

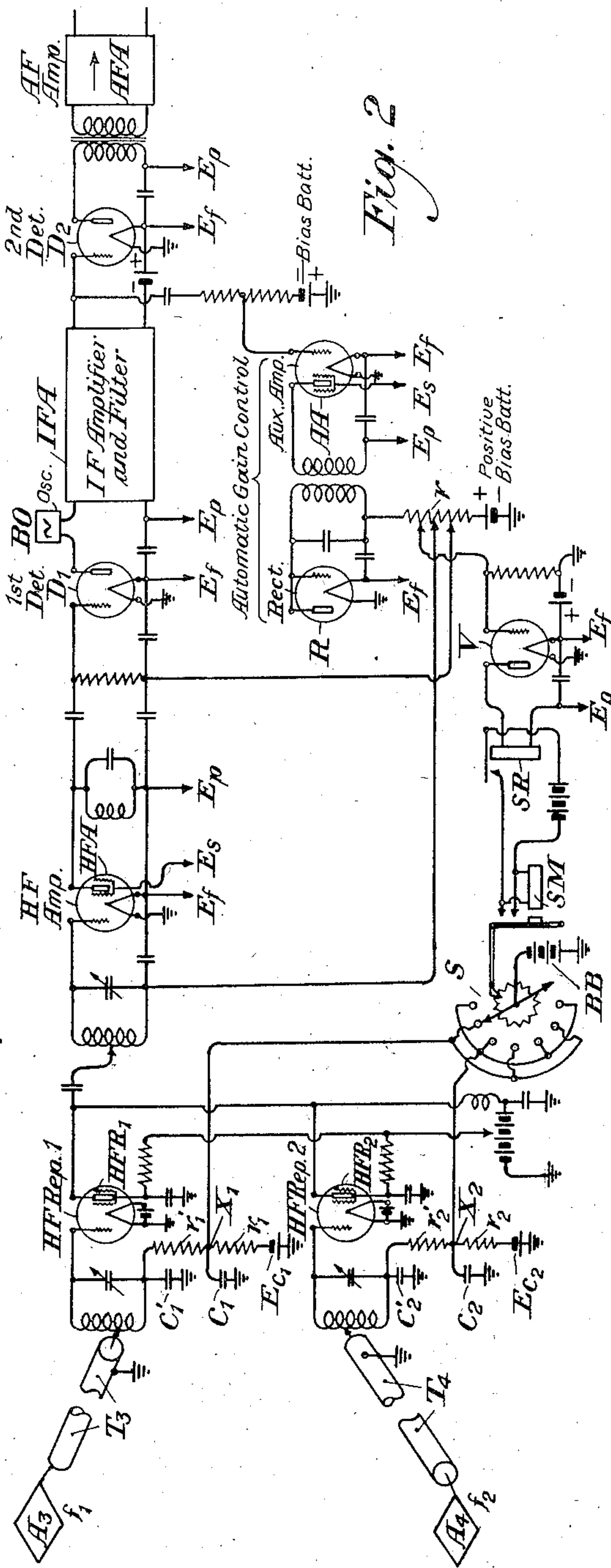
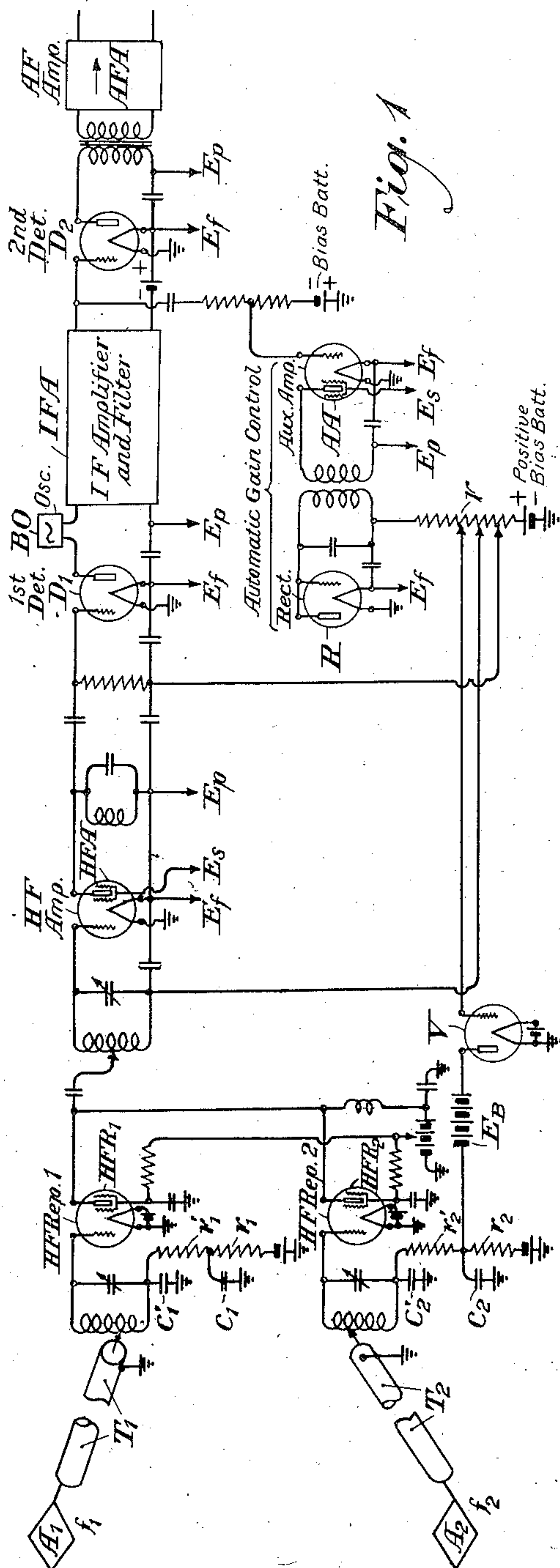
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DIVERSITY RECEPTION SYSTEM

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DIVERSITY RECEPTION SYSTEM

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This invention relates to radio reception, and more particularly to a diversity reception system in which, as between several signaling receiving instrumentalities, that one will be selected, from moment to moment, which at any given time will give the most desirable signal.

In radio signaling, and particularly in connection with short wave reception, the phenomenon known as fading results in considerable variation in the volume and quality of the signal from time to time. It has heretofore been proposed to overcome this difficulty by providing several receivers each associated with separate antennae so especially arranged with respect to each other that the effect of fading will be different upon different receivers, means being provided to select from time to time, the receiver whose signal has a desired characteristic. In accordance with the present invention, however, it is proposed to simplify the diversity reception system by arranging several antennae, or the equivalent thereof, so that they may be connected to only one receiver, the selecting mechanism being so controlled by the receiver that the selection of the antenna circuit giving the most desirable signal is accomplished in the high frequency stages ahead of the receiver. This selection may be effected indirectly by means of a blocking bias applied to a tube acting as a high frequency repeater between the corresponding antenna and the receiver.

The selection may be effected in either of two ways: (a) by applying the blocking bias under the control of the receiver to one only of two antennae, both of which are normally connected to the receiver so that one antenna is in effect blocked and only the other antenna becomes effective when the received signal falls below a preassigned limit; (b) the bias may be applied to any antenna by a switching arrangement controlled by the receiver to render a particular selected antenna effective. In this latter arrangement the antennae are effectively connected to the receiver, one at a time, and a new antenna is selected whenever the output of the receiver falls below a preassigned minimum.

The invention will now be more fully understood from the following description when read in connection with the accompanying drawing, Figures 1 and 2 of which, respectively, illustrate two embodiments of the invention.

When two antennae outputs are combined directly upon a common receiver the signals from both may be high and yet, the combined output may be very low due to a phase difference between the carrier waves contributed by the two spaced

antennae. The combined signal may also be of poor quality since some of the side band components may still be in the same phase even though the carrier components approach a difference of 180 degrees with the result that the side band components are very high compared to the combined carrier. This produces the equivalent of over-modulation, and consequently, poor quality. In the arrangement about to be described, this interference effect is reduced to a considerable extent by a change in the relative amplitude of the contributions by the two antennae when the vector relation between the carriers is such that the carrier becomes partially suppressed.

Referring to Fig. 1, two antennae A_1 and A_2 which may be of the horizontal double V variety, are shown connected by means of transmission lines T_1 and T_2 to a common point. The transmission lines T_1 and T_2 are shown as being of the concentric conductor type, but may be of any well known type. The transmission lines are connected through tuned circuits to individual high frequency repeaters HFR_1 and HFR_2 corresponding to the two antennae. The output or plate circuits of these repeaters are connected together through a common condenser to the tuned input circuit of a receiver which is common to the two antennae. This receiver includes a high frequency amplifier HFA which is connected to a first detector or demodulator D_1 whose circuit is connected to a beating oscillator BO which supplies the beating wave for stepping down the received wave to an intermediate frequency. Beyond the first detector D_1 is an intermediate frequency amplifier IFA which may be of any well known type, the output of this intermediate frequency being connected to a second detector D_2 which in turn is connected to the final outgoing circuit through an audio frequency amplifier AFA .

The receiver is also provided with an automatic gain control arrangement for tending to automatically maintain the gain at a more or less constant level. The automatic gain control comprises an auxiliary amplifier AA whose output is connected to a rectifier tube R . The input circuit of the auxiliary amplifier AA has its grid normally negatively biased in the usual manner, but a connection also extends from the output of the intermediate frequency amplifier to the grid of the auxiliary amplifier with the result that some of the carrier component from the intermediate frequency amplifier is applied to the grid and amplified by the auxiliary amplifier AA . The amplified carrier component is then recti-

fied by means of the rectifier R and connected to a resistance r to which is connected a positive bias battery, as shown. Taps from the resistance r are connected to the grids of the high frequency amplifier HFA and of the first detector D₁ for varying the bias thereof. When the automatic gain control decreases, as it does when the received signal is reduced in volume, the voltages on the grids of the tubes HFA and D₁ become less negative, and the gain of the receiver is correspondingly increased to tend to bring the output signal up to normal.

The gain control bias (supplied through the resistance r) is also used to place a blocking bias on the grid of one of the high frequency repeaters associated with the two antennae. This is accomplished by taking a third tap from the resistance r and connecting it to the grid of the biasing tube V whose plate circuit is connected through the plate battery to the junction point between the resistances r_2 and r_2' associated with the grid circuit of the high frequency repeater HFR₂.

When the output of the automatic gain control decreases, with decrease in the received signal, the rectified component flowing through the resistance r is decreased, and the voltage applied to the grid of the tube V becomes less negative. Consequently, the current in the plate circuit of the tube V increases. This increase in the plate current of the tube V which flows in the resistance r_2 associated with the high frequency repeater HFR₂, makes the voltage at the junction point between the resistances r_2 and r_2' more negative. This increases the negative bias on the grid of the high frequency repeater HFR₂, and when the negative bias reaches a sufficiently high value the tube HFR₂ becomes ineffective and its output is suppressed so that only the output from the antenna A₁ is supplied to the receiver.

Normally, of course, both antennae are effectively connected to the receiver in which components from both antennae are combined. When the combined result falls below a preassigned minimum the tube V acts to suppress the repeater HFR₂ and hence the antenna A₂, so that only the antenna A₁ is effective. It might at first thought appear that since the antenna A₂ is always suppressed when the combined signal falls below a preassigned value, that the signal from the antenna A₁ might, under some circumstances, be less than that from the antenna A₂ with the possible result that when the antenna A₂ is suppressed the signal received from antenna A₁ alone might be less than that received from both antennae. Such will not ordinarily be the case, however, because the suppression mechanism does not become effective unless the combined signal falls below a quite low value and this would only occur when the signals from the two antennae are both large and not greatly different in value. Consequently, the difference between the two signals ought to be smaller than either signal taken alone at the time when one antenna is suppressed, with the result that the signal from the antenna which remains in circuit will be greater than the combined signal from the two antennae.

However, there is one very special case under which an arrangement such as that just described, would not necessarily reduce the interference, but might even tend to exaggerate it for an instant. This might occur when the carrier vectors representing the outputs of the two an-

tennae are 180 degrees apart and the automatically biased repeater output is somewhat stronger than the output of the unbiased repeater HFR₁. The automatic bias would then tend to decrease the amplitude of the larger vector causing the resultant carrier to be still further decreased during the time required for the output of the biased repeater HFR₂ to drop below that of the unbiased repeater HFR₁. This condition would, however, seldom occur since in practically all cases the interference is produced by a relative rotation of the vector in combination with a resulting relative amplitude change which is of minor importance.

These difficulties may be overcome by using the arrangement illustrated in Fig. 2 in which the output of only one antenna is used at any one time, and the antennae are switched one at a time to the single receiver on the principle that whenever the carrier signal output drops below a predetermined level the receiver is automatically switched over to another antenna. Two or more antennae may be included in the switching cycle so that if there are more than two antennae the switching mechanism may be arranged to "hunt" from the output of one antenna to another, until one of a sufficiently high output is selected.

The mechanism embodying these principles is shown in Fig. 2. In Fig. 2, that part of the system including antennae, the transmission lines, the high frequency repeaters HFR₁ and HFR₂, and the various elements making up the common receiver, are similar to those already described in Fig. 1. The automatic gain control arrangement involving the auxiliary amplifier AA and rectifier R, is also similar to that previously described in connection with Fig. 1. As before, the rectified current from the rectifier R passes through the resistance r to which is connected the positive bias battery. From the resistance r , taps extend to the grids of the high frequency amplifier HFA and the first detector D₁, respectively, for effecting the automatic gain regulation of the receiver.

In addition to changing the gain of the receiver the automatic gain control is used in Fig. 2 to operate the switching device S. For this purpose a tap from the resistance r leads to the grid of the vacuum tube V.

When a normal signal strength is being received, the grid of the tube V is biased so far negative that the relay SR in its plate circuit is not operated. When, however, the signal falls below a predetermined limit the rectified current from the rectifier R decreases in value sufficiently so that the negative bias on the grid of the tube V attains such a small value that the relay SR is operated. The operation of the relay SR in turn causes the stepping magnet SM to energize, thereby attracting the armature and stepping the switch S in advance one step. The wiper of the switch S would have been previously resting upon a contact connected to one or other of the points x_1 or x_2 , as the case may be, these points being the junction points between the resistances in the grid circuits of the high frequency repeaters. When the stepping magnet SM is energized, however, the switch is advanced one point and the wiper rests on a contact which is connected to the other of the two junction points. If, for example, the wiper was originally connected to the junction point x_2 , after being advanced it would be connected to the junction point x_1 . In this way the bias potential from the bias battery BB is con-

nected over the wiper of the switch selectively to the high frequency repeaters. The circuit is such that a given repeater will only be energized when the proper biasing current is applied over the wiper of the switch S, and other high frequency repeaters will be disabled. Consequently, the receiver only receives from one antenna at a time.

It will be noted that when the stepping magnet SM is energized its armature short-circuits the winding of the stepping magnet so that the armature is again caused to fall off. If the new antenna which has now been selected does not supply sufficient energy to cause the stepping magnet to be disabled, the stepping magnet would continue to be alternately energized and deenergized, thus stepping the switch from contact to contact. Obviously, therefore, by providing a sufficient number of antenna connections with their associated high frequency repeaters, the switch will hunt until it does find an antenna supplying sufficient power to stop the switching action.

The rate at which the change-over from one antenna to the other is accomplished, and the period during which both antennae are connected to the receiver, is determined by the operating characteristics of the stepping relay SR and the stepping magnet SM, and also by the time constants of the relay operating vacuum tube circuit, the resistances r_1, r_1', r_2, r_2' in the bias circuits, and capacities c_1, c_1', c_2, c_2' . It is desirable that the switching take place more or less deliberately in order that there shall be no sudden change in the output due to the instantaneous difference in the selective fading of the signals on the two antennae involved.

There are obviously several advantages inherent in the foregoing arrangement. The expense is reduced by the cost of one receiver in a two antennae system, and is further reduced as the number of spaced antennae is increased. The operation is simplified by a reduction of the number of receiving circuits to be tuned. It does not place such a rigid requirement upon the similarity of performance of the separate receivers in the matters of circuit noise and transmission circuits. The arrangement can, obviously, be applied economically to very special and costly types of short wave receivers.

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 by the following claims.

What is claimed is:

1. In a diversity receiving system, a plurality of receiving antennae, a radio receiver comprising a detector common to said antennae, an individual coupling from each antenna to the input of said receiver through which waves from said antenna may be transmitted to said receiver without change in frequency, and means having an actuating connection from the output side of said detector to suppress transmission from one of said antennae through its coupling to said receiver and at the same time to establish transmission from the other antenna to said receiver.

2. In a diversity receiving system, a plurality of receiving antennae, a radio receiver comprising a detector common to said antennae, an individual coupling from each antenna to the input of said receiver through which waves from said antenna may be transmitted to said receiver without change in frequency, and means having an actuating connection from the output side of said detector and operable when the signal volume in

the receiver passes beyond a preassigned limit to suppress transmission from one of said antennae through its coupling to said receiver and at the same time to establish transmission freely from the other antenna to the receiver.

3. In a diversity receiving system, a plurality of receiving antennae, a radio receiver comprising a detector common to said antennae, an individual coupling from each antenna to the input of said receiver through which waves from said antenna may be transmitted to said receiver without change in frequency, and means having an actuating connection from the output side of said detector and responsive to the volume of signal from said receiver to suppress transmission from one of said antennae through its coupling to said receiver and establish transmission freely from the other antenna to the receiver.

4. In a diversity receiving system, a plurality of receiving antennae, a radio receiver comprising a detector common to said antennae, an individual coupling from each antenna to the input of said receiver through which waves from said antenna may be transmitted to said receiver without change in frequency, and means having an actuating connection from the output side of said detector and operative when the signal volume in the receiver passes beyond a preassigned limit to suppress transmission from one of said antennae through its coupling to said receiver and to establish transmission freely from the other antenna to the receiver.

5. In a diversity receiving system, a plurality of receiving antennae, a radio receiver comprising a detector common to said antennae, a vacuum tube repeater individual to each antenna for coupling said antenna to said receiver so that waves from said antenna may be transmitted through said repeater to said receiver without change in frequency, and means having an actuating connection from the output side of said detector and operative when the signal volume in the receiver passes beyond a preassigned limit to disable one of said repeaters, and when the first repeater is disabled to establish transmission freely through said other repeater.

6. In a diversity receiving system, a plurality of receiving antennae, a radio receiver comprising a detector common to said antennae, a vacuum tube repeater individual to each antenna for coupling said antenna to said receiver so that waves from said antenna may be transmitted through said repeater to said receiver without change in frequency, a device for rectifying some of the energy from said receiver, and means having an actuating connection from the output side of said detector and controlled in accordance with said rectified energy and operative to apply a disabling bias to the grid of one of said repeaters and when the first repeater is disabled to establish transmission freely through said other repeater.

7. In a diversity receiving system, a plurality of receiving antennae, a radio receiver comprising a detector common to said antennae, a vacuum tube repeater individual to each antenna for coupling said antenna to said receiver so that waves from said antenna may be transmitted through said repeater to said receiver without change in frequency, said repeaters normally repeating the signals from all of said antennae and combining them in the receiver, and means having an actuating connection from the output side of said detector and operative when the signal volume in the receiver passes beyond a preassigned limit to disable one of said repeaters and when the

first repeater is disabled to establish transmission freely through said other repeater.

8. In a diversity receiving system, a plurality of receiving antennæ, a radio receiver comprising a detector common to said antennæ, a vacuum tube repeater individual to each antenna for coupling said antenna to said receiver so that waves from said antenna may be transmitted through said repeater to said receiver without change in frequency, said repeaters normally repeating the signals from all of said antennæ and combining them in the receiver, a device for rectifying some of the energy from said receiver, and means having an actuating connection from the output side of said detector and controlled in accordance with said rectified energy to apply a disabling bias to the grid of one of said repeaters when the first repeater is disabled and to establish transmission freely through said other repeater.

9. In a diversity receiving system, a plurality of receiving antennæ, respective high frequency repeaters associated therewith, a receiver comprising a detector common to said repeaters, a switching arrangement, and means having an actuating connection from the output side of said detector and responsive when the signal volume in the receiver passes beyond a preassigned limit to operate said switching arrangement to effectively switch said receiver from connection with one repeater to connection with another.

10. In a diversity receiving system, a plurality of receiving antennæ, respective high frequency repeaters associated therewith, a receiver comprising a detector common to said repeaters, a switching arrangement for associating said receiver with said repeaters, means to rectify some of the signal energy from said receiver, and means having an actuating connection from the output side of said detector and operating when the rectified energy exceeds a preassigned limit to operate said switching arrangement to effectively switch said receiver from connection with one repeater to connection with another.

11. In a diversity receiving system, a plurality of receiving antennæ, a receiver comprising a detector common to said antennæ, a vacuum tube repeater individual to each antenna for coupling each antenna to said receiver so that waves from said antenna may be transmitted through said repeater to said receiver without change in frequency, a switching arrangement to apply biasing potential selectively to the grid of one of said repeaters, and means having an actuating connection from the output side of said detector and responsive when the signal volume in the receiver passes beyond a preassigned limit to operate said switching arrangement to shift the biasing potential from the grid of one repeater to another.

12. In a diversity receiving system, a plurality

of receiving antennæ, a receiver comprising a detector common to said antennæ, a vacuum tube repeater individual to each antenna for coupling each antenna to said receiver so that waves from said antenna may be transmitted through said repeater to said receiver without change in frequency, a switching arrangement to apply biasing potential selectively to the grid of one of said repeaters, means to rectify some of the signal energy from said receiver, and means having an actuating connection from the output side of said detector and operating when the rectified energy passes beyond a preassigned limit to operate said switching arrangement to shift the biasing potential from the grid of one repeater to another.

13. In combination, a plurality of high frequency receiving antennæ, respective high frequency repeaters associated therewith, a common detector with high frequency input and low frequency output standing in like relation to said repeaters, intensity responsive means on the low frequency output side of said detector, and means actuated by said intensity responsive means selectively to disable one of said repeaters and its respective antenna.

14. In combination, a plurality of high frequency receiving antennæ, respective high frequency repeaters associated therewith, a common detector with high frequency input and low frequency output standing in like relation to said repeaters, intensity responsive means on the low frequency output side of said detector, and means actuated by said intensity responsive means selectively to disable said repeaters in cyclic order.

15. In combination, a plurality of antennæ, one detector, respective high frequency paths from the said antennæ to the said detector, a gain control device having its actuating input connected from the output side of said detector and its actuating output connected to the input side of said detector, and means also actuated by said gain control device relatively to enable one said path and disable the others.

16. In combination, a plurality of antennæ, one detector, respective high frequency paths from said antennæ to said detector, and means relatively to enable one said path and disable the others, said means having its actuating input connected from the output side of said detector.

17. In combination, a plurality of antennæ, one detector, respective high frequency paths from the said antennæ to the said detector, and means operating cyclically and selectively relatively to enable one said path and disable the others, said means having its actuating input connected from the output side of said detector.

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