

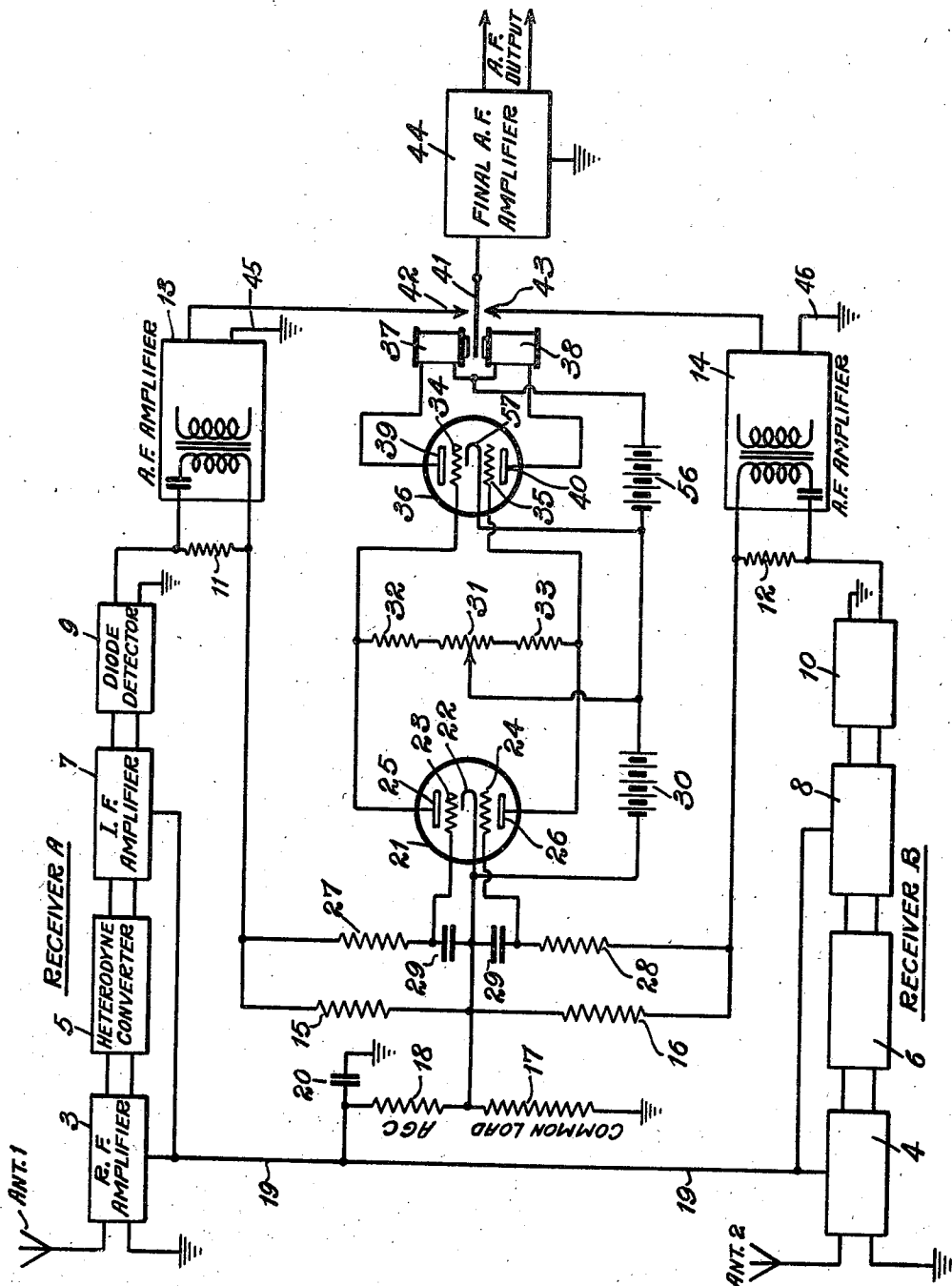
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SELECTOR FOR DIVERSITY RECEIVING SYSTEMS

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SELECTOR FOR DIVERSITY RECEIVING SYSTEMS

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This invention relates to radio receiving systems and more particularly to an arrangement for diversity reception employing a plurality of antennas and receivers which control a common utilization device or circuit.

As is well known, radio signals are subject to fading, which varies both in frequency and degree in an unpredictable manner. Inasmuch as the fading at any instant may differ very widely at geographically spaced points or in different planes of polarization, it has been found to be a practical expedient to provide a number of antennas whose energies when collected are fed selectively to a single responsive means.

It is an object of the present invention to improve upon diversity receiving systems heretofore known.

It is a more specific object of my invention to provide a diversity receiving system which shall be effective in reducing to a minimum the fading and noise present in the output from a receiver.

It is another object of my invention to provide a switching system in a diversity receiver such that the switching action from one to another of the operating antennas will be complete, and substantially instantaneous in its effect.

It is still another object of my invention to provide a switching system for diversity receivers which will operate in response to a very small difference in input voltages impressed on two or more of the component radio receivers supplying the common responsive means, or utilization circuit.

The use of an automatic gain control system common to two or more receivers results in the instantaneous output signals from the separate receivers being proportional to the instantaneous inputs delivered to these receivers by the separate signal sources, or antennas. This permits the strongest one (having the best signal-to-noise ratio) to predominate at any instant. To further accentuate this inherent switching action, use is made of relatively low impedance diodes as final detectors to supply the common load circuit. Experience and theory have both shown that such low impedance diodes (instead of relatively high resistance detectors of the biased triode type) give a decided "switching" action in themselves when working into a common resistance load of given value. This is due to the voltage regulation inherent in such a circuit. A zero impedance diode source would give 100% complete switching for an infinitesimal difference in input voltages.

To prevent the overall distortion which certain types of fading conditions produce in a combined output from two or more receivers of a diversity system, complete switching is provided by means of relays operated in accordance with the differences between rectified outputs from the two or more individual receivers.

Certain systems heretofore in use have employed a common automatic gain control supply from and to the two or more receivers; and have also taken advantage of the further improvement in "switching" action resulting from the use of relatively low impedance final detectors supplying the common load circuit.

In order to obtain the desired switching action certain other systems in use have relied entirely on variations in signal voltages at the antennas and on the use of relays to choose between the individual outputs of the several receivers.

Systems of the first type do not make available the possibility of 100% switching on small differences in signal strengths at the several antennas. The result, under certain specific fading conditions, is an out-of-phase addition of the modulation frequency components of the outputs of the several detectors. This results in distortion.

Systems of the second type, which employ automatic gain control on each individual receiver, but which rely on relay switching (electro-mechanical or electron tube) instead of employing an automatic gain control system common to the several receivers, have the disadvantage of high noise level in the output of any receiver having a momentarily poor signal-to-noise ratio due to the signal supplied by its separate antenna having faded to a low value. Choice must then be made between two or more receiver outputs of approximately the same voltage—due to individual automatic gain control systems—but of greatly different signal-to-noise ratios.

The system of this present invention retains the proven advantages of an automatic gain control supply common to the several receivers; thereby permitting the signal from the receiver having the best signal-to-noise ratio to predominate. The arrangement and functioning of the circuit herein disclosed then selects this predominantly best of the output signals from the two or more receivers in use.

A further advantage of the system herein proposed is that the selection is effective, in its functioning, whether or not modulation is present. It is, therefore, ready at every instant to

deliver the best possible output whenever modulation is impressed on the distant radio transmitter. Systems which utilize voice modulation output from the receivers to operate the switching means do not enjoy this advantage and simplicity.

My invention will now be explained in more detail by description of a specific embodiment which is given by way of example, and is shown in the accompanying drawing, the sole figure of which is in the form of a circuit diagram including the essential elements which are provided in combination for carrying out the invention.

Referring to the drawing, I show two antennas 1 and 2 each feeding to an appropriate radio frequency amplifier. Amplifier 3 is connected to antenna 1, while amplifier 4 is connected to antenna 2. I have shown also a pair of heterodyne converters 5 and 6 each appropriately connected to its own R. F. amplifier. Each converter feeds to its associated intermediate frequency amplifier 7 or 8. The output from each I. F. amplifier is then fed to its associated diode detector 9 or 10. The rectified intermediate frequency energy from diode detector 9 is effective for three purposes: (1) to control an audio frequency amplifier 13; (2) to provide a suitable automatic switching voltage obtained from the voltage drop across resistor 15; and (3) to provide automatic gain control from the voltage drop across the common load resistor 17.

In like manner the rectified output energy from the diode detector 10 produces a voltage drop across resistors 12, 16, and 17.

Resistors 15 and 16 are both connected to one terminal of a common load resistor 17, the other terminal of which is grounded. A common automatic gain control voltage is, therefore, provided by the "time constant" circuit connected across resistor 18. Voltage supplied through resistance 18 to capacitor 20 is fed through connection 19 to the conventional grid biasing circuits for the R. F. amplifiers 3 and 4, as well as the I. F. amplifiers 7 and 8.

In addition to the primary function of applying automatic gain control voltages through the circuits 19 to the several amplifiers, a switching function is provided by the voltages appearing as drops across resistors 15 and 16.

The switching system is differential in its action. The apparatus includes preferably a twin triode tube 21 having a common cathode 22 connected to the junction point between resistors 15 and 16. This tube has two grids 23 and 24 and two anodes 25 and 26. The grid 23 is connected through resistor 27 to the terminal of resistor 15 remote from its connection with the common cathode 22. Correspondingly, grid 24 is connected through resistor 28 with that terminal of resistor 16 which is remote from the common cathode 22. "Time constant" condensers 29 are provided from grids 23 and 24 to the common cathode 22, to suitably determine the speed of the switching action and to make said switching action non-responsive to modulation frequencies which are to be utilized.

Tube 21 has two output circuits, one extending from the cathode 22 through an anode supply source 30 and one portion of a potentiometer 31 through resistor 32 to the anode 25. The other output circuit includes said source 30, the other portion of the potentiometer 31 and resistor 33 which is connected to the anode 26.

The twin triode tube 21 operates as an amplifier for feeding differential potentials to the grids 34 and 35 respectively of another twin triode tube 36. The cathode 57 of this tube constitutes the common connection between the positive terminal of source 30 and the negative terminal of a different source 56. Source 56 supplies current, through the windings 37 and 38 of a differential relay, to the anodes 39 and 40.

The relay windings 37, 38 are opposed to each other in their control of a common armature 41 having contacts 42 and 43 on either side thereof.

The ultimate responsive device is not shown in the drawing, but may be considered as one which is operative under control of a common audio frequency amplifier 44. This amplifier derives its input energy from one or the other of the two amplifiers 13 and 14 depending upon the operation of the armature 41 on the differential relay 37, 38.

Amplifier 13 has an output circuit which includes the contact 42, armature 41 and an input lead to the amplifier 44. The return circuit traverses conductor 45. Similarly the amplifier 14 has an output circuit which includes contact 43, armature 41, one input terminal from amplifier 44, and a return circuit indicated by conductor 46.

With receivers A and B adjusted to have the same overall gain, and with potentiometer 31 properly adjusted to compensate for differences in tube characteristics, armature 41 of the differential relay will be actuated in accordance with any difference existing between the input voltages to the two receivers A and B.

The functioning of the system will now be explained in more detail. Consider first the case in which receiver A (comprising the units fed successively with energy from antenna 1) has a greater input voltage than the other receiver B.

Output from the diode detector 9 being greater, it will further depress the output from receiver B. This is because the diode source 13 of the receiver B must overcome the voltage drop across the common load resistor 17 before it can contribute any rectified output to the common load circuit and therefore supply any rectified output through resistors 12 and 16.

Resistor 15, under the conditions now considered, will have a voltage drop across it which will swing the grid 23 negative with respect to the cathode 22. Anode current between the cathode 22 and anode 25 will, therefore, be cut off. At the same time resistor 16 will have little or no voltage drop across it, and, therefore, current will flow between cathode 22 and anode 26.

With potentiometer 31 properly adjusted for the particular tubes in use, the result of the condition described will be to permit current to flow in the upper portion of tube 36, (that is, between cathode 57 and anode 39), but current will be cut off between cathode 57 and anode 40. Differential relay winding 37 is then energized so as to pull up the armature 41 against contact 42. This causes amplifier 44 to be supplied with modulation energy input from amplifier 13, and amplifier 14 is for the time being switched off from the final utilization circuit. As soon as conditions are so changed, however, that the output from diode detector 10 exceeds that of diode detector 9, the switching apparatus will reverse itself, thus causing the armature 41 to move against contact 43 so that the audio frequency amplifier 14 will be connected to the amplifier 44 supplying the final utilization circuit or device.

It is within the scope of my invention to provide switching apparatus which will be effective where three or more antennas are to be used for diversity reception. In this case the principles set forth in my Patent #2,004,126, granted June 11, 1935, may be applied. In that patent it was shown how two selectors having differential relay windings might be made to operate in conjunction with a third selector so as to finally deliver modulation frequency energy from whichever of three receiving sets might be delivering the best output signal at a given instant.

It is also within the scope of my invention to provide the improvements hereinbefore set forth in connection with a volume control combined system such as shown in my Patent #1,849,362, dated March 15, 1932.

I claim:

1. In a diversity receiving system, a plurality of antennas, a separate receiving circuit for each antenna, means for deriving rectified signal energy from each said circuit, an automatic gain control device common to said receiving circuits and fed with components of rectified signal energy from the several receiving circuits, means for comparing the values of said components, switching means under control of the dominating one of the compared components, and a utilization device connectable by said switching means to that one of said receiving circuits which delivers the maximum intensity of signal energy.
2. The device according to claim 1 in which the first said means comprises discharge tubes of the diode type.
3. The device according to claim 1 in which said switching means comprises a differential relay.
4. The device according to claim 1 in which a common load resistor is provided for absorbing said components of rectified signal energy.
5. In combination with a plurality of heterodyne receivers each actuated by a separate antenna, each receiver including a detector in circuit between an intermediate frequency stage and an audio frequency stage, an automatic volume control device effective to regulate said receivers in response to variations in the combined output energies of said detectors, means including balanced impedances and discharge tubes for comparing the amplitudes of signal energy from two of said detectors, a differential relay operable under control of said comparison means, a utilization circuit, and contacts selectively closeable by said relay and constituting means for connecting said utilization circuit to that audio frequency stage which delivers the maximum signal energy.
6. In a diversity receiving system which uses a plurality of heterodyne receivers having amplifier stages, each receiver being controlled by a separate antenna and each being capable of de-

livering signals to a common responsive device when connected thereto by switching means, the method of applying an automatic volume control voltage to the amplifier stages of said receivers and of simultaneously selecting the receiver which delivers the maximum of rectified output power for singly controlling said responsive device, which method includes deriving said automatic volume control voltage from a combination of rectified components of energy delivered by all said receivers, comparing said rectified components from different ones of said receivers, and using the dominating energy of said components, when compared, to switch said common responsive device into operative connection with said receiver which delivers the maximum power.

7. The method of radio signal reception which includes separately collecting signal energy at two geographically spaced positions, distinctly amplifying and rectifying the separately collected energies, comparing said energies to determine which is the greater, combining said energies, automatically controlling the gain in each distinct amplifying step under control of said combined energies, and producing a signal response under the exclusive control of that amplified and rectified signal energy which is derived from the one position where the collected energy is greater as determined by said comparison step.

8. The method of radio signal reception which includes separately collecting signal energy at a plurality of geographically spaced positions, distinctly amplifying and rectifying the separately collected energies, comparing said energies to determine which is the greatest, combining said energies, automatically controlling the gain in each distinct amplifying step under control of said combined energies, and producing a signal response under the exclusive control of that amplified and rectified signal energy which is derived from the one position where the collected energy is greatest as determined by said comparison step.

9. The method of diversity reception which includes simultaneously making a plurality of separate energy collections of relatively different fading characteristics, separately amplifying and rectifying the collected energies, comparing the magnitudes of the energies thus rectified, combining the compared components of said energies, controlling the gain in the aforesaid amplifying step under control of said combined components, and selecting for responsive utilization a single component of rectified energy corresponding to the separate energy collection which exceeds the others in magnitude, said selecting step being in accordance with the results of said comparison step.

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