

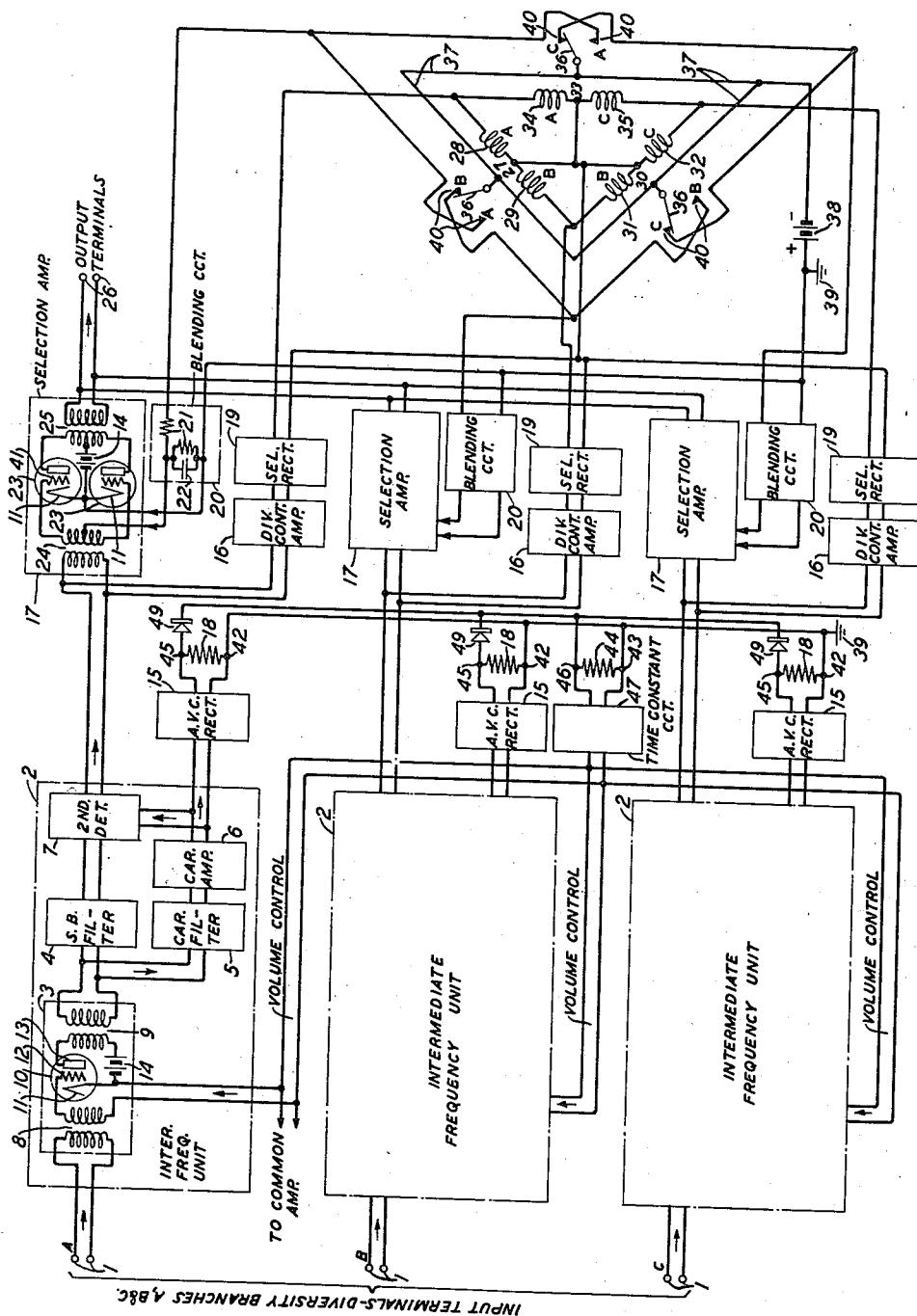
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VOLUME CONTROL CIRCUIT

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VOLUME CONTROL CIRCUIT

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This invention relates to volume control circuits and particularly to automatic volume control circuits for diversity radio receiving systems.

As is known, in diversity systems either the signal waves received in the several diversity branches are combined to produce the final detector output, or the wave from only the diversity branch having the incoming signal of greatest intensity is selectively supplied to the utilization circuit. Heretofore, in both the combination diversity and the selection diversity systems, it has been customary to regulate or control automatically the intensity of the output current supplied to the utilization circuit in accordance with a combined rectified current obtained from the signals in the several diversity branches. While accurate output intensity regulation is obtainable in the combination diversity system with the volume control circuit arrangement mentioned above, it has been found that satisfactory output volume control is not obtainable with this arrangement in the selection diversity system.

It is one object of this invention to secure an output of constant intensity in a selection diversity receiving system.

It is a further object of this invention to regulate the output intensity in a selection diversity in accordance with the intensity of only the selected incoming signal.

According to one embodiment of the invention, in a system arranged for three branch diversity selection operation, each branch including an intermediate frequency amplifier and a volume control rectifier, the rectifier output circuits are each connected through a separate switching rectifier to the same point in each amplifier input circuit. More particularly, the branch rectifier output circuits are connected through a separate rectifier to the same terminal of a common volume control resistance, whereby the volume control voltage used to control the gain of the intermediate frequency amplifiers in each branch, and the high frequency amplifiers, if any, common to the branches, is derived only from the branch circuit having the strongest incoming signal. A branch selection system, which does not form part of the invention, is provided to connect selectively only the branch having the strongest incoming signal to the translation device.

The invention will be more fully understood from the following specification taken in conjunction with the drawing on which like reference characters denote elements of similar function.

Referring to the drawing, reference characters A, B and C refer to the individual branch circuits of a three branch diversity receiving system arranged for selection diversity operation. The separate input terminals of the three branches are connected, when angle diversity is employed, to the same antenna unit or antenna array, as disclosed in Patent 2,041,600, H. T. Friis, May 19, 1936; and to geographically spaced antennas when space diversity is employed. Preferably, assuming angle diversity is used, the input terminals of each of branches A, B and C are connected to the same antennas through equipment (not illustrated) comprising separate steering phase shifters for the branches, a common first intermediate frequency amplifier, a common first detector and a common radio frequency amplifier, as disclosed in Patent 2,173,858, N. J. Pierce and F. A. Polkinghorn, September 26, 1939.

Each branch circuit includes an intermediate frequency unit 2 comprising a second intermediate frequency amplifier 3, a side-band filter 4, a carrier filter 5, a carrier amplifier 6 and a second detector 7. The intermediate frequency amplifier 3 comprises an input transformer 8, an output transformer 9, a space discharge tube 10 having a cathode 11, control electrode 12 and an anode 13. Reference numeral 14 designates a source of anode potential. In addition, each branch circuit includes an automatic volume control rectifier 15, a diversity control amplifier 16 and a selection or voice frequency amplifier 17, the rectifier 15 being connected to the output terminals of the carrier amplifier and the amplifiers 16 and 17 to the output of the second detector 7. Also, each branch includes a volume control resistance 18 connected to the output circuit of the volume control rectifier 15, a diversity selection rectifier 19 connected to the output of the diversity control amplifier 16 and a blending circuit 20 comprising resistances 21 and a condenser 22 and included in the input circuit of amplifier 17. The blending circuit 20 is in effect a two-terminal network having one terminal connected to the grids and the other terminal connected to the cathodes of tubes 23. More particularly, this network includes three paths, one path comprising condenser 22, another path comprising one of the resistances 21, and the remaining path comprising the other resistance 21 and a grid bias battery. The last-mentioned resistance 21 and associated battery are, as explained below, either connected together or disconnected, dependent upon the position of the

relay armatures in the diversity selection circuit. Each selection amplifier 17 comprises two tubes 23 connected in push-pull, an input transformer 24 and an output transformer 25. The output terminals of the three selection amplifiers 17 are connected to the common output terminals 26 and a translation device (not illustrated) is connected to the common output terminals 26.

The diversity selection circuit associated with diversity control amplifier 16 and the selection amplifier 17 comprises a relay 27 having windings 28 and 29 connected, respectively, across the output terminals of the branch A selection rectifier 19 and branch B selection rectifier 19; a relay 30 having windings 31 and 32 connected, respectively, across the output terminals of the branch B selection rectifier 19 and the branch C selection rectifier 19, and a relay 33 having the windings 34 and 35 connected, respectively, across the output terminals of the branch A selection rectifier 19 and the branch C selection rectifier 19. Each of relays 27, 30 and 33 has an armature 36 connected through conductor 37 to the negative terminal of a grid bias selection battery 38, the positive terminal of which is connected to the ground 39 and the cathodes 11 of the tubes 23 in the amplifiers 17. Each of the two contacts 40 of relays 27, 30 and 33 is connected through one of the resistances 21 in the blending circuit 20 to the grids 41 of the tubes 23 in one of the selection amplifiers 17. The characters A, B and C adjacent the contacts 40 and relay windings indicate the manner in which these elements are associated with the branch circuits. More specifically, one of the contacts 40 of relay 27 is connected to a resistance 21 in the branch A blending circuit 20 and the other contact 40 of this relay is connected to a resistance 21 of the branch B blending circuit 20. Similarly, the contacts 40 of relay 30 are connected to the resistances 21 in the blending circuits in branches C and B; and the contacts 40 of relay 33 are connected to the resistances 21 in the blending circuits of branches A and C. Relay windings 28 and 34 are connected to the output terminals of the branch A rectifier 19; relay windings 29 and 31 to the branch B rectifier 19, and relay windings 32 and 35 to the branch C rectifier 19.

Referring to the volume control circuit associated with the volume control rectifiers 15, one terminal 42 of each volume control resistance 18 is connected to ground 39 and to one terminal 43 of a common volume control resistance 44. The remaining terminal 45 of each resistance 18 is connected, each through a switching rectifier as explained below, to the other terminal 46 of the common resistance 44. A volume control timing circuit 47 is included between the common resistance 44 and the input or grid circuit of each of the controlled amplifiers 3 in the branches A, B and C and other amplifiers (not illustrated) including the common radio or intermediate frequency amplifiers, if any. In accordance with this invention a separate switching rectifier 49 is included in each branch between the terminal 45 of the branch volume control resistance 18 and terminal 46 of the common volume control resistance 44 whereby, as explained below, the volume control voltage across resistance 44 is obtained only from the branch having the highest incoming signal.

In operation, currents representing a received signal wave, each comprising a single side-band and a reduced carrier, are supplied to the input terminals 1 of the branches A, B and C, the cur-

rents supplied to the three branches each corresponding to a different path in the ether. While conceivably the received wave components may be equal in intensity, ordinarily in practice they differ considerably. Considering each branch unit 2, after amplification in amplifier 3, the side-band component passes through the side-band filter 4 to the input circuit of the second detector 7 and the carrier component, after passing through filter 5 is amplified by carrier amplifier 6 and supplied to the second detector 7 and to the branch volume control rectifier 15. Different portions of the second detector output energy are supplied to the input circuits of the diversity control amplifier 16 and voice frequency amplifier 17. Assuming the branch volume control voltages appearing across the resistances 18 in the three branches differ from each other, the magnitude of the current through the common volume control resistance 44 is determined solely by the highest branch volume control voltage, since the rectifiers 49 in effect cause the highest branch volume control voltage to oppose or block the other two branch volume control voltages. Stated differently, the rectifiers 49 function as automatic switching devices for impressing across the load impedance or resistance 44 only the greatest of the three independent direct current voltages appearing across the three branch volume control resistances 18. The control voltage across resistance 44 is then supplied through the time constant circuit 47 to the grid-cathode circuit of the controlled amplifiers in the three branches for controlling the amplification in these tubes, in the manner well known in the art. Thus, as the intensity of the highest incoming signal increases, the voltage across resistance 44 increases and the negative bias voltage supplied to all controlled tubes increases whereby the amplification in these tubes decreases. Similarly, the amplification in all controlled tubes in all branches is increased when the intensity of the greatest branch signal decreases.

Referring now to the branch selection circuit, the rectified output energies of tubes 19 in the three branches are each supplied to two relay windings, the branch A rectified energy being supplied to windings 28 and 34, the branch B rectified energy to windings 29 and 31 and the branch C rectified energy to windings 32 and 35. In a sense, relay 27 functions to compare the intensities of the branch A and B signal waves, relay 30 the intensities of the branch B and C waves and relay 33 the intensities of the branch A and C waves. Thus, assuming the incoming signals supplied to the input terminals of branches A and C have, respectively, the greatest and smallest intensities, the currents in windings 28 and 34 are stronger respectively than those in windings 29 and 35 and the current in winding 31 is stronger than that in winding 32, whereby the armatures 36 will assume the positions shown. It will be seen that under the assumed conditions, a negative potential from battery 38 is impressed on the grid or control electrode 11 of the selection amplifier 17 in branch B through the armature 36 and one contact 40 of relay 27 and the same negative potential is also impressed on the control electrode 11 of the selection amplifier 17 in branch C through the armature 36 and contacts 40 of relays 30 and 33, whereby these two selection amplifiers are rendered inoperative to convey voice frequency waves. Selection amplifier 17 of branch A remains operative, however, and the

energy supplied to the output terminals 26 is obtained entirely from branch A. Also, as previously explained, the amplification in all branches is controlled, under the conditions assumed, only by the carrier energy supplied to branch A. Similarly, if the signal energy incoming to branch B is the strongest, only the branch B signal energy is selected for utilization and it alone controls the amplification, and if the signal energy incoming to branch C is the strongest only the branch C signal energy is delivered to the translation device and the branch C carrier energy alone controls the amplification in the controlled amplifiers in all branches. Thus, the gain in all branches is the same whereby proper comparison and selection is obtained and at the same time, in accordance with the invention, the volume control voltage accurately controls, and maintains constant, the selected output energy.

The blending circuit 20 functions to minimize, at the moment of switching, the output 26 from one branch selection amplifier 17 to another, the undesired effects due to differences in intensity of the signals received by the selected branch and by the previously selected branch.

Although the invention has been explained in connection with a specific embodiment, it is not to be limited thereto, inasmuch as other apparatus may be satisfactorily employed in practicing the invention.

What is claimed is:

1. In combination, a plurality of amplifiers for receiving different sets of waves of variable intensity, a separate rectifier connected to the output of each amplifier, a plurality of continuously conductive and independently operative unilateral devices and a common volume control resistance, one set of corresponding output terminals of said rectifiers being connected to the same terminal of said resistance and the other set of corresponding terminals of said rectifiers being connected to the other terminal of said resistance each through a different device, and said resistance being entirely included in the input circuit of each amplifier.

2. In combination, a plurality of amplifiers having separate input circuits for receiving currents representing received wave components of different intensity, said amplifiers having a common output circuit, means for equally controlling the amplification in said amplifiers, said means comprising a volume control resistance energized only with the received current of greatest intensity and included entirely in the input circuit of each amplifier, and means for selectively supplying to said output circuit only current representing the received current of greatest intensity.

3. In combination, a plurality of diversity branches having separate input circuits and each

including an amplifier having an input circuit and an output circuit, the input circuits of said branches being energized with radio waves received over different ether paths, a plurality of volume control branch rectifiers each having an input circuit and an output circuit, the input circuit of a different branch rectifier being connected to the output circuit of each amplifier, a common volume control resistance included in the input circuit of each amplifier, and a plurality of auxiliary rectifiers a different one of which is included in series with the output circuit of each branch rectifier and said resistance.

4. A diversity radio receiving system comprising a plurality of branches each including at least one gain varying element having an input circuit and a volume control rectifier, and means for utilizing only the strongest rectified output to adjust said elements for equal gains, substantially, and to simultaneously prevent the other rectified outputs from controlling said gains, said means comprising a common volume control resistance connected in shunt to said rectifiers and included entirely in each of said input circuits.

5. A radio receiving system for receiving signal waves incoming over diverse ether paths comprising a plurality of diversity branch circuits each comprising at least one intermediate frequency amplifier having input and output circuits and a volume control rectifier having input and output circuits, the output circuit of each amplifier being connected to the input circuit of its associated control rectifier, plurality of switching rectifiers, a common volume control resistance included in the input circuit of said amplifiers, the output circuit of each volume control rectifier being connected through a different switching rectifier to said volume control resistance.

6. A diversity radio receiving system for receiving waves of varying intensity comprising a plurality of branch input circuits a plurality of amplifiers each having input and output circuits, a plurality of control rectifiers each having input and output circuits, a plurality of switching rectifiers, each branch input circuit being connected through a separate amplifier to the input circuit of a different control rectifier and the output circuits of said control rectifiers being connected through a separate switching rectifier to the same point in the input circuit of each amplifier, a utilization circuit, and means for connecting only the branch circuit having the strongest incoming signal to said output circuit whereby the gain in each of said amplifiers is controlled only in accordance with the variations in the strongest branch input signal and the output voltage is maintained constant.

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