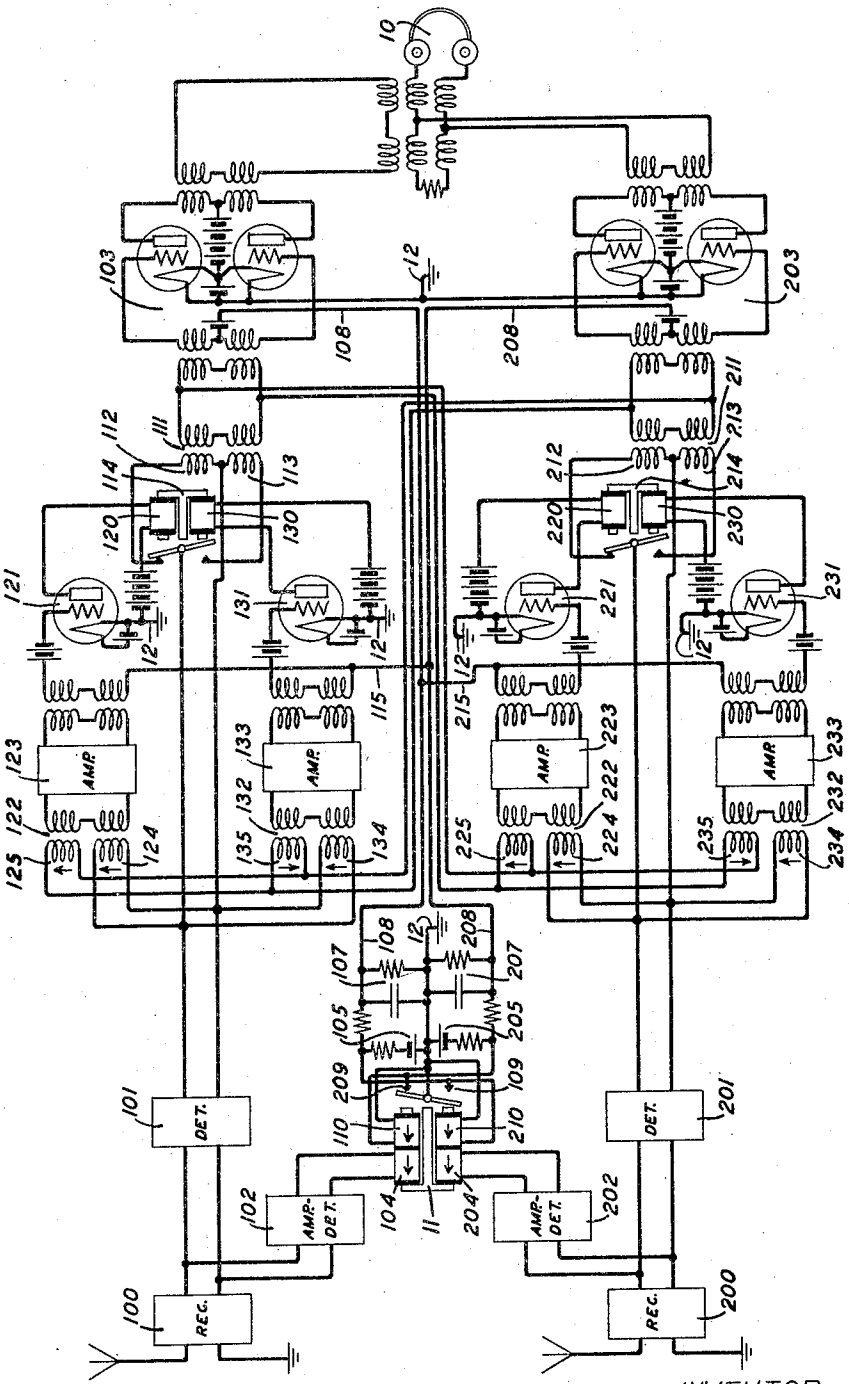
June 13, 1933. B. G. BJÖRNSON 1,914,103

SIGNALING SYSTEM

Filed Oct. 2, 1931



INVENTOR

B. G. BJÖRNSON

BY G. H. Stevenson

ATTORNEY

Patented June 13, 1933 1,914,103

UNITED STATES PATENT OFFICE

BJÖRN G. BJÖRNSON, OF BROOKLYN, NEW YORK, ASSIGNOR TO BELL TELEPHONE LABORATORIES, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK

SIGNALING SYSTEM

Application filed October 2, 1931. Serial No. 566,390.

This invention relates to signal controlled switching circuits and particularly to radio receivers.

One of the outstanding difficulties encountered in radio signaling, particularly when short waves are employed, is fading, that is, variations in the waves as received from the transmission medium. It has been found that a number of receiving stations can be so located in a relatively small area that the signal fades differently at each. Consequently, by continuously and automatically selecting between the signal outputs of such stations so as always to supply to the signal circuit the output of that station at which the wave fades least, it is possible to greatly minimize the effects of rapid changes and to reduce the possibility of the signal entirely fading out.

However, the waves received at a group of receiving stations as described above will vary in phase as well as in amplitude and both variations appear to be quite at random. Consequently, when the phase variations are such as to produce at the time of switching any material difference in phase between the output signal currents of the two receivers being switched, the result is to produce distortion in the signal. This distortion may be sufficient to seriously reduce the intelligibility particularly when the rate of switching is at all rapid.

One object of this invention is to reduce the distortion produced by such variations in phase.

In accordance with a specific preferred embodiment of this invention, a plurality of radio receivers are so arranged geographically that fading varies differently at each and continuous and automatic control is provided to select that station the output of which at any instant gives a useful signal. The signal channel leading from each station is provided with two branches, by employing a switching mechanism for reversing the polarity of each circuit. The control circuit disables the reversing mechanism in the channel in operation and controls the reversing mechanism in the other channel or channels so that at the time another channel is selected the phase difference between the signal current in the channel being cut out and that being cut in will not exceed 90°.

Under ordinary conditions of operation, this circuit will permit switching from one channel to another without any serious difficulty due to phase difference.

This invention is not limited to the specific embodiment described but, for example, may be employed in systems other than radio in which it is desired to select between signal channels or, when more accurate adjustment is required, may be modified to include in each channel a plurality of branches of small difference in phase shift.

The invention can be more readily understood by reference to the following detailed description in connection with the drawing which shows diagrammatically one embodiment of the invention in a radio telephone receiver. There are provided two radio receivers, 100 and 200, the outputs of which are detected in the detectors 101 and 201 respectively and supplied in common to the telephone receiver 10. A switching circuit controls the two audio frequency paths so that the telephone receiver 10 will always be responsive to the output of that one of the receivers 100 or 200 which affords the best reception.

The control circuit comprises the push-pull amplifiers 103 and 203 connected in the audio frequency paths from the receivers 100 and 200 respectively and the polarized relay 11 which controls the grid bias of these amplifiers. In each case the output of the receivers 100 and 200 is branched off to amplifier-detectors 102 and 202 respectively. The amplifier-detectors 102 and 202 may be of any of the well known types for amplifying and rectifying alternating current waves to produce direct current of instantaneous amplitude determined by the amplitude of the respective waves supplied thereto. Preferably they are made selective to the carrier frequency. The direct current outputs of the amplifier-detectors 102 and 202 are supplied to the operating windings 104 and 204 respectively of the relay 11. The relay will be operated by the current from that one of

the receivers 100 or 200 having the larger output, to impress such a negative biasing potential upon the grids of the tubes of the amplifiers 103 and 203 associated with the corresponding other receiver as to block that circuit for the transmission of audio frequency waves to the telephone receiver 10. These biasing potentials are obtained from the batteries 105 and 205 which are connected between the cathodes of the amplifiers 103 and 203 at the common ground connection 12 and their grids through the connections 108 and 208 respectively. Thus when the relay is in the position shown in the drawing, being operated by a larger current output from the receiver 200 than from the receiver 100, the battery 205 is short-circuited through the contact 209 and armature of the relay, so that the amplifier 203 is rendered operative to permit the transmission of the audio frequency output of the receiver 200 to the telephone receiver 10. On the other hand, the contact 109 associated with the battery 105 is open so that the potential of the battery 105 is impressed between the cathodes and grids of the tubes of the amplifier 103, blocking those tubes to render inoperative the audio frequency path from the receiver 100.

This control circuit is of the type disclosed and claimed in Patent 1,470,954 to W. E. Beatty, October 16, 1923, in which the use of the push-pull amplifiers eliminates disturbances due to the switching operation. Any clicks produced due to the change of bias on the two tubes of the push-pull amplifier are balanced out since the biasing potentials are impressed in parallel on the two tubes, while the output circuits of the amplifier are only responsive to waves impressed in opposition upon the grids.

However, imperfections in the balance between the two tubes of either amplifier may result in the effect that any such change in grid potential such as that produced by switching operations will cause a click in the output. Consequently, resistance-condenser networks 107 and 207 are provided in the biasing circuit for retarding any change in grid potential.

In order to secure a definite and quick action of the relay 11 there are provided auxiliary throwing windings 110 and 210. These windings are so connected that the relay is biased in favor of the side on which its armature rests. Thus with the relay in the position shown in the drawing, current is supplied from the battery 105 to the winding 210 to bias it in the position shown, while the winding 110 is short-circuited through the contact 209 and armature of the relay. This prevents indecision in operation of the relay during periods in which there may be a rapid and small variation in the relative level of the outputs of the two receivers since the carrier of the block receiver must exceed that of the operating receiver by a certain amount dependent upon the value of the bias before the armature begins to move. These windings also have the effect of accelerating the movement of the armature since, as soon as the armature leaves the contact, the bias is removed. Further, due to the fact that when the armature makes contact on the other side the bias is thrown on, the tendency to chatter is reduced.

The circuit so far described is effective for selecting between the outputs of the two radio receivers so that that one which affords the best reception will always be supplying signals to the telephone receiver 10. Any changes in the transmission conditions, such as fading, which produce a change in the relative outputs of the two receivers will result in a reselection. However, such changes may produce, in addition to variations in the amplitude of the received signals, variations in the relative phase thereof. If, at the time of switching the receiver 10 from one receiver to the other, there is a material difference in the phase of the signal outputs of the two receivers there will result a disturbance in the telephone receiver. In order to reduce such disturbances each of the signal channels is provided with a phase controlling circuit which operates automatically to reduce the phase change at the moment of switching.

For this purpose each of the channels is provided with a transformer, 111 and 211, respectively. Each of these transformers is provided with two primary windings wound to induce voltages of opposite polarities in the secondary winding. The connection of the primary windings in the audio frequency channel is controlled by the relays 114 and 214, respectively.

Only the control circuit of relay 114 will be described in detail, since the control of each relay is effected by a similar circuit.

The relay 114 is operated by two differential windings 120 and 130, connected in the output of two rectifiers 121 and 131 respectively. The rectifier 121 is operated by current supplied from the transformer 122 through the amplifier 123. The rectifier 131 is similarly energized by current supplied from the transformer 132 through the amplifier 133. The transformer 122 is provided with one primary winding 124 which is connected to the output of detector 101, and a second primary winding 125 which is connected to the secondary winding of the transformer 211. These windings 124 and 125 are arranged to induce aiding electromotive forces in the secondary winding.

The transformer 132 is similarly provided with two primary windings 134 and 135, connected respectively to the output of the detector 101 and to the secondary winding of the transformer 211. However, in this case the windings 134 and 135 are so arranged as

to induce opposing electromotive forces in the secondary winding of the transformer.

Thus it will be seen that the relay 114 is controlled by the difference between two currents, one depending upon the sum of the current from the output of the detector 101 and the current in the secondary winding of the transformer 211, and the other depending upon the difference of these two currents. The operation of the relay 114 will take place when the two currents are about equal and the pull on the armature will be proportional to the sine

$$\left(\frac{\alpha}{2}-45°\right),$$

where α is the phase difference between the two currents. It will be seen that when the phase difference is 90°, the pull on the armature is zero but otherwise the pull will be directed to make the phase difference between the currents in the outputs of the transformers 111 and 211 less than 90°. The correction is effected by switching between the primary windings 112 and 113 which are arranged to induce electromotive forces of opposite polarities in the secondary winding of the transformer 111.

The connections 115 and 215 from the circuit of the relay 11 are provided for supplying blocking potential to the grids of the tubes 121, 131, 221 and 231 so that that pair of the rectifiers 121 and 131 or 221 and 231 associated with the receiver not in operation will be the only pair operated. Thus, under the conditions indicated in the drawing in which only the receiver 200 is supplying signals to the telephone receivers 10, the amplifier 103 being blocked by the action of the relay 11, the rectifiers 221 and 231 are inactive. Under this condition the rectifiers 121 and 131 control the relay 114 so that the difference in the phase of the currents in the secondary windings of the transformers 111 and 211 will always be less than 90°. During the moment of switching from one of the receivers (200) to the other (100) the armature of the relay 11 is off both of the contacts 109 and 209 so that both pairs of rectifiers 121 and 131, 221 and 231, are inactive and the relay 114 will remain in the last position preventing any disturbance due to a phase correction during the instance of switching from one receiver to the other.

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, means associated with said circuit to select from said receivers one whose signal output conforms to a desired requirement, and means effective at the instant of selection for automatically controlling the phase of the signal supplied from the selected receiver to said circuit to prevent phase differences between the signals supplied from said receivers from causing disturbances in said circuit.

2. In a radio signaling system, a plurality of receivers 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 signal circuit, means for continuously and automatically selectively connecting to said circuit that one of said receivers having a signal output conforming to a preassigned requirement, a group of paths of different phase characteristics for each of said receivers, means for selectively connecting any path of each of said groups between the corresponding receiver and said receiving circuit, means for rendering inoperative the path selecting means for that receiver which at any instant is supplying signals to said circuit, and means for controlling the path selecting means in another receiver so that at any time of changing from one receiver to said other receiver the phase difference between the currents of said one and said other receivers will be a minimum.

3. In a radio signaling system, a plurality of receivers each receiving a wave representing the same carrier modulated by the same signal band and so related to each other that the received waves vary differently at the several receivers with variations in transmission conditions, a signal frequency circuit, means for continuously and automatically selectively connecting to said signal frequency circuit that one of said receivers having a signal output conforming to a preassigned requirement, polarity reversing means for each receiver, means controlled by the selectively connecting means for rendering inoperative the polarity reversing means of that receiver which at any instant is supplying signals to the signal frequency circuit, and means for controlling the polarity reversing means in the other receivers so that at any time of changing from one receiver to another the polarity of the output current from said other receiver will be such as to give the minimum phase difference between said output current and the output current from said one 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 signal circuit, means associated with said circuit for automatically and continuously selecting from said receivers one whose signal output conforms to a desired requirement, a plurality of transmission paths of different

phase characteristics connected between each of said receivers and said selecting means, and means associated with each of said receivers for automatically and continuously selecting that one of the respective plurality of transmission paths which will give a minimum phase difference between the signal output of the path and the signal current being supplied to the signal receiving circuit.

5. In a radio signaling system, a plurality of receivers 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 for continuously and automatically selectively connecting to said receiving circuit that one of said receivers having a signal output exceeding that of the other by a predetermined amount, polarity reversing means in the path from each of said receivers to said receiving circuit, and means responsive to the relative phase of the waves received in said receivers for controlling said polarity reversing means to give a minimum phase difference between the waves in the paths from said receivers.

6. In a signaling system subject to variable transmission conditions, a first receiver, a second receiver, said receivers both receiving the same signal and being so related to each other that the received signals vary differently at each with variations in transmission conditions, a signal circuit, an automatic selecting circuit responsive to differences in the signals received by said receivers, a first signal transmission path connecting said first receiver with said signal circuit, a second signal transmission path connecting said second receiver with said signal circuit, means controlled by said automatic selecting circuit for alternately blocking said transmission paths to select that receiver the signal output of which meets a predetermined requirement, a group of branch paths of different phase shifts associated with each of said plurality of the signal transmission paths, means responsive to the relative phases of the output of the corresponding receiver and of the signal supplied to said signal circuit for selecting between the branch paths of the corresponding group, and means responsive to said automatic selecting means for rendering inoperative that one of the branch path selecting means associated with that one of said transmission paths over which signals are being transmitted to said signal circuit.

7. In a signaling system subject to variable transmission conditions, a first receiver, a second receiver, said receivers both receiving the same signal and being so related to each other that the received signals vary differently at each with variations in transmission conditions, a signal circuit, an automatic selecting circuit responsive to differences in the signals received by said receivers, a first signal transmission path connecting said first receiver with said signal circuit, a second signal transmission path connecting said second receiver with said signal circuit, means controlled by said automatic selecting circuit for alternately blocking said transmission paths to select that receiver the signal output of which meets a predetermined requirement, phase reversal means in each of said transmission paths, and means for automatically controlling the phase reversal means of the blocked transmission path comprising means for comparing the sum and difference of the current output of the receiver associated with said blocked transmission path and the current being supplied to said signal circuit.

8. In a signaling system subject to variable transmission conditions, a first receiver, a second receiver, said receivers both receiving the same signal and being so related to each other that the received signals vary differently at each with variations in transmission conditions, a signal circuit, an automatic selecting circuit responsive to differences in the waves received by said receivers, a first signal transmission path connecting said first receiver with said signal circuit, a second signal transmission path connecting said second receiver with said signal circuit, means controlled by said automatic selecting circuit for alternately blocking said transmission paths to select that receiver the signal output of which meets a predetermined requirement, a first phase reversal means in said first transmission path, a second phase reversal means in said second transmission path, means for controlling said first phase reversal means in response to the difference between the sum and difference of the signal output of said first receiver and the signal output of said second transmission path, and means for controlling the second phase reversal means in response to the difference between the sum and difference of the signal output of said second receiver and the signal output of said second transmission path.

9. In a signaling system subject to variable transmission conditions, a first receiver, a second receiver, said receivers both receiving the same signal and being so related to each other that the received signals vary differently at each with variations in transmission conditions, a signal circuit, an automatic selecting circuit responsive to differences in the waves received by said receivers, a first signal transmission path connecting said first receiver with said signal circuit, a second signal transmission path connecting said second receiver with said signal circuit, means controlled by said automatic selecting circuit for selectively blocking said transmission paths to select that receiver the signal output of which meets a predetermined requirement,

a phase reversal means in said first transmission path, a second phase reversal means in said second transmission path, means for producing a rectified current proportional to the sum of the signal output of said first receiver and the signal output of said second transmission path, means for producing a rectified current proportional to the difference in the signal output of said first receiver and the signal output of said second transmission path, relay means responsive to the difference in said rectified currents for controlling said first phase reversal means, means for producing a rectified current proportional to the sum of the signal output of said second receiver and the signal output of said first transmission path, means for producing a rectified current proportional to the difference in the signal output of said receiver and the signal output of said first transmission path, and relay means responsive to the difference in the last mentioned rectified currents for controlling said second phase reversal means.

10. In a signaling system according to claim 9, means responsive to the operation of said automatic selecting means to block said first transmission path for rendering inoperative the first two mentioned means for producing rectified current, and means responsive to the operation of said automatic selecting means to block said second transmission path for rendering inoperative the last two mentioned rectified current producing means.

11. In a transmission system, two sources of current of varying phase, a transmission path associated with each source, and means for reducing the phase difference between the current output of said transmission paths comprising a phase reversal means in one of said transmission paths, and means for controlling said phase reversal means in response to the sum and difference of the current from the respective one of said sources and the current output of the other transmission path.

In witness whereof, I hereunto subscribe my name this 29th day of September, 1931.

BJÖRN G. BJÖRNSON.