May 28, 1963 W. R. SMITH-VANIZ 3,091,739

TRANSISTOR MULTICOUPLER WITH PLURAL OUTPUTS

Filed July 15, 1960 2 Sheets-Sheet 1

Fig. 1a.

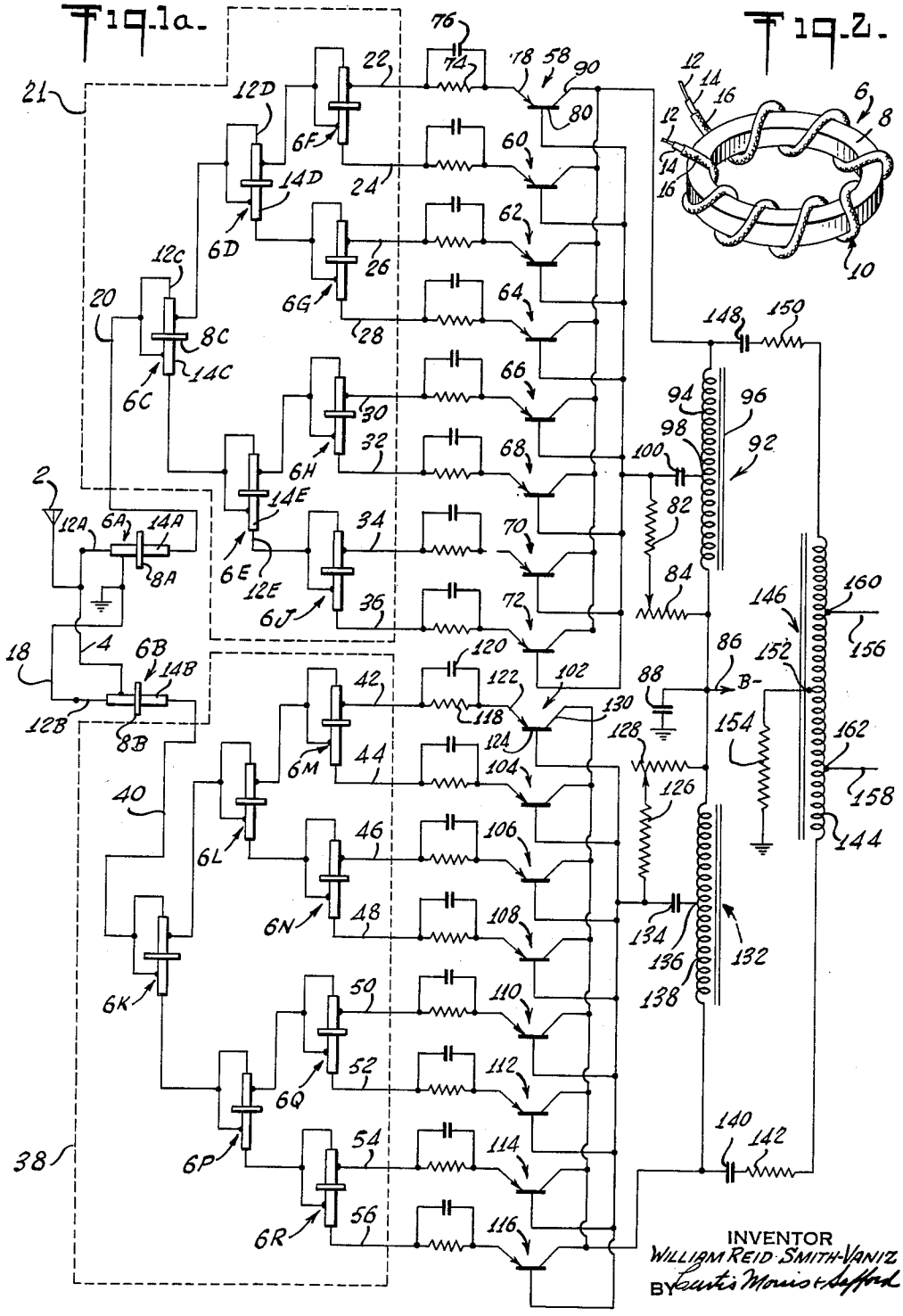


Fig. 2.

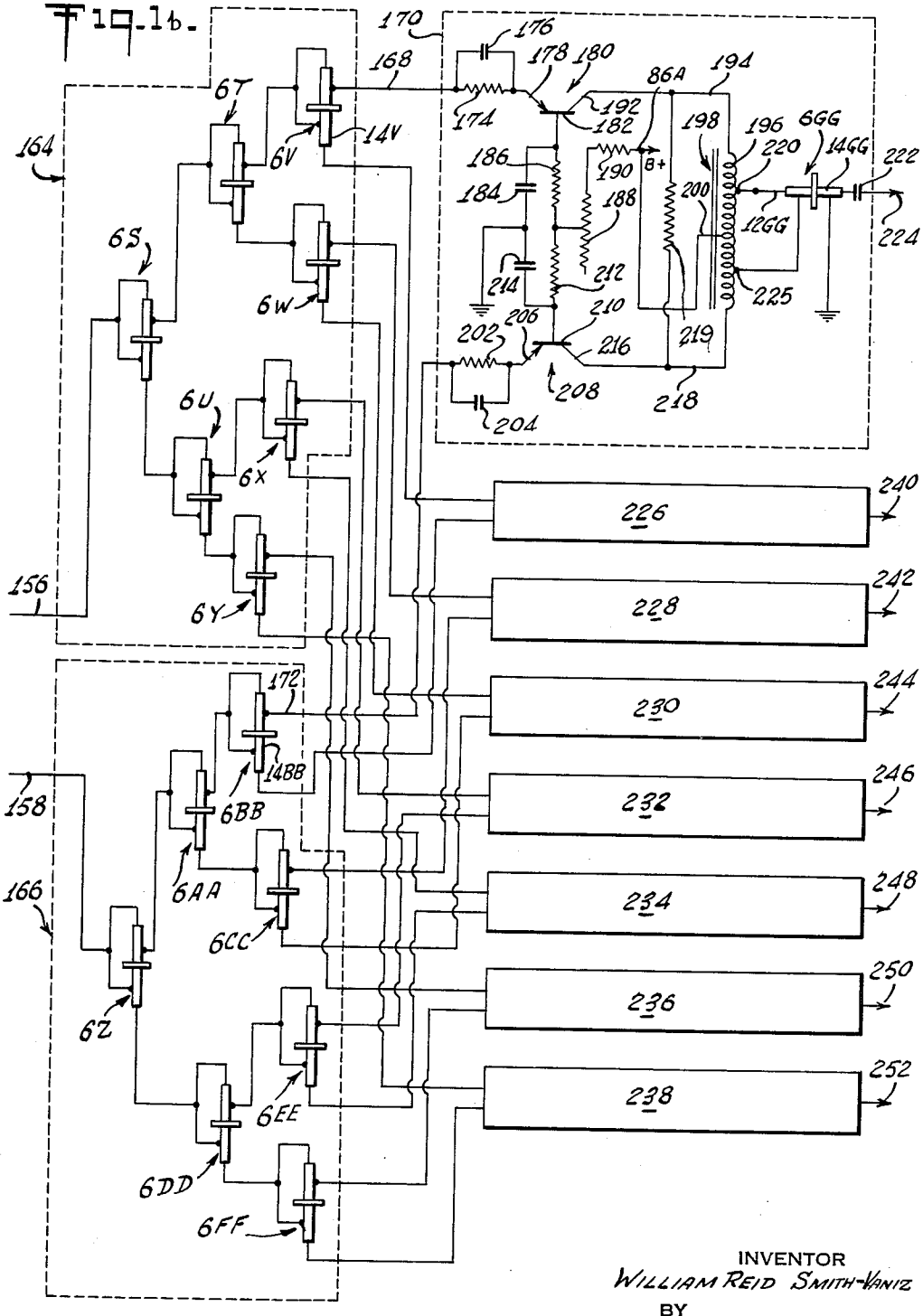
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Fig. 1b.



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TRANSISTOR MULTICOUPLER WITH PLURAL OUTPUTS

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This invention relates to wide band amplification systems and more particularly to active multicouplers for coupling a common signal source to a number of separate output circuits.

Such multicouplers are widely used for coupling a single antenna to several radio receivers. The performance requirements of such multicouplers are stringent: the amplifying system must be so linear that spurious signals are not generated within the system, the multicoupler must not introduce excessive noise, and the output circuits must be isolated from each other so that signals produced in one receiver are not coupled into others. In specific applications other parameters such as bandwidth, gain, and phase shift may be important.

The present invention is described as embodied in such a multicoupler capable of operation having the ability to handle relatively large input signals with minimum distortion, the introduction of minimum noise and good isolation of the output circuits. The device is capable of operating over wide frequency ranges, for example, from 2 to 30 megacycles.

It is an object of this invention to provide an improved wide band amplifier having a high degree of linearity.

It is another object to provide an electronic distribution system having improved operating characteristics.

These and other objects will become apparent from a consideration of the following description of a multicoupler embodying the invention considered in conjunction with the accompanying drawings in which

FIGURES 1*a* and 1*b* show a schematic drawing of the electrical circuits; and

FIGURE 2 is a perspective view of one of the transformers used in constructing the multicoupler.

In FIGURE 1, an antenna **2**, representing a source of radio frequency signals, is connected by a lead **4** to two transformers generally indicated at **6A** and **6B**. These transformers are identical with the transformer **6** shown in FIGURE 2. The transformer **6** consists of a ring core **8**, formed of ferrite or other suitable magnetic material, over which is wound a few turns, for example four to eight, of flexible coaxial cable, indicated generally at **10**. This cable includes an inner conductor **12** surrounded by and insulated from an outer tubular conductor **14** formed of braided metal or other suitable material. The outer conductor **14** is covered with a layer of insulating material **16**. Thirty-one of these transformers are used in the multicoupler of FIGURE 1 and are indicated symbolically as shown by **6A**. Each transformer is indicated by the figure **6** followed by an identifying suffix and all parts of the transformers are correspondingly numbered with suitable suffixes.

In FIGURE 1, the lead **4** is connected to the inner conductor **12A** of the transformer **6A** and to the outer conductor **14B** of the transformer **6B**. The adjacent end of the outer conductor **14A** is connected by a lead **18** to a common ground circuit and to the adjacent end of the inner conductor **12B** of the transformer **6B**. The opposite end of the inner conductor **12A** is connected by a lead **20** to one end of the outer conductor **14C** of the transformer **6C** and also to the opposite end of the inner conductor **12C**. The adjacent end of the outer conductor **14C** is connected to the outer conductor **14D** and inner

conductor **12D** of the transformer **6D**. In a like manner the inner and outer conductors **12D** and **14D** are connected from opposite ends to the transformers **6F** and **6G**.

The end of inner conductor **12C** of transformer **6C** not already connected is connected to transformer **6E** which in turn is connected to the transformers **6H** and **6J** in the same manner as described above.

Thus the transformers **6C**, **6D**, **6E**, **6F**, **6G**, **6H**, and **6J** form a current-dividing network. In each transformer one end of the outer conductor **14** is connected to the opposite end of the inner conductor **12**. Thus the outer conductor **14** and the inner conductor **12** may be considered as two series halves of the transformer winding so that connection between them serves as a center tap of the entire winding. In the case of transformers **6C**, **6D** and **6E**, the other ends of inner conductors **12** and outer conductors **14**, which may be considered the end terminals of the transformer winding, are each connected to drive another like transformer. With this dividing network shown within the broken line **21** the current in the lead **20** is divided equally among eight output leads **22**, **24**, **26**, **28**, **30**, **32**, **34** and **36**.

Seven more transformers **6K**, **6L**, **6M**, **6N**, **6P**, **6Q**, and **6R** are connected in a similar arrangement as shown within the broken line **38** so that current through the lead **40** from the inner conductor **12B** of the transformer **6B** is divided equally among eight output leads **42**, **44**, **46**, **48**, **50**, **52**, **54**, and **56**.

The transformers **6A** and **6B** are arranged to provide a transformation between the unbalanced input from the antenna **2** and the balanced output between leads **20** and **40**. Thus the current from the antenna is divided equally between the sixteen output leads mentioned above and this division of currents remains equal even though load impedance coupled to the output leads may differ significantly from each other. The first set of output leads **22**, **24**, **26**, **28**, **30**, **32**, **34**, and **36** deliver currents which are in-phase with each other, but 180 degrees out of phase from the currents in the output leads **42**, **44**, **46**, **48**, **50**, **52**, **54**, and **56**.

A first bank of transistors **58**, **60**, **62**, **64**, **66**, **68**, **70**, and **72** are connected to the output leads from dividing network **21**. Because these transistors are connected in identical manners and with their respective collectors and bases connected in parallel, a description of the connections to one of them will be sufficient.

The lead **22** is connected through a D.-C. isolating circuit consisting of a resistor **74** and a parallel capacitor **76** to the emitter electrode **78** of the transistor **58**. This D.-C. isolator circuit limits the direct current through the emitter of the transistor. The base lead **80** of the transistor is connected to the bases of the other transistors **60**, **62**, **64**, **66**, **68**, **70** and **72** and through a fixed resistor **82** and a variable resistor **84** to a power supply terminal **86**. This terminal is connected to the negative terminal of any suitable source (not shown) of direct voltage. The positive terminal of this source is connected to the common ground circuit. A capacitor **88** is connected between the terminal **86** and the common ground circuit.

The collector **90** of the transistor **58** is connected to the collectors of each of the other transistors **60**, **62**, **64**, **66**, **68**, **70** and **72**, and through a load impedance in the form of an auto-transformer **92** to the power supply terminal **86**.

The transformer **92** includes a winding **94** on a core **96** of ferrite or other suitable magnetic material. A tap **98** on the winding **94** is positioned, in this example, so that about one-seventh of the total turns of the winding **94** are between the tap **98** and the end of the winding which is connected to the power supply terminal **86**.

The voltage which appears at the tap 98 is applied as negative feedback through a capacitor 100 to each of the bases of the transistors 58, 60, 62, 64, 66, 68, 70 and 72.

The use of this negative feedback increases the input impedance of the transformers so that a better match with the antenna impedance is obtained. The feedback also stabilizes the input impedances against differences or changes in the transistor characteristics.

A second bank of transistors 102, 104, 106, 108, 110, 112, 114 and 116 are connected in like manner to the output leads of the dividing network 38.

The output lead 42 is connected through a D.-C. isolating circuit formed by a resistor 118 and a capacitor 120 to the emitter electrode 122 of the transistor 102. The base 124 of this transistor is connected to the bases of the other transistors 104, 106, 108, 110, 112, 114 and 116 and through a fixed resistor 126 and a variable resistor 128 to the negative power supply terminal 86.

The collector 130 of the transistor 102 is connected to the collectors of the transistors 104, 106, 108, 110, 112, 114, and 116 and through a load impedance in the form of an auto-transformer 132, identical with the transformer 92, to the power supply terminal 86. Negative feedback is provided by a capacitor 134 connected between a tap 136 on winding 138 of transformer 132 and the bases of transistors 102, 104, 106, 108, 110, 112, 114, and 116.

The collectors of transistors 102, 104, 106, 108, 110, 112, 114, and 116, which are connected to the transformer 132 are connected also through a series capacitor 140 and a resistor 142 to one end of a winding 144 of an output transformer 146.

The collectors of transistors 58, 60, 62, 64, 66, 68, 70 and 72, which are connected to the transformer 92, are conected also through a series capacitor 148 and a resistor 150 to the other end of the winding 144 of the transformer 146.

A center tap 152 on the winding is connected through a fixed resistor 154 to the common ground circuit.

The amplified signal appears between leads 156 and 158 connected respectively to symmetrical taps 160 and 162 on the winding 144. Because in this particular use, the signal is to be divided between eight radio receivers, the leads 156 and 158 are connected respectively to two current dividing networks indicated within the broken lines 164 and 166. These dividing networks are identical with the dividing networks shown at 21 and 38 and therefore are not described in detail. The network 164 is formed of transformer 6S driving transformers 6T and 6U which in turn drive transformers 6V, 6W, 6X, and 6Y. The network 166 is formed of transformer 6Z driving transformers 6AA and 6DD which in turn drive transformers 6BB, 6CC, 6EE, and 6FF.

A lead 168 from one end of the outer conductor 14V of transformer 6V is connected to an output isolation stage shown within the broken line 170.

Another lead 172 from one end of the outer conductor 14BB is also connected to the isolation stage 170.

The lead 168 is connected through a D.-C. isolator circuit, comprising a resistor 174 and parallel capacitor 176, to the emitter 178 of a transistor 180. The base 182 of this transistor is by-passed to the common ground circuit by a capacitor 184 and is connected also to the power supply terminal 86A through a fixed resistor 186, a variable resistor 188 and a fixed resistor 190.

The collector 192 of the transistor 180 is connected by a lead 194 to one end of a winding 196 of an output transformer 198. A center tap 200 on the transformer winding 196 is connected to power supply 86A which in turn is connected (lead not shown) to the terminal 86.

The lead 172 is connected through a D.-C. isolator circuit formed of a resistor 202 and a parallel capacitor 204 to the emitter 206 of a transistor 208 which is arranged to operate in push-pull with the transistor 180. The base 210 of the transistor 208 is connected through a fixed resistor 212 to the junction of resistors 186 and 188 and also is by-passed to the common ground circuit through a capacitor 214. The collector 216 of this transistor is connected by a lead 218 to the end of the winding 196. A resistor 219 is connected in parallel with the winding 196.

A transformer 6GG, identical with transformer 6 of FIGURE 2, is connected to the output transformer 198 to provide an unbalanced output circuit. A tap 220 is connected to one end of the inner conductor 12GG, the opposite end of which is connected through a capacitor 222 to an output lead 224. Another tap 225, symmetrically positioned on the winding 196 with respect to taps 200 and 220, is connected to one end of the outer conductor 14GG, the opposite end of which is connected to the common ground circuit.

The system is provided with seven additional isolator stages indicated by the boxes 226, 228, 230, 232, 234, 236, and 238, each of which is identical with the isolator stage 170. Each isolator stage is driven by a connection from one of the transformers 6V, 6W, 6X, and 6Y in dividing network 164 and a corresponding connection on a corresponding one of the transformers 6BB, 6CC, 6EE, and 6FF of the dividing network 166. The separate output signals are provided, in addition to lead 224, on leads 240, 242, 244, 246, 248, 250 and 252, each of which may be connected to the antenna terminal of a radio receiver or used in any other desired manner.

I claim:

1. In a multicoupler arrangement, a source of input signals, means for equally distributing said input signals to a first plurality and a second plurality of amplifier circuits, said distributing means including phase determining means for determining said input signals so directed to said first and said second plurality of amplifier circuits to be out-of-phase, first means for connecting the outputs of said first plurality of amplifier circuits in parallel, second means for connecting the outputs of said second plurality of amplifier circuits in parallel, a common return circuit, a first autotransformer connected between said first means and said common return circuit, said autotransformer having a tap thereon connected to said first amplifier circuits for providing negative feedback thereto, a second autotransformer connected between said second means and said common return circuit, said second autotransformer having a tap thereon connected to said second amplifier circuits for providing negative feedback thereto, and output means coupled to said first and said second means.

2. In a multicoupler arrangement as set forth in claim 1 wherein said first and said second plurality of amplifier circuits each includes a transistor device having an emitter connected through said distributing means to said source of input signals, said first connecting means including means for multiplying the collector electrodes of said first plurality of amplifier circuits, and said second connecting means including means for multiplying the collector electrodes of said second plurality of amplifier circuits.

3. In a multicoupler arrangement as set forth in claim 1 wherein said distributing means includes a first and a second plurality of transformers, each of said transformers having an effective winding with a center tap connection and two output connections, and means for connecting a center tap of a transformer of said first plurality to said phase determining means and for connecting each output connection thereof to the respective center taps of a pair of transformers of said first plurality and for connecting the four output connections of said pair of transformers to the respective center taps of four transformers of said first plurality thereby forming a first transformer pyramid arrangement and for connecting the eight output connections of said four transformers to said first plurality of amplifier circuits and for connecting a center tap of a transformer of said second plurality to said phase determining means and for connecting each output connection thereof to the respective center taps of

a pair of transformers of said second plurality and for connecting the four output connections of said pair of transformers to the respective center taps of four transformers of said second plurality thereby forming a second transformer pyramid arrangement and for connecting the eight output connections of said four transformers to said second plurality of amplifier circuits.

4. In a multicoupler arrangement as set forth in claim 3 said first and second plurality of amplifier circuits each including a transistor having an emitter electrode, and direct current isolation means for connecting the output terminals of said first and said second pyramid arrangements to said emitter electrodes of said first and said second plurality of amplifier circuits.

5. In a multicoupler arrangement, a source of input signals having a particular output impedance, a plurality of amplifier circuits, means for equally distributing said input signals to said plurality of amplifier circuits, circuit means for parallelly connecting the outputs of said plurality of amplifier circuits, an autotransformer connected to said circuit means and having a tap thereon, and feedback promoting means connected from said tap to said plurality of amplifier circuits for effecting a matching of said particular output impedance of said source with the input impedance of said multicoupler arrangement.

6. In a multicoupler arrangement, a source of input signals, a first and a second plurality of amplifier circuits, first means for equally distributing said input signals to said first and said second plurality of amplifier circuits, said distributing means including means for determining said input signals directed to said first and said second pluralities of amplifier circuits to be out-of-phase, first means for connecting said outputs of said first plurality of amplifier circuits in parallel, second means for connecting said outputs of said second plurality of amplifier circuits in parallel, means for directing the combined output signal of said first plurality of amplifier circuits to a first distributing network and the combined output signal of said second plurality of amplifier circuits to a second distributing network, said first and said second distributing networks each having a number of output terminals, a plurality of receiving means each including push-pull amplification means and a first and a second input terminal, and means for coupling a first input terminal of each of said plurality of receiving means to at least one of said output terminals of said first distributing network and for connecting a second input terminal of each of said plurality of receiving means to at least one of said output terminals of said second distributing network.

7. In a multicoupler arrangement as set forth in claim 6 wherein each of said first and said second distributing networks comprises a plurality of transformers having winding means defining an effective center tap connection serving as an input connection to said winding means and two output connections from said winding means, and means for connecting said plurality of transformers in a pyramid arrangement including means for connecting the two output connections of a transformer to the respective input connections of a pair of transformers and for connecting the four output connections of said pair to the respective input connections of four transformers.

8. In a multicoupler arrangement as set forth in claim 6 first direct current isolation means connecting said first input terminal to at least one of said output terminals of said first distributing network, and second direct current isolation means connecting said second input terminal to at least one of said output terminals of said second distributing network.

9. A multicoupler system for coupling a source of input signals to a plurality of separate output circuits comprising a source of electric power, means for equally distributing the input signals to a first plurality of amplifier circuits and out-of-phase therewith to a second plurality of amplifier circuits, said first plurality of amplifier circuits including a first plurality of transistors and said second plurality ot amplifier circuits including a second plurality of transistors, first means for connecting the base electrodes of said first plurality of transistors in parallel, resistance means in circuit between said power source and said first means, second means for connecting the collector electrods of said transistors in parallel, a first autotransformer in circuit between said second means and said power source and having a tap thereon, first feedback coupling means in circuit between said tap and said first means, third means for connecting the base electrodes of said second plurality of transistors in parallel, resistance means in circuit between said power source and said third means, fourth means for connecting the collector electrodes of said transistors in parallel, a second autotransformer in circuit between said fourth means and said power source and having a tap thereon, and second feedback coupling means in circuit between said tap and said third means.

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