July 28, 1959 J. W. MARSHALL ET AL 2,897,499

UHF ANTENNA MULTICOUPLER SYSTEM OR THE LIKE

Filed Feb. 7, 1956 3 Sheets-Sheet 1

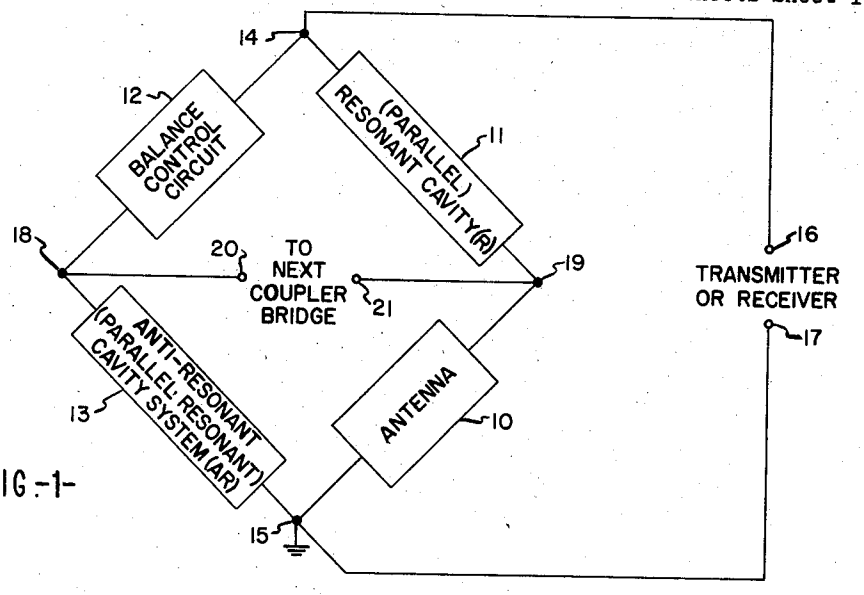


FIG.-1-

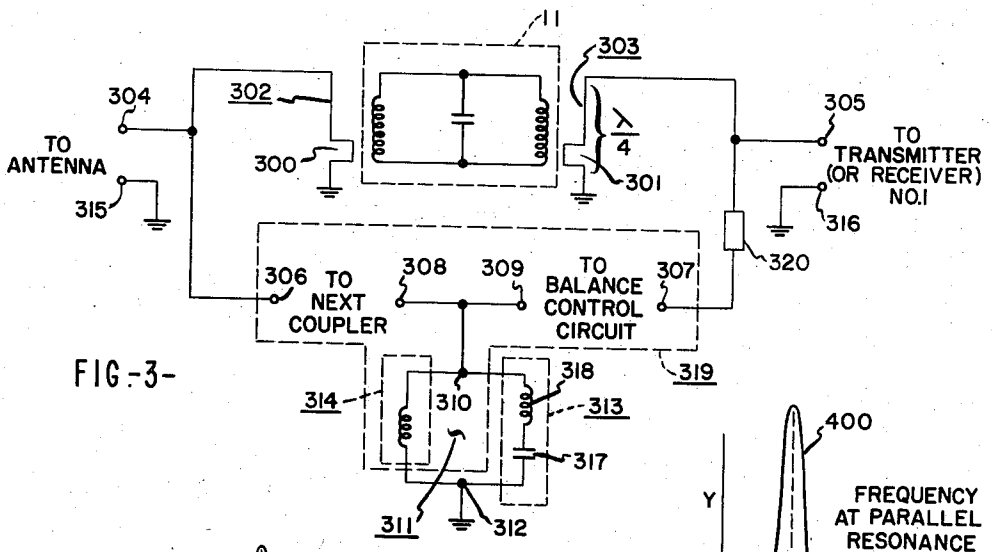


FIG.-3-

FIG.-4-

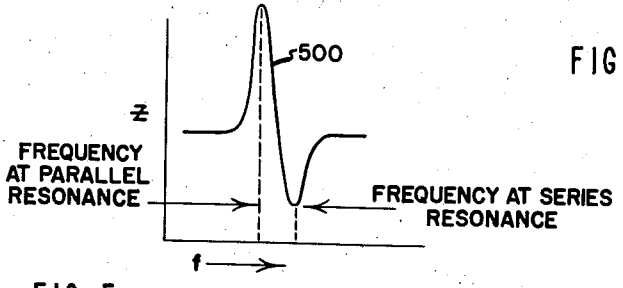


FIG.-5-

HAROLD W. COWAN
JAMES W. MARSHALL
INVENTORS

BY

THEIR ATTORNEY

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UHF ANTENNA MULTICOUPLER SYSTEM OR THE LIKE

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3 Sheets-Sheet 2

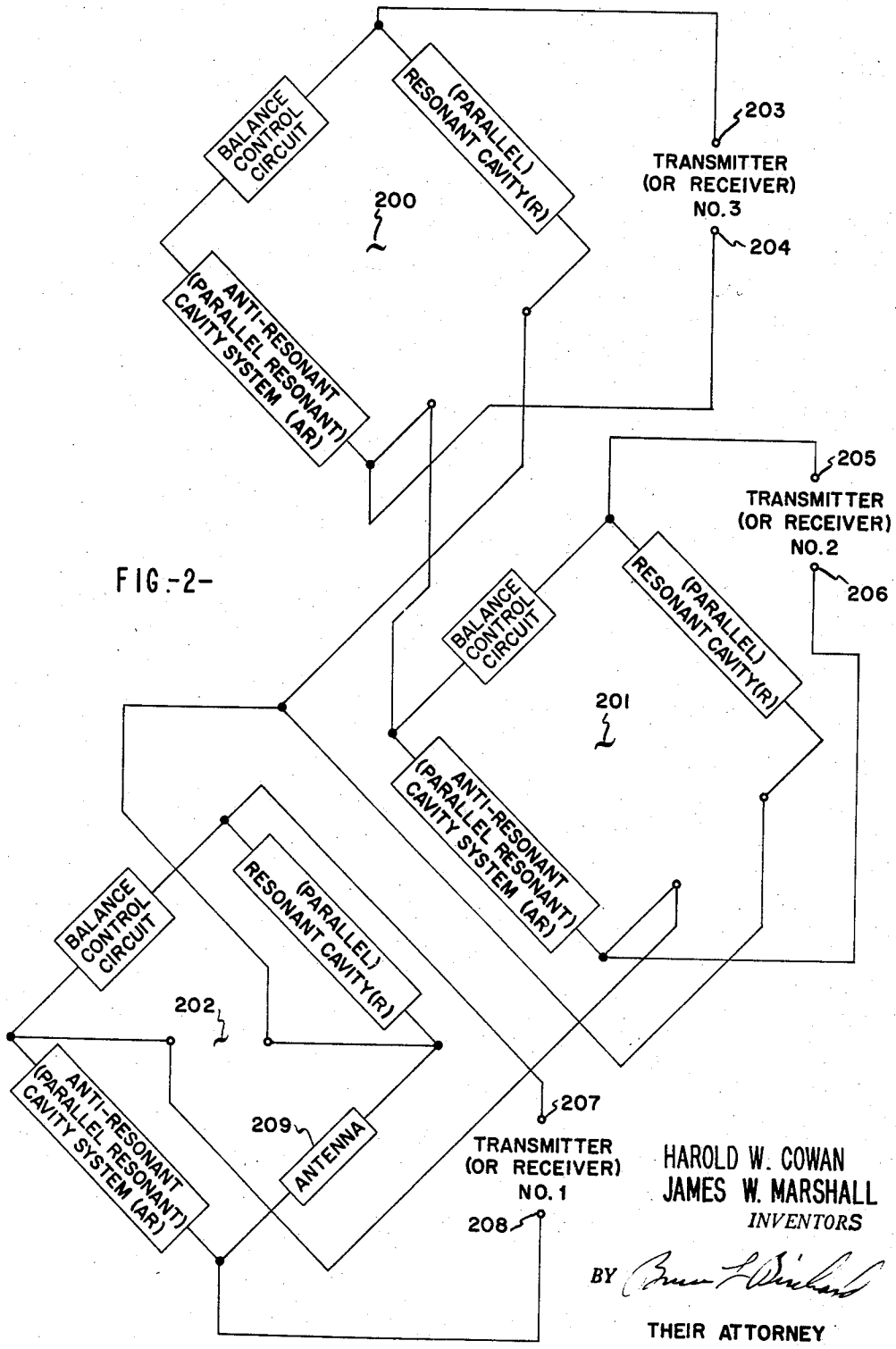


FIG.-2-

HAROLD W. COWAN
JAMES W. MARSHALL
INVENTORS

BY

THEIR ATTORNEY

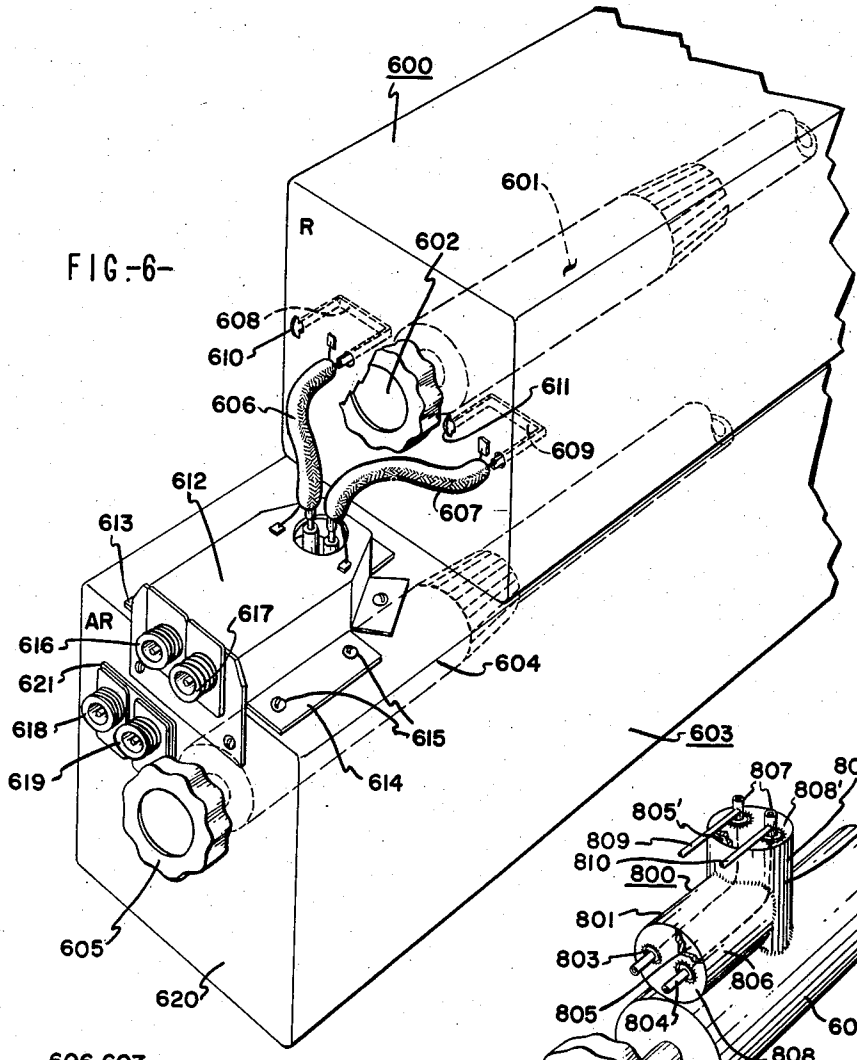
July 28, 1959 J. W. MARSHALL ET AL 2,897,499

UHF ANTENNA MULTICOUPLER SYSTEM OR THE LIKE

Filed Feb. 7, 1956

3 Sheets-Sheet 3

FIG.-6-



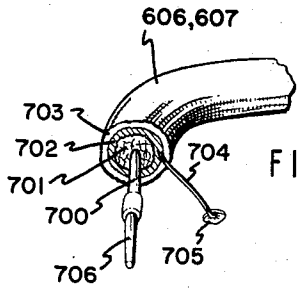


FIG.-7-

FIG.-8-

HAROLD W. COWAN
JAMES W. MARSHALL
INVENTORS

BY

THEIR ATTORNEY

United States Patent Office 2,897,499 Patented July 28, 1959

2,897,499

UHF ANTENNA MULTICOUPLER SYSTEM OR THE LIKE

James W. Marshall, Long Beach, and Harold W. Cowan, Gardena, Calif., assignors to Hoffman Electronics Corporation, a corporation of California

Application February 7, 1956, Serial No. 563,920

12 Claims. (Cl. 343—850)

This invention is related to UHF antenna multicoupler systems employable in multiplexing systems which provide for a single antenna a plurality of transmitter or receiver channels or paths, and more particularly to a new and improved UHF antenna multicoupler system which will insure adequate channel isolation of the order of 60 db for channel frequency spacings of 3 mc. in the frequency spectrum of 225–400 mc., for example, and yet exhibit a low channel insertion loss of the order of 1 db or less for each channel when in resonance. The above de-coupling figure (60 db) is deemed to be ample to prevent receiver signal distortion when a high powered transmitter is adjacent a high sensitivity receiver.

In the past, there have been devised many types of UHF antenna multicoupler systems. The most common type is the conventional filter multiplexing system in which tunable cavity filters are disposed in series or in parallel with respect to each other. Obviously, for economy of bandwidth the central frequency of the several cavity filters should be as close to one another as possible; yet, for such systems, it has been found that a filter spacing of 15 mc. or more may be required to achieve a de-coupling figure of the order of 30 db, which of course is not enough to prevent substantial receiver signal overload where a high power transmitter is operating on a channel adjacent to that to which a local high sensitivity receiver is tuned.

A second and more recent antenna multicoupler system employs the bridge principle with the antenna, a "resonant cavity," a balance circuit, and an "anti-resonant cavity" forming the four legs of the bridge, with the transmitter or receiver being coupled across first and second opposite junctions of the bridge and the next coupler coupled across the third and fourth opposite junctions of the bridge. The bridge is balanced by the appropriate adjustment or design of the balanced control circuit for the resonant and anti-resonant frequencies of each respective bridge. With the bridge in balance, substantially no energy is transmitted to the succeeding coupler since the third and fourth opposite junction points will be substantially at the same instaneous potential, owing to bridge balance.

This second, bridge-type system has proven to be a considerable improvement over the first type of multicoupler; however, present designs of the bridge-type multicoupler employ a "resonant cavity" which is excited to series resonance, either by end-feeding the stub or by floating the stub, i.e. by removing the base of the stub from its ground plane. Physical realization of the bridge employing a series-resonant "resonant cavity" leg has proven exceedingly difficult and involves the design of a double coaxial system in which it is impractical to couple mechanically temperature compensation devices to the tuning stubs of the "resonant" and "anti-resonant" cavities. Also, the necessary capacitive coupling of the series-resonant cavity necessarily results in an unsymmetrical cavity response curve generally resembling that of a crystal inasmuch as the series and parallel resonances

of the cavity occur at closely spaced frequencies. It would of course be highly desirable to improve the response curve of the resonant cavity so that it might be more symmetrical with respect to the Q at the cavity frequency. It would also be desirable to realize a satisfactory embodiment for the bridge, by which temperature compensating means may be applied directly to the tuning stubs of both the resonant and the anti-resonant cavities.

Therefore, it is an object of the present invention to provide a new and useful UHF antenna multicoupler system.

It is a further object of the present invention to provide a new and useful UHF antenna multicoupler system which will admit of the incorporation therewith of temperature compensating means or devices exteriorly associated therewith and thus not require the employment of zero-expansion metal combinations.

It is another object of the present invention to provide a new and useful resonant and anti-resonant cavity combination which will exhibit an optimum response curve for its associated frequency band.

It is a still further object of the present invention to provide a new and useful UHF antenna multicoupler system employing a plurality of intercoupled bridge networks each of which exhibits a low insertion loss at the coupler frequency of the order of 1 decibel or less and also which exhibits inter-channel isolation of the order of 60 decibels or more.

According to the present invention, the resonant cavity leg of each bridge network comprises a stub-tuned cavity operated at parallel resonance. The resonant and anti-resonant cavities are inter-associated in a physical embodiment thereof avoiding concentric, coaxial configurations, thus lending the combination to direct, tuning stub, mechanical coupling to temperature compensation devices exterior to the combination, if desired and as needed. Being excited in parallel resonance, the resonant cavity leg of the bridge exhibits a symmetrical response curve and relies upon the high impedance of the circuit including the anti-resonant cavity when in parallel resonance for supplying maximum energy or, in the case of a receiver, receiving maximum energy from the antenna leg of the bridge. At the frequency of the next channel (which is equal to the series resonant frequency of the anti-resonant cavity leg of the first bridge) a condition exists in the first bridge such that 60 decibels or more isolation will exist between the first bridge and the second bridge (which has been excited to resonance). Insertion losses of the several cavity bridges are, at the cavity frequency of parallel resonance, of the order of 1 decibel or less. Realization of the anti-resonant cavity leg configuration is achieved in a novel manner.

The features of the present invention which are believed to be novel are set forth with particularity in the appended claims. The present invention, both as to its organization and manner of operation, together with further objects and advantages thereof, may best be understood by reference to the following description, taken in connection with the accompanying drawings, in which:

Figure 1 is a block diagram of the fundamental bridge network employed by the present invention.

Figure 2 is a block diagram of a plurality of intercoupled bridge networks, similar in each network to the network of Figure 1.

Figure 3 represents an equivalent circuit of the network of Figure 1.

Figure 4 is a diagrammatic representation of the response curve of the (R) resonant cavity.

Figure 5 is a diagrammatic representation of the response curve of the (AR) anti-resonant cavity.

Figure 6 is a perspective view of the resonant cavity, anti-resonant cavity combination of the present invention.

Figure 7 and Figure 8 are detailed views of certain portions of the apparatus in Figure 6.

In Figure 1 is shown in block diagram the fundamental bridge network employed by the present invention. The four arms of the bridge include antenna **10**, resonant cavity (R) **11**, balance control circuit **12**, and anti-resonant cavity (AR) **13**. Junction points **14** and **15** are adapted for coupling to terminals **16** and **17**, themselves adapted for coupling to a transmitter or receiver, and junction point **15** is grounded. Junction points **18** and **19** of the bridge are coupled, respectively, to terminals **20** and **21**, which themselves are adapted for coupling to the next coupler bridge. A more detailed description of resonant cavity (R) **11** and anti-resonant cavity (AR) **13** shall be given hereinafter.

The operation of the circuit of Figure 1 is as follows. For a given central frequency the bridge may be balanced by the appropriate adjustment of balance control circuit **12**. When the bridge is in balance, the energy translated to the next or preceding coupler bridge (if a transmitter is coupled to terminals **16** and **17**) will be at a minimum, and there will be a maximum transfer of energy to antenna **10**. Suppose now that electrical energy is supplied across terminals **20** and **21** at a frequency at which the impedances of resonant cavity **11** and, in particular, anti-resonant cavity **13**, are materially reduced as for example if anti-resonant cavity **13** is series resonant at this new frequency. In such a case, substantially all of the electrical energy from this source will be coupled directly across antenna **10**, owing to the low resistance of cavity **13** when in a series resonant condition and the high resistance of the resonant cavity path. By virtue of the unique construction of the antenna coupler (hereinafter described in detail) the insertion loss of the bridge of Figure 1 with respect to a signal frequency 3 megacycles removed from the Figure 1 bridge frequency will be of the order of 1 decibel or less.

It is to be noted in Figure 1 that cavity **11** is termed "(parallel) resonant cavity **11**," or the (R) cavity, and that cavity **13** is termed the "anti-resonant (parallel resonant) cavity system **13**," or (AR) cavity **13**. The (R) and (AR) designation of the resonant cavity and the anti-resonant cavity system are conventional in the art. It should be noted and shall be hereinafter explained that while resonant cavity **11**, if in resonance, operates only in parallel resonance, yet the anti-resonant cavity system **13** will operate either in parallel resonance at the bridge frequency in conjunction with a choke shunting the cavity or will operate in series resonance at that frequency of the adjacent channel. It shall be demonstrated hereinafter that, by virtue of the above operation of the anti-resonant cavity, the operation of the antenna multicoupler system is made possible.

In Figure 2, several bridge networks are coupled in tandem as shown, i.e. bridge networks **200**, **201**, and **202**. Associated with the several bridge networks are terminals adapted for coupling to a respective transmitter or receiver, terminal **203** and **204**, terminals **205** and **206**, and terminals **207** and **208**. It is to be noted that each of the three bridge networks shown is identical except for the non-inclusion of antenna **209** in the fourth legs of bridge networks **200** and **201** directly, but in actual fact it is indirectly included therein. By referring to the discussion relating to Figure 1, the operation of the tandem bridge networks of Figure 2 becomes apparent; also the fact that additional bridge networks may be added, as the multi-channel system requires. Consider a signal at frequency f_1 being applied across terminals **207** and **208**, a signal at frequency f_2 applied across terminals **205** and **206**, and a signal at frequency f_3 applied across terminals **203** and **204**. Consider also that the resonant and anti-resonant cavities are both parallel resonant at

that signal frequency directly supplied each respective bridge. Consider also that the anti-resonant cavity is series resonant at the frequency of the adjacent bridge. In such a case, signal frequency f_1 will be translated to antenna **209** with perhaps a half decibel loss. Signal frequency f_2 will be translated to antenna **209** with two times the half decibel loss or about a loss of 1 decibel, owing to the fact that two bridge networks will add their insertion losses. An additional half decibel loss may be encountered by signal frequency f_3 owing to an additional bridge network being involved in the translation circuit to the antenna. It is to be noted, however, that since each anti-resonant cavity is series resonant for the preceding frequency that optimum transfer of energy to the antenna is assured, owing to maximum bridge unbalance for the preceding frequency, and also low insertion loss will be preserved.

In Figure 3 is shown an electrical equivalent circuit of the block diagram of Figure 1, excepting however the conjugate matching, balance control circuit **12**, which will comprise of course a conventional RLC balance circuit. The (R) cavity **11** is shown to comprise a simple, double inductance, parallel resonant circuit to which are coupled ground adjacent, low impedance coupling, inductive probe portions **300** and **301** of quarter wave length lines **302** and **303**, respectively. Quarter wave length lines **302** and **303** are coupled, respectively, to antenna terminal **304** and to transmiter or receiver terminal **305**, respectively. Antenna terminal **304** is also coupled to next coupler terminal **306**. Transmitter or receiver terminal **305** is in addition coupled, preferably through time delay line **320**, to balance control circuit terminal **307**. The inclusion of delay line **320** will compensate for the time delay experienced between the terminals **304** and **305** by virtue of the shift in time across the center-grounded combination of quarter wave resonant lines **302** and **303**. The remaining next coupler terminal **308** and the remaining balance control circuit terminal **309** are each coupled to terminal **310** of resonant circuit **311**. The remaining terminal **312** of resonant circuit **311** is connected to ground. Resonant circuit **311** includes (AR) cavity **313** which is or may be excited to series resonance and choke **314**, coupled across (AR) cavity **313**.

The operation of the circuit of Figure 3 is best considered after a discussion of the graphs of Figures 4 and 5. Figure 4 illustrates by curve **400** the admittance $(1/Z)-$, frequency response curve of the combination of circuit **11** and quarter wave lines **302** and **303** in Figure 3. Cavity Q's well above 1000 may of course be easily attained. Thus, at or near the frequency of parallel resonance of circuit **11** there will be a maximum translation of energy between antenna terminals **304** and **315** and transmitter or receiver terminals **305** and **316**. Quarter wave lines **302** and **303** are of course designed to be resonated at the parallel resonant frequency of circuit **11**. At the parallel resonant frequency of circuit **11** it will of course be desirable to have as high an impedance as possible between terminals **310** and **312** of circuit **311** so as to preclude tendencies of resonant lines **302** and **303** from being loaded down excessively, which would lower the input impedances to the antenna terminals and to the transmitter or receiver terminals, thus shorting out the signal energy. Hence, circuit **311** will be designed for parallel resonance at that frequency at which circuit **11** is parallel resonant. Hence, at that frequency, the reactance of capacitance **317** must have an absolute value which exceeds the absolute value of the reactance of choke **314** by an amount equal to the absolute value of the reactance of inductance **318**. Hence, inductance **318** will be resonated out of circuit **311** at the parallel resonant frequency of circuit **11**. Now for an increased value in operating frequency there will be a point at which the absolute values of the reactances of capacitance **317** and inductance **318** will be equal; hence, leg **319** of

circuit 311 will exhibit series resonance and will shunt out choke 314. It of course would be highly desirable to design leg 319 for series resonance at that frequency at which the adjacent channel bridge (see Figure 2 for example) exhibits parallel resonance. In such a case, for that frequency of the adjacent cavity bridge at which that bridge becomes parallel resonant, not only may one rely upon a high Q of cavity circuit 11 in Figure 3 but also circuit 311 will be series resonant at that frequency, thus shorting out in effect any tendencies of circuit 311 to resonate at this new frequency and also reducing the input impedance to the antenna terminals and to the transmitter or receiver terminals. These combined effects operate to give extremely high channel isolation figures, of the order of 60 decibels, while not appreciably affecting over-all attenuation of the several transmission paths of each frequency source or receiver to the antenna. A typical response curve for the choke 314, leg 313 circuit is illustrated in Figure 5 by curve 500.

Figure 6, Figure 7, and Figure 8 illustrate the manner in which physical realization of the circuit of Figure 3 may be obtained. In Figure 6, (R) cavity 600 includes variable tuning stub 601 and tuning knob 602. (AR) cavity 603 includes tuning stub 604 and tuning knob 605. Of course, rather than employing manual tuning knobs, the two cavities might just as easily have had their tuning stubs coupled through temperature compensating devices to mechanical tuning apparatus. Resonant lines 606 and 607 correspond to resonant lines 302 and 303, respectively, in Figure 3. Inductive probes 608 and 609 correspond to inductive probes 300 and 301, respectively, in Figure 3. It is to be noted that inductive probes 608 and 609 are grounded to the base of cavity 600 at points 610 and 611, respectively. The reason that grounding point 611 is located near to tuning stub 601 and yet ground 610 is located relatively far away from tuning stub 601 is (referring again to Figure 3) to compensate for the 90° phase lag arising from transformer coupling in each leg in Figure 2. In Figure 6 again, were the inductive probes to be mere opposites with respect to tuning stub 601, the phase lag produced by the effective transformer coupling would be 180°, rather than 0° as is contemplated by the present configuration. Brief mention is now made of Figure 7 which shows that resonant lines 606 and 607 include line portion 700, insulating portions 701, shielding portions 702, and insulating portion 703. While this configuration for the resonant lines is deemed to be desirable, yet the outer insulating portion may be deleted, if desired. Shielding 702 is of course grounded to cavity 603 by means of element 704 having end portion 705. Conductor portion 700 may be provided with pin insert connector 706.

Referring again to Figures 6 and 7, it is shown that several elements 704 with adjoining elements 705 are provided to connect electrically coaxial shield 702 of Figure 7 not only to (R) cavity 600 but also to T-junction member 612, which itself is affixed to cavity 603 by means of flanges 613 and 614 and screw elements 615. Antenna and transmitter (or receiver) coaxial receptacles 616 and 617, respectively, may be affixed to T-junction member 612 in a conventional manner. The "next coupler" and "balance control circuit" coaxial receptacles 618 and 619, respectively, may be mounted to bottom portion 620 of cavity 603 through insulating member 621 which insulates the receptacles from each other and from bottom portion 620. That such insulation is required is clearly shown in Figure 3 in which, at the parallel resonant frequency of circuit 311, terminal 310 will be isolated from ground by a high impedance.

The intercoupling of the several coaxial receptacles with resonant lines 606 and 607 is illustrated in Figure 8. In Figure 8 is shown again tuning knob 605 and adjustable or alignable tuning stub 604. Affixed to tuning stub 604 is T-junction device 800 having horizontal and vertical portions 801 and 802, respectively. Preferably, each portion 801 and 802 of T-junction device 800 is coaxial having connecting lines 803 and 804 which are adapted for direct connection to coaxial receptacles 618 and 619 in Figure 6, these coaxial lines being housed within an insulating body portion 805 and an exterior metal shell 806. Pin receptacles 807 are each adapted to accommodate the insertion of pins 706 associated with resonant lines 606 and 607. Pin receptacles 807 are also connected electrically to the center conductors of coaxial receptacles 616 and 617, by means of leads 809 and 810, respectively. The elements 805' and 806' of portion 802 are for all intent and purposes the same as or similar to the corresponding elements of portion 801. Of particular importance is the fact that the outer coaxial shields of coaxial lines 803 and 804 may be connected directly to outer shells 806 and 806' by means of solder or other metallic means. See for example end portions 808 and 808'. The central leads of the coaxial lines are of course insulated from their respective coaxial shields. It should now be possible to visualize the physical disposition and electrical intercoupling of T-junction device 800 within T-junction member 612 in Figure 6.

The operation of the coupler shown in Figure 6, Figure 7, and Figure 8, is as follows. Refer also to Figure 3. The tuning stubs 601 and 604 may be adjusted in a conventional manner for cavity resonance at a desired frequency, namely, the bridge frequency at which both cavities are to be in effect in parallel resonance. Thus, for an appropriate adjustment of (R) cavity tuning stub 601, a transmitter, for example, coupled through coaxial receptacle 616 will excite (R) cavity 600 to resonance, that is, to parallel resonance. The signal may be coupled from cavity 600 by means of inductive probe 609 which is a portion of quarter-wave length resonant line 607, which in turn is coupled to antenna coaxial receptacle 616. At this particular frequency, it will of course be desirous to have the (AR) cavity system operate in parallel resonance, although in fact the cavity is excited, or is to be excited, in series resonance. At this point the T-junction device 800 of Figure 8 comes into play, for the outer metallic shells 806 and 806' together with end portions 808 and 808' operate as a single, ultra high frequency choke. That is, by reason of the skin-effect conduction of the outer shell surfaces and their leading back to the ground plane of cavity 603, a choke or inductance is inserted in parallel with the series resonant cavity, or otherwise series resonant cavity, as is shown in Figure 3. The inductance of this choke and the design of the (AR) cavity itself is such as to operate as the parallel resonant circuit of Figure 3 (circuit 311) when excited by a signal frequency associated with its particular bridge network. However, for a particular higher frequency, namely the series resonant frequency of cavity 603 (which frequency is identical to the natural cavity bridge frequency of the next adjacent bridge) the choke inductance exhibited by the T-junction device will in effect be shorted out by the series resonant cavity at this new frequency so that, as has been heretofore explained, the first bridge network will impose only negligible attenuation upon the signal frequency from the adjacent bridge network whereas bridge network isolation as far as resonant tendencies are concerned will be very high.

Particularly with reference to Figure 6, it is seen that the physical embodiment of the circuits of Figure 1 and Figure 3 is relatively simple, and adaptable to temperature compensating devices extant, an important contrast to the prior art.

While particular embodiments of the present invention have been shown and described, it will be obvious to those skilled in the art that changes and modifications may be made without departing from this invention in its broader aspects, and, therefore, the aim in the appended claims is to cover all such changes and modifications as fall within the true spirit and scope of this invention.

We claim:

1. In combination, a first cavity having an adjustable tuning stub, a second cavity having an adjustable tuning stub and disposed in proximity with respect to said first cavity, first means for coupling energy to said first cavity, second means for coupling energy from said cavity, first, second, third, and fourth coaxial receptacles fixedly disposed with respect to said second cavity, said third and fourth coaxial receptacles being insulated from said second cavity, said coaxial receptacles each having a central connector, said central connector of said first coaxial receptacle coupled to said first means, said central connector of said second coaxial receptacle coupled to said second means, and choke means intercoupling said third and fourth coaxial receptacles with said first and second means respectively, said choke means being fixedly disposed with respect to said tuning stub of said second cavity.

2. Apparatus according to claim 1 in which said first means comprises a quarter wave resonant line having an inductive probe portion in proximity with said tuning stub of said first cavity, and in which said second means comprises a quarter-wave resonant line having an inductive probe portion also disposed in proximity with said tuning stub of said first cavity.

3. Apparatus according to claim 1 in which said choke means includes: first and second coaxial coupling lines each having a central lead adapted for respective coupling to said central connectors of said third and fourth coaxial receptacles and to said first and second means and a coaxial shield adapted for ground coupling to said second cavity; and an outer shell electrically connected to said coaxial shields of said first and second coaxial coupling lines and adapted for grounded electrical contact with said second cavity.

4. Apparatus according to claim 1 in which said first means comprises a coaxial quarter wave resonant line having a central lead provided with an inductive probe portion and a coaxial shield, said coaxial shield being grounded to said first cavity, said first cavity having a first aperture adapted to admit said inductive probe portion for disposition within said cavity in proximity to said tuning stub, said inductive probe being grounded to said first cavity at a remote point with respect to said tuning stub; and in which said second means comprises an additional coaxial quarter wave length resonant line provided with an inductive probe portion and a coaxial shield, said coaxial shield being grounded to said first cavity, said first cavity having a second aperture adapted to admit said inductive probe portion of said additional resonant line for disposition within said cavity in proximity with said tuning stub, said inductive probe portion of said additional resonant line being grounded to said first cavity at a point near said tuning stub.

5. Apparatus according to claim 4 in which said choke means includes: first and second coaxial coupling lines each having a central lead adapted for respective coupling to said central connectors of said third and fourth coaxial receptacles and to said central leads of said coaxial quarter wave resonant lines and a coaxial shield adapted for ground coupling to said second cavity; and an outer shell electrically connected to said coaxial shields of said first and second coaxial coupling lines and adapted for grounded electrical contact with said second cavity.

6. A UHF antenna multicoupler bridge network including, in combination: a balance control circuit, a resonant cavity excitable in parallel resonance and having first and second coupling terminals; said balance control circuit being coupled to said first coupling teminal; an antenna coupled to said second coupling terminal; first and second exciter lines coupled between said first and second coupling terminals, respectively, and the internal wall of said resonant cavity, each of said exciter lines having a probe portion supported internally of said cavity, and each of said lines having an electrical length of substantially one-quarter of the resonant wavelength of said resonant cavity; an antiresonant cavity system coupled to said antenna and forming a first junction therewith; said balance control circuit being coupled to said anti-resonant cavity to form a second junction therewith, said anti-resonant cavity system also being excitable in parallel resonance; third and fourth terminals coupled to said first coupling terminal and said first junction, respectively, and adapted for coupling to an electronic component; and fifth and sixth terminals coupled to said second coupling terminal and said second junction, respectively, and adapted for coupling to associated multicoupler apparatus.

7. Apparatus according to claim 6 in which a delay line is interposed between said balance control circuit and said first junction.

8. A UHF antenna multicoupler bridge network including, in combination: a balance control circuit; a resonant cavity excitable in parallel resonance at a first frequency and having first and second coupling terminals; said balance control circuit being coupled to said first coupling terminal; an antenna coupled to said second coupling terminal; first and second exciter lines coupled between said first and second coupling terminals, respectively, and the internal wall of said resonant cavity, each of said exciter lines having a probe portion supported internally of said cavity, and each of said lines having an electrical length of substantially one-quarter of the wavelength corresponding to said first frequency; an anti-resonant cavity system coupled to said antenna and forming a first junction therewith; said balance control circuit being coupled to said anti-resonant cavity system to form a second junction therewith, said anti-resonant cavity system being excitable in parallel resonance at said first frequency and in series resonance at a second frequency; third and fourth terminals coupled to said first coupling terminal and said first junction, respectively, and adapted for coupling to an electronic device; and fifth and sixth terminals coupled to said second coupling terminal and said second junction, respectively, for coupling to associated multicoupler apparatus.

9. Apparatus according to claim 8 in which a delay line is interposed between said balance control circuit and said first junction.

10. A plurality of intercoupled bridge networks including, in combination: a first balance control circuit; a first resonant cavity excitable in parallel resonance and coupled to said balance control circuit to form a first junction therewith; an antenna coupled to said first resonant cavity and forming a second junction therewith; a first anti-resonant cavity system coupled to said antenna and forming a third junction therewith; said first balance control circuit being coupled to said first anti-resonant cavity to form a fourth junction therewith, said first anti-resonant cavity system being excitable in parallel resonance; first and second terminals coupled to said first and third junctions and adapted for coupling to an electronic component; third and fourth terminals coupled to said second and fourth junctions; at least one additional bridge network, including: at least one additional anti-resonant cavity; at least one additional balance control circuit coupled to its associated additional anti-resonant cavity system to form a fifth junction therewith; at least one additional resonant cavity coupled to its associated additional balance control circuit to form a sixth junction therewith and adapted for excitation in parallel resonance; each such additional resonant cavity and said first resonant cavity being coupled to each other and to said second junction; said fourth terminal being coupled to said additional anti-resonant caivty system of the next preceding bridge network in said plurality; and said fifth junction and corresponding junctions of any other of said additional bridge networks being coupled to the anti-resonant cavity system of its next preceding bridge network, if any.

11. Apparatus according to claim 10 in which said resonant cavities are provided with input and output quarter-wavelength resonant exciter lines having probe portions.

12. Apparatus according to claim 10 in which each of said resonant cavities and each of said anti-resonant cavities exhibits parallel resonance at a predetermined common frequency.

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