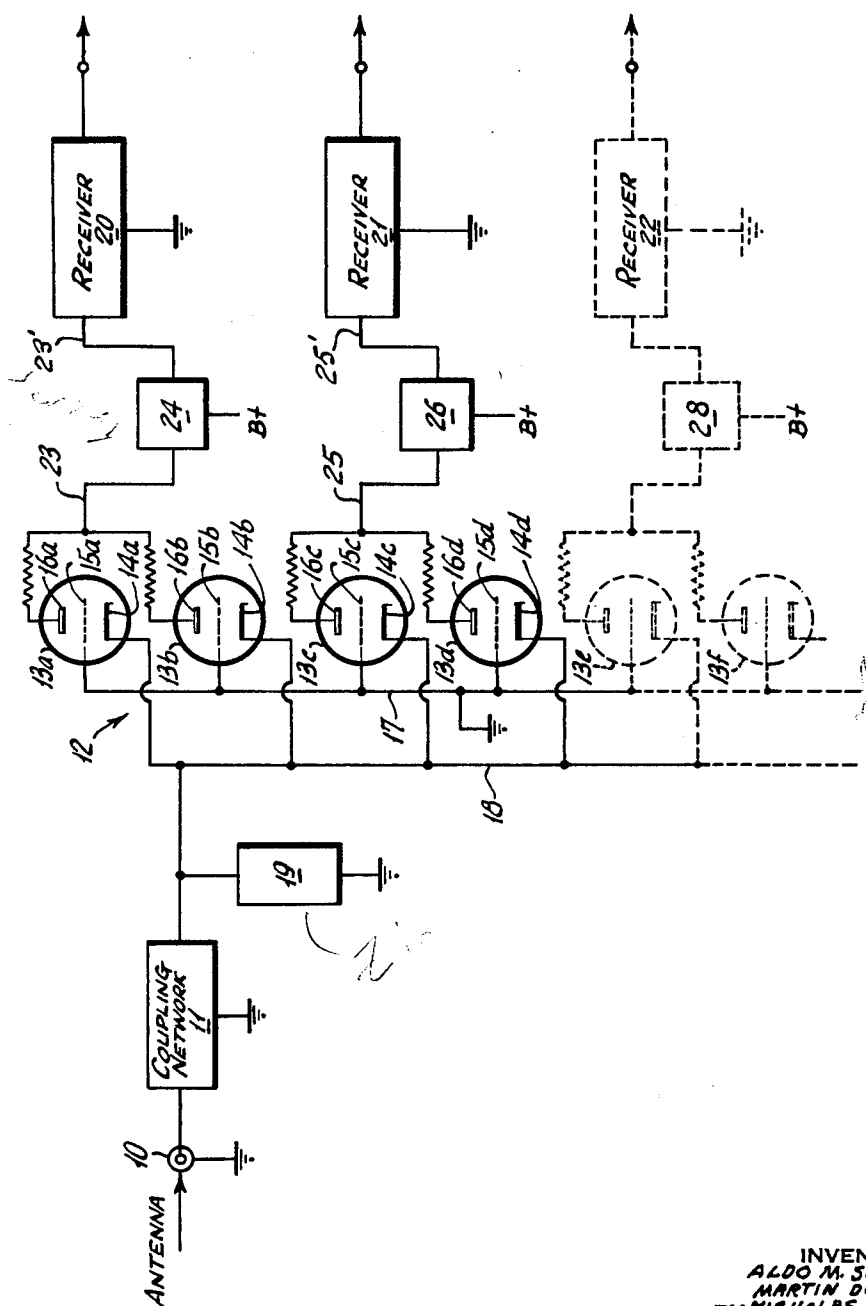


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MULTI-COUPLING APPARATUS

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This invention relates to multicoupling apparatus of the type generally utilized for coupling a plurality of radio or radar receiving devices to a common radio frequency source such as an antenna or the like and more specifically concerns improved couplers including amplifying means that will afford a high dynamic range of operation, linear response, and maintenance of cross modulation products at a very low level.

Multicoupling devices for connecting a plurality of receivers to a single antenna have been proposed, but such devices have not been found satisfactory for a number of reasons, including poor coupling efficiency, limited amplitude range of operation, distortion, interaction between receiving devices and relatively high cross modulation products. This invention overcomes problems heretofore encountered and provides improved coupling apparatus that is characterized by its stability, simplicity, capability of handling large signals, good isolating characteristics and phased transfer function. Furthermore, a relatively large number of receivers can be connected to a single RF source antenna with very little loss of minimum discernible signals in the presence of very large signals. By reason of the improved arrangement and coordination of the circuit elements, the invention may be utilized to couple as many as 16 and even more receivers to a common antenna and at the same time minimize requirements for tube selection to insure uniform operation.

The above and other objects of the invention will become more apparent from the following description and accompanying drawing which shows one embodiment of the invention.

The invention now to be described, while generally applicable to any radio frequency range, is particularly useful in the high, very high, and ultra-high frequency ranges; and because of its inherent characteristics, may be readily arranged for broad band operation to permit a plurality of receivers tuned to different frequencies to be connected to the common broad band antenna.

It has been found that improved coupling apparatus can be attained by the utilization of the grounded grid amplifier in which the input signal prior to application to the cathode is reduced by a substantial factor. It is to be understood in the following description that while conventional vacuum tubes are illustrated, the invention may be utilized with other types of amplifying devices such as transistors, and in each case, the terms "cathode," "grid" and "plate" are considered to be generally the equivalents of the "emitter," "base" and "collector" of a transistor.

Multicouplers, as previously mentioned, present numerous difficulties since operation must be effected over a very broad band. In actual practice, signal levels as great as 100 volts may be experienced at one frequency while at adjoining frequencies significant signals may have strengths only slightly greater than the noise level. Among the important considerations for a multicoupler are (1) capability of handling large RF signals of 100 volts or more, (2) attainment of good isolation, (3) maintenance of accurate phasing of all outputs, (4) preservation of a low noise level, (5) avoidance of cross product modulation particularly between very strong and very weak signals, (6) maintenance of low distortion and good linearity and

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(7) reduction of effects of nonuniform tubes and transistors on the uniformity of the output channels. Known circuits which endeavored to attain these objectives have relied on the procedures involving voltage amplification of signals to a substantial degree and in many cases the utilization of inductive elements causing considerable phase shifts.

With this invention, it has been found possible to attain the preceding and other objectives by the use of improved circuitry that insures stable and dependable operation at relatively low cost. More specifically, the invention involves the utilization of voltage reduction circuitry coupled with low impedance amplifying means which affords power gain and uniform phasing of all outputs. Moreover, the only frequency limitation of the apparatus is the internal capacities of the tubes or amplifying devices.

Referring now to the figure, the numeral 10 denotes a coaxial connector for attachment of a suitable broad band antenna or other RF source of any desired impedance. In the case of antennas of the character utilized in high frequency reception, the impedance is generally of the order of 50 to 300 ohms and voltages having a magnitude just discernable above the noise level to voltages as high as and even exceeding 100 volts are received. Under such conditions most effective results are attained by utilization of an amplifier having an exceedingly low impedance and matching the impedance of the antenna or other source to the amplifier input. The circuit configuration is arranged to effect a voltage reduction to the input of the amplifier by a factor of 10 or more depending on the nature of the incoming signals. With signals having peaks of the order of 100 volts or more reductions by factors of 15 to 20 and even higher are preferable. Voltage reduction and impedance matching is effected by the network 11 which may be in the form of an appropriate transformer of any configuration and may be tuned or untuned, or the network may consist of a filter network tuned to pass a predetermined band width and being arranged with its input matching the antenna and its output matching the amplifier. Since this network is common to all amplifiers, phase shifts do not present any problem; all channels will be affected in an identical manner.

The amplifier is generally denoted by the numeral 12 and includes a number of triode vacuum tubes 13a, b, c, d, e, f, etc., although only tubes 13a through d will be discussed. It will be evident, however, that additional tubes may of course be utilized for connecting a relatively large number of receivers to the single antenna or other source. The grids 15a, 15b, etc. are connected together and to ground through a common conductor 17 and the cathodes 14a, 14b, etc. are also connected together by way of conductor 18 and to ground through a conductive input impedance represented by the block 19. The input impedance may be a tuned or untuned circuit such as a parallel resonant network, resistor or the like, to provide a return for the cathode to ground. It is desirable that impedance 19 properly match the input impedance of the tubes which is effectively the input impedance of one tube divided by the number of tubes in parallel. For instance, if one tube has an input impedance of 50 ohms, then four tubes in parallel would have an input impedance of 12.5 ohms. If the impedance of the signal source is of the order of 125 ohms this will enable a voltage reduction of 10 to 1. It follows from the foregoing that substantial voltage reductions can be effected by adjusting the total number of tubes so that the magnitude of voltage can be attenuated to any desired value.

The output circuit of the amplifier 12 is divided into a plurality of individual circuits isolated one from the others to feed individual receivers 20, 21, 22, etc. More

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specifically, in the illustrated embodiment of the invention plates 16a and 16b are fed through separate series resistors to the network 24 via lead 23 and thence to the receiver 20 by the lead 23'. A plate voltage is applied to the plates through an impedance 24 that may be resistive or an impedance adjusted to pass the range of frequencies to be handled by the receiver 20. Similarly, the plates 16c and 16d are fed through series isolating resistors and to the receiver 21 via lead 25 network 26 and lead 25'. Plate voltage is supplied to the plates by means of the impedance network 26 similar to the network 26. The tubes 13e and 13f and network 28 and additional tubes would be connected similarly to the tubes 13a to d, and the associated receivers tuned to different frequencies. All of the receivers would, however, operate on bands within the broad range comprehended by the signal source. The output impedance of each pair of tubes may vary over wide ranges, though normally it would be in the range of 1000 to 2000 ohms.

It will be observed from the foregoing that through the initial voltage reduction the signal is maintained well within the linear dynamic range of the amplifier tubes and in so doing undesirable cross products are maintained at an exceedingly low level. In actual tests it has been found that undesirable cross products are maintained at least 20 to 30 db below the cross product level of known multicouplers. The low input impedance to the amplifiers effects improved isolation characteristics and at the same time power gains are obtained without increasing the noise level. Moreover, degeneration in the cathodes functions to minimize noise or unwanted signals occurring within the amplifiers themselves. As for networks 24, 26, 28, etc., they may have identical configurations such as π or π formations or may be in the form of transformers. It is of course preferable that these networks have output impedances not greater than and preferably less than the input impedances so that the resultant voltage gain of the system is maintained at a relatively low level.

The utilization of multiple amplifying devices, such as tubes or transistors, in parallel greatly minimizes the need for tube selection to maintain channel uniformity. This is particularly the case where as many as four devices are connected in parallel for driving a single receiver.

Another important aspect of the invention is that small signals having amplitudes close to the noise level encounter very small attenuation in the presence of large signals, such attenuations being of the order of only 3 db. Thus the invention effects its ends with the maximum preservation of information, great reduction in undesirable cross product, maintenance of low noise levels, improved isolation and uniform phasing of all channels.

While only one embodiment of the invention has been described, it is apparent that modifications, alterations and changes may be made without departing from the true scope and spirit as defined by the appended claims.

What is claimed is:

1. Apparatus for coupling a single energy source to at least two receivers comprising at least two low impedance input amplifiers each having at least one amplifying device with a cathode, a plate and at least one

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grid, connections between said source and the cathodes of said amplifying devices to effect a voltage reduction, and connections between each plate and one of said receivers.

2. Apparatus for coupling a single R.F. source to a plurality of receivers comprising a plurality of amplifying devices connected as grounded grid amplifiers, a common voltage reducing connection between each amplifier and said source and individual connections between each amplifier and one of said receivers.

3. Apparatus according to claim 2 wherein each of said amplifying devices comprises at least two devices each having a cathode, a grid, and a plate and wherein the plates are connected in parallel.

4. Apparatus for coupling a single R.F. source to a plurality of receivers comprising a plurality of amplifying devices each having a cathode, a plate and a grid, connections between each grid and ground, a cathode impedance having one side connected to ground and the other side connected to said cathodes, means including a voltage reducing coupling network for connecting said source to said cathodes, a plate impedance individual to each device and connected at one side to a source of plate voltage and at the other side to the plate of its associated device, and connections between each receiver and the plate of one of said devices.

5. Apparatus according to claim 4 wherein each receiver is tuned to operate within a predetermined frequency range which differs from the ranges of the other receivers, said source will receive signals in the frequency ranges of all of the receivers, said coupling network and cathode impedance have a frequency band width corresponding to the total frequency range of said receivers, and said plate impedances are each tuned to at least the frequency range of its associated receiver.

6. Apparatus according to claim 5 wherein said amplifying devices each include at least two triode vacuum tubes with each element of one tube connected to corresponding elements of the other tube.

7. Apparatus for coupling a plurality of receivers to a single antenna comprising a plurality of amplifiers each having a relatively low input impedance and a relatively high output impedance, means including a voltage reducing network connecting the inputs of the amplifiers to said antenna, and means for connecting the output of each amplifier to an individual receiver whereby said coupling apparatus affords substantial power gain, wide dynamic range of operation and low cross modulation products.

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