

[54] **MULTI-FUNCTION ANTENNA COUPLER**

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[58] Field of Search. **343/175, 180; 325/15, 21, 22; 333/6, 8, 12**

[56] **References Cited**

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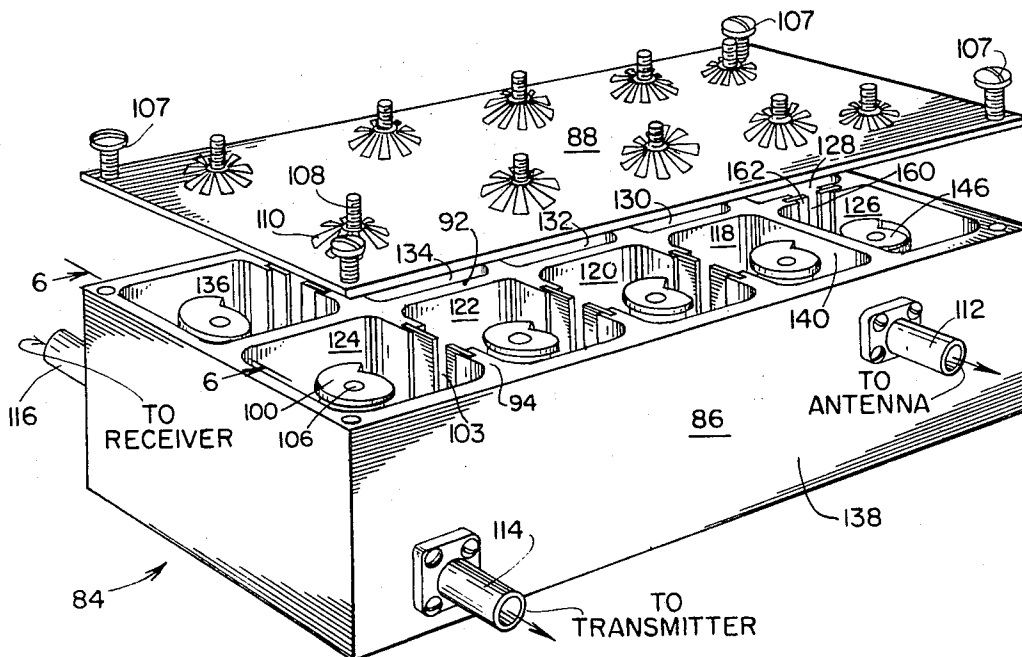
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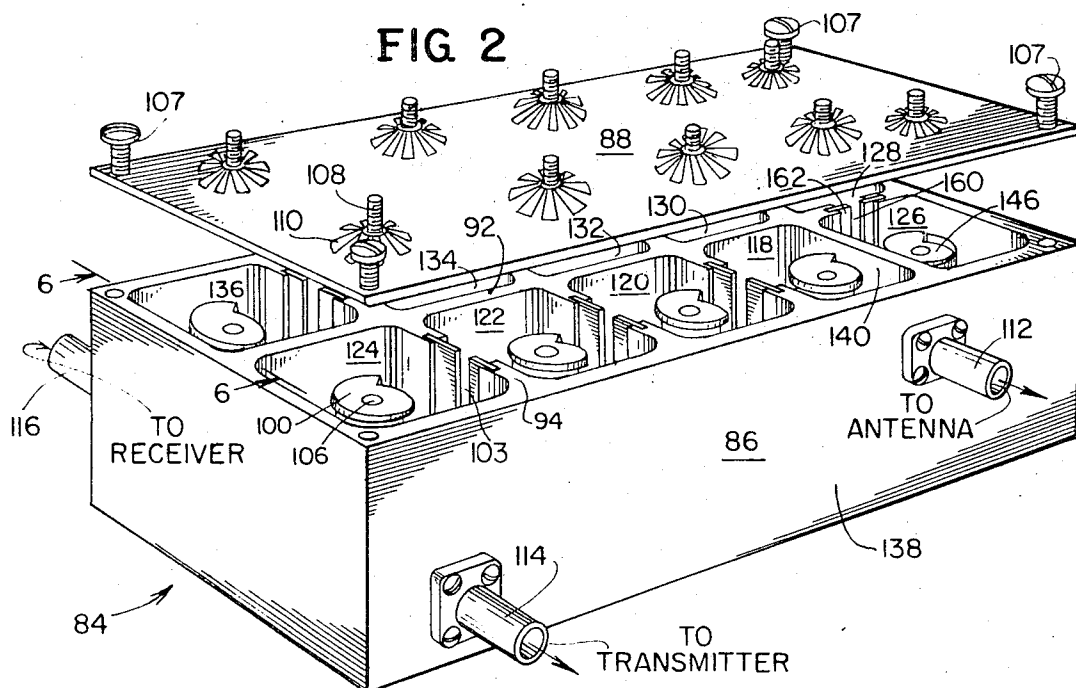
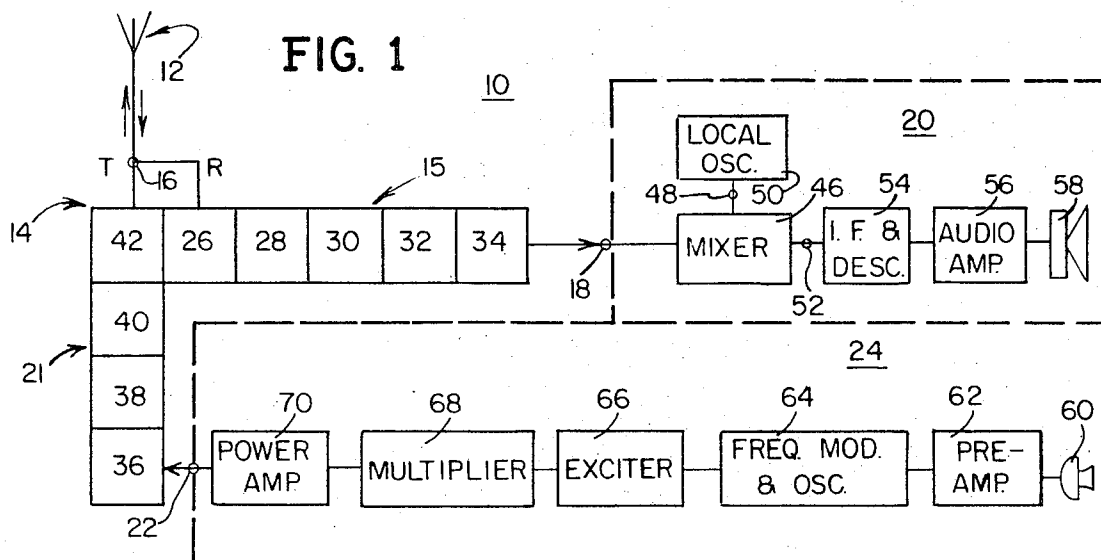
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[57] **ABSTRACT**

The antenna coupling circuit facilitates simultaneous reception and transmission of information carrying radio signals through a common antenna. A single filter having a plurality of helical resonator sections forms the harmonic filter of the transmitter, the preselector of the receiver, and a duplexer for connecting both the transmitter and receiver to a single antenna. A first plurality of the helical resonator sections are connected between the antenna and the input stage of a receiver which passes the band of frequencies to be received while reflecting the frequencies to be transmitted. A second plurality of helical resonator sections are connected between the output of a transmitter and the antenna which passes the frequencies to be transmitted while reflecting the frequencies to be received. The coupling between individual helical resonators is arranged to discriminate against frequencies higher than the passband. All of the cells of the filter circuit are mechanically connected together to form an integral compact structure.

7 Claims, 6 Drawing Figures





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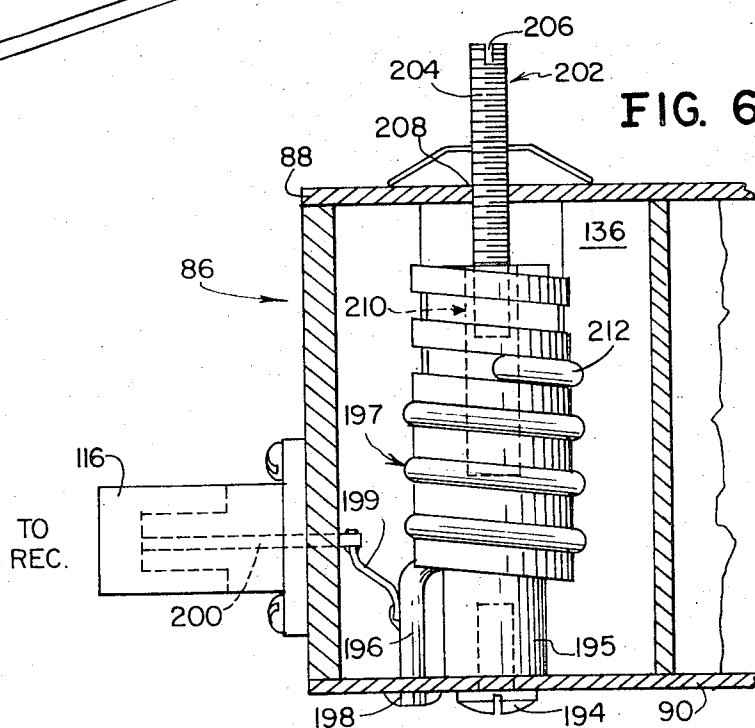
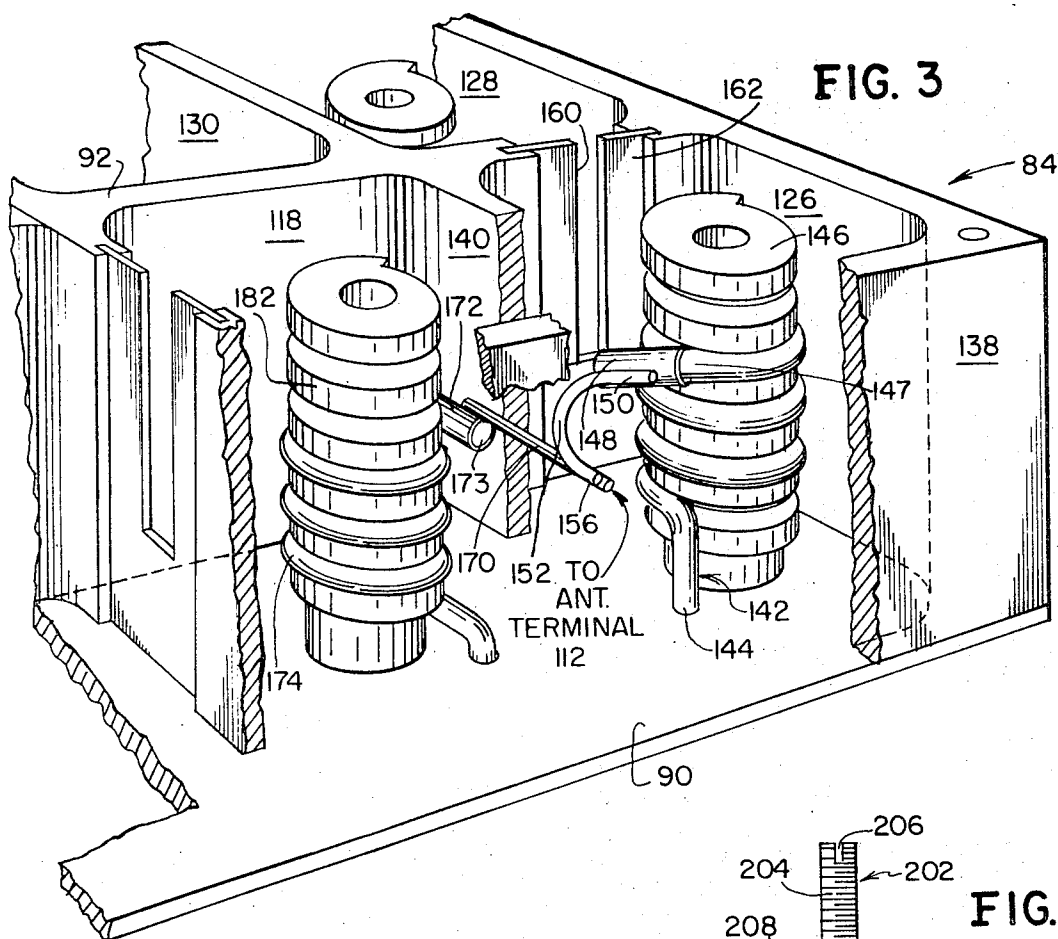
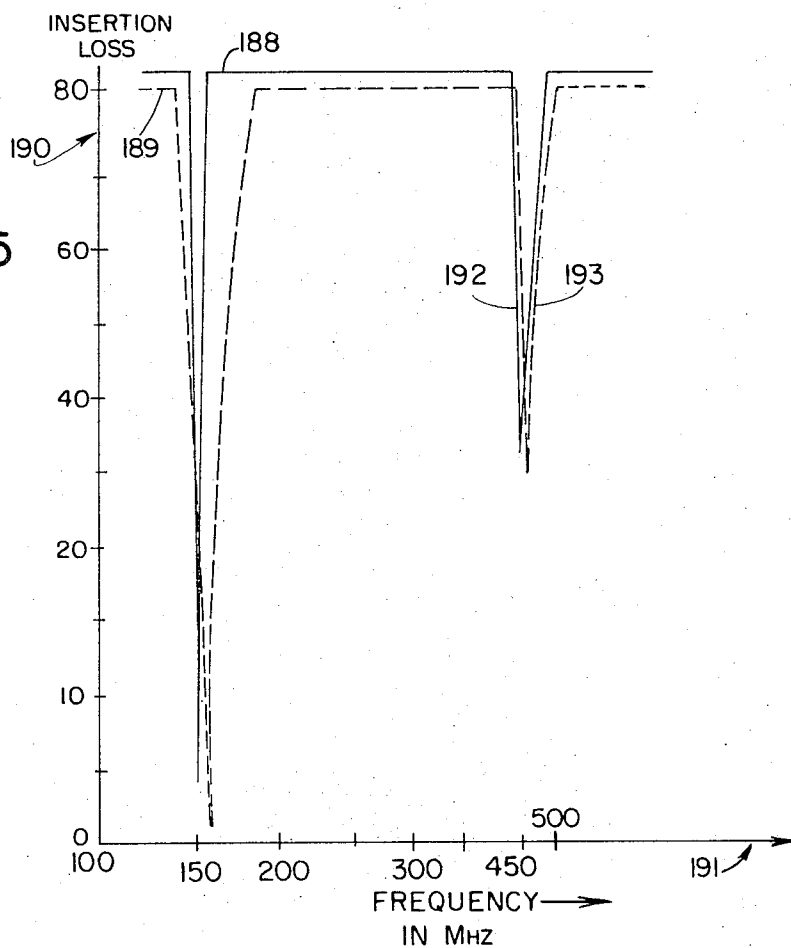


FIG. 5



COUPLING
COEFFICIENT
SQUARED

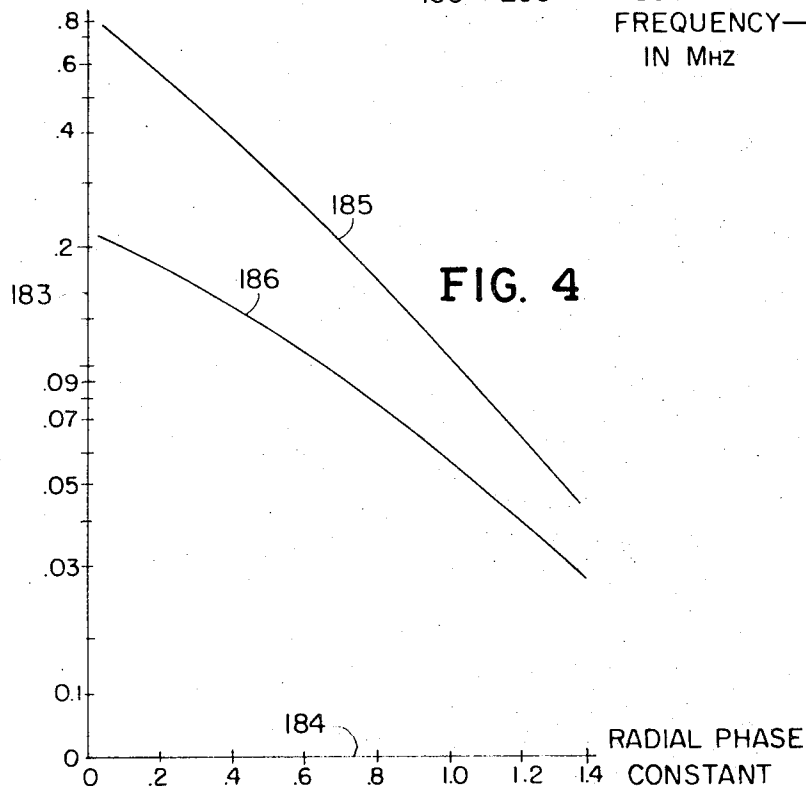


FIG. 4

MULTI-FUNCTION ANTENNA COUPLER

BACKGROUND OF THE INVENTION

Many types of communication apparatus include both transmitters and receivers which either simultaneously or individually, operate on adjacent frequencies. Mobile, portable and hand-held apparatus of this type frequently each employ a single, common antenna which accommodates both transmission and reception. It is usually necessary in these applications to provide one coupling network (preselector) between the antenna and the input of the receiver and another coupling network (harmonic filter) between the antenna and the output of the transmitter. These networks allow the transmitted signal to flow to the antenna and the received signal to flow into the receiver.

In the past, a plurality of different kinds of filtering networks have often been included in a single communication apparatus to facilitate duplex operation. For instance, a duplex filter arrangement might include a duplexer connected to an antenna, a preselector connected between the duplexer and a receiver, and a harmonic filter connected between a transmitter and the duplexer. Furthermore, trap circuits are often respectively utilized in cooperation with the harmonic filter and the preselector to reject the received frequency and transmitted frequency by dissipation. Sometimes this prior art combination employs different kinds of filters having both lumped and distributed components, such as transmission lines, in a single communication system. Transmission lines and connectors are used to form the signal flow paths between the various component filters of the prior art antenna coupling systems.

These prior art networks have been found to have disadvantages in communication systems which must take up limited amounts of space and which are required to have high efficiencies. Provision for a plurality of different types of filter, their connecting cables and connectors often require an excessive amount of space. Moreover, the connectors, connecting cables and dissipating trap circuits have losses inherent which reduce the overall efficiency of the communications system. Moreover, particularly in commercial products where cost must be kept to a minimum, the manufacturing costs of prior art antenna coupling and filtering systems have been excessive. Furthermore, some networks employing a plurality of different types of filters have been found to be unreliable and difficult to align. Also, prior filters have undesirable spurious frequency responses.

SUMMARY OF THE INVENTION

One object of this invention is to provide a multi-function filter network for allowing operation of a transmitter and a receiver through a common antenna, and which is inexpensive, reliable and requires a minimum amount of space.

Another object of the invention is to provide a single compact filter structure for a radio transmitter and receiver, comprised of integral, homogeneous cells which facilitate easy and inexpensive construction.

Still another object of the invention is to provide a multifunction antenna coupling network which is easy to accurately align at high level signals.

A further object of the invention is to provide an efficient antenna coupling circuit having a first leg which

passes information bearing signal to be transmitted and reflects all other signals within a substantial range above and below the center frequency of the transmitted signal and a second leg which passes a received signal and reflects, all other signals within a substantial range above and below the frequency of the received signal.

A still further object of the invention is to provide a multi-function antenna coupling circuit, for selectively coupling a common antenna to a receiver and transmitter, which utilizes helical resonators but which provides a greater degree of attenuation to frequencies above its passband than conventional helical resonator filters.

The antenna coupling circuit facilitates simultaneous reception and transmission of radio signals through a common antenna. A first leg of the circuit includes a first plurality of helical resonator cells forming an input stage of a receiver, which is connected between the antenna and a subsequent stage of a receiver, and a second leg includes a second plurality of helical resonator cells forming an output stage of a transmitter, which is connected between another stage of the transmitter and the antenna. All of the cells of the filter are mechanically connected together to form an integral structure. Lumped capacitors are connected between the antenna terminal and endmost helical windings of the transmitter and receiver legs, to facilitate reflection rather than dissipation of the frequencies rejected by each leg. Each of these capacitors utilize dielectric material affixed to a winding and a conductor affixed to the dielectric material to form an inexpensive capacitor structure. Apertures between cooperating cells are arranged to allow capacitive coupling therebetween to facilitate maximum attenuation of spurious responses having frequencies greater than the highest frequency in the passband. Tuning elements for both the transmitter and receiver portions pass through a common member and facilitate simultaneous tuning adjustment of both legs of the filter at high power levels.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram showing the connection of a multi-function antenna coupling circuit of one arrangement between a stage of a receiver, a stage of a transmitter, and an antenna;

FIG. 2 is an approximately full scale perspective view of a partially exploded, multi-function coupling circuit having another arrangement;

FIG. 3 is a broken away view of an enlarged portion of the structure of the coupler of FIG. 2 showing the connection of the antenna terminal to the endmost resonators of the transmitter and receiver legs;

FIG. 4 is a graph of the square of the coefficients of capacitive and inductive coupling verses radial phase constant;

FIG. 5 is a graph of the insertion loss of a multi-function coupling circuit of FIG. 2 with respect to a logarithmic frequency scale; and

FIG. 6 is an enlarged end section view of the coupling circuit of FIG. 2 showing the connection of a helical resonator to a receiver connector terminal and a frequency adjusting member.

DETAILED DESCRIPTION

Referring now to FIG. 1, a block diagram of a duplex communication system 10 is shown which facilitates simultaneous transmission and reception of information bearing radio signals through antenna 12. Multi-function antenna coupler or filter circuit 14, which includes a plurality of cells mechanically arranged in an L-configuration, is comprised of first and second reflective narrow band filter legs 15 and 21. Antenna coupling network 14 performs signal selecting functions previously performed by the combination of a duplexer, preselector and harmonic filter. Receiver filter 15, which may be considered to be the input stage of the receiver, is connected between antenna port 16 and input terminal 18 of receiver 20, and transmitter filter 21, which may be considered to be the output stage of the transmitter, is connected between output terminal 22 of transmitter 24 and port 16. Receive leg 15 includes series connected cells 26, 28, 30, 32 and 34; and transmit leg 21 includes series connected cells 36, 38, 40 and 42. Each cell is a high-Q shunt helical resonator which has a narrow passband characteristic at high frequencies.

Input terminal 18 of receiver 20 is connected to a first input of mixer 46, output terminal 48 of local oscillator 50 is connected to a second input of mixer 46. Output 52 of mixer 46 is connected to an intermediate frequency (I.F.) amplifier and discriminator 54. Audio amplifier 56 is connected between the output of block 54 and loudspeaker 58. Although the block diagram of a frequency modulation (FM), superhetrodyne receiver has been shown and described, a receiver of any of the known types could be advantageously employed with circuit 14.

Transmitter 24 includes microphone 60 which is connected to the input of preamplifier 62. The input of frequency modulated oscillator 64 is connected to the output of preamplifier 62. Exciter 66 is connected between the output of frequency modulated oscillator 64 and the input of multiplier 68. Power amplifier 70 is connected between the output of multiplier 68 and the input port of transmitter filter leg 21. Although a block diagram of a FM transmitter has been shown and described, other known types of transmitters could be advantageously employed in place thereof.

In operation, if antenna 12 receives a signal falling within the signal passband of filter 15, filter cells 26 through 34 form a preselector which passes the received signal to input 18 of mixer 46. Receiver filter leg 15 also reflects, and thereby attenuates, all signals passed from input 16, to input 18 having frequencies outside of its passband, including signals being developed by transmitter 24. Filter cells 36 through 42 reflect signals received by antenna 12 which are outside of its passband so that they are not developed at transmitter output terminal 22. Otherwise, these received signals could interfere with the operation of transmitter 24. Since signals having frequencies within the passband of receiver filter 15 are reflected rather than dissipated by filter 21, desired received signals being induced in antenna 12 are efficiently applied to receiver input 18. Similarly, since the transmitter signals passing through filter 21 are reflected rather than dissipated by filter 15, the transmitted signals are efficiently applied to antenna 12. Furthermore, filter

cells 36 through 42 form a harmonic filter to pass only the desired components of the modulated output signals developed by transmitter 24 so that virtually no unwanted interference is created on adjacent channels. Although the cells of filter 14 are arranged in an "L" shape, there are many other possible ways in which they could be arranged to facilitate utilization of available space within the structure of a particular product. Each of the cells of the filter of FIG. 1 can be constructed in a manner similar to the cell structure shown in FIG. 2.

A partially exploded, perspective view of multi-function filter 84, which includes helical resonator cells arranged in a rectangular configuration, is shown in FIG. 2. Filter 84 of FIG. 2 is comprised of a conductive housing 86 having rectangular side walls and end walls. Flat rectangular top plate 88 and flat rectangular bottom plate 90, which can be seen in FIG. 3, are adapted to be attached to housing 86. The interior space of housing 86 is divided into a plurality of separate cells by a longitudinal partition 92 and a plurality of transverse partitions, e.g., 94, which are perpendicular to partition 92 and to the side walls of housing 86. Each cell has a housing member formed by associated parts of the partitions, the end walls, side walls and the top and bottom plates.

Each of the cells includes a coil form, e.g., 100, which is made from an insulating or dielectric material such as polystyrene plastic. A conductor, as shown in FIGS. 3 and 6, is wound on each coil form to provide a helical winding or coil. The inner surfaces of each cell facing each coil are comprised of or coated with a conductive material. Apertures or windows e.g., 103, are selectively provided in selected ones of the transverse partitions to allow electromagnetic coupling between cooperating cells. Top plate 88 and bottom plate 90 may be fastened to the housing by screws 107.

Each of the coil forms, e.g., 100, has a cylindrical hole 106 which runs along a longitudinal axis thereof and intersects the end of the coil form facing the underside of top plate 88. As later explained in greater detail, each of these cylindrical holes receives an associated tuning element, e.g. 108, when top plate 88 is mounted onto housing 86. Radio frequency (RF) connectors 112, 114 and 116 respectively, facilitate electrical connection to antenna 12, the output of transmitter 24 and the input of receiver 20. Cells 118, 120, 122 and 124 form a transmitter filter leg of antenna coupler 84 and cells 126, 128, 130, 132, 134 and 136 form a receiver filter leg. The antenna coupling network of FIG. 2 is comprised of integral homogeneous cells which facilitate easy and inexpensive construction of both legs of the filter.

Corresponding parts of multi-function antenna coupler 84 are referred to by the same reference numbers and in FIGS. 2, 3 and 6. Each helical coil cooperates with the inner conductive walls of the housing and plates which surround it to form a resonant chamber or shunt helical resonator. The electrical characteristics of each helical resonator are similar to those of a very high-Q parallel resonant circuit. Therefore, each filter leg includes a plurality of cooperating resonators which would provide a very high impedance to signals applied directly thereto which have frequencies near its resonant frequency. Thus, a helical resonator filter

generally passes signals having frequencies which are substantially equal to its resonant frequency and reflects frequencies which are substantially unequal to its resonant frequency. This desirable result is obtained by inserting lumped capacitors respectively, between input cell 126 of the receiver leg and antenna terminal 112 and between output cell 118 of the transmitter leg and antenna terminal 112.

Referring now to FIG. 3, portions of side wall 138, transverse partition 140, and transverse partition 142 are broken away to more clearly show the capacitive coupling between antenna connector or terminal 112 and the helixes of cells 118 and 126. Partition 140 is a solid wall extending from longitudinal partitions 92 to side wall 138. Helical winding 142 of cell 126 is formed from copper or other conductive wire having a circular configuration. End 144 of winding 142 is mechanically and electrically connected to conductive base plate 90 thereby forming a "low impedance" end adjacent to base plate 90. Winding 142 lies in a helical groove molded into nonconductive coil form 146. "High impedance" end 147 of conductor 142 extends away from coil form 146 toward cell 118. Tubular sleeve 148, which is formed from nonconductive or dielectric material, is inserted over end 147 of conductor 142. Curved conductor 149 includes: first end 150 which is glued or otherwise attached to nonconductive sleeve 148, an intermediate portion 152 which passes through a small insulated hole in partition 140, (not shown) and a second end 156 which is connected to a center piece of RF connector 112, which is shown in FIG. 3. End 147 of helical coil 142, nonconductive material 148 and end 150 of curved conductor 152 respectively, form a first plate, a dielectric and a second plate for a first lumped capacitor connected between the antenna connector and the input cell 126 of the receiver leg of filter 84. In a similar manner, conductor 170 forms a first plate, insulating sleeve 172 forms a dielectric and end 173 of conductor 174 forms a second plate of a second lumped capacitor coupling the antenna connector to output cell 118 of the transmitter leg of filter 84.

Since the two above described coupling or impedance inverting capacitors are included within the structure of filter 84 no additional space is required for them. Moreover, the capacitors are inexpensive and easy to fabricate. They may be adjusted by selectively cutting away portions of either the first or the second plates. If desired, the capacitors could be formed by portions of the helixes other than the ends thereof.

Helical resonators generally have undesired spurious responses at odd multiples of their resonant frequencies. The coupling between cooperating helical resonators is arranged to provide maximum attenuation to spurious responses having frequencies in excess of the desired passband of each leg of the network. Rectangular coupling insert 162 of FIG. 3, is comprised of a thin sheet of conductive material having an aperture 160 located therein. Tracks are provided in longitudinal partition 92 so that insert 162 may be slid in and out to facilitate adjustment therein, if desired. Alternatively, insert 162 could be integrally molded into longitudinal partition 92. As cell 126 is energized by a received signal having a frequency within its passband, magnetic fields are generated at end 144 of helical conductor 142 and electric fields are generated at end 147

thereof. Aperture or window 160 is located closer to end 147 of the helical coil than to end 144. Therefore, aperture 160 facilitates predominately electric field or capacitive coupling between cell 126 and cell 128. If the position of insert 162 was reversed so that aperture 160 was located near base plate 90, the coupling between cells 126 and 128 would be predominantly through magnetic field or inductive coupling.

Increased attenuation to spurious frequencies in excess of the passband of a filter including a plurality of cooperating helical resonators has been discovered to result from the use of capacitive coupling rather than inductive coupling. This beneficial result is believed to stem from the observation that the capacitive coupling coefficient between adjacent helical resonator cells decreases more rapidly than the inductive coupling coefficient in response to increasing frequency. More specifically, FIG. 4 shows the relation between the square of the inductive coupling coefficient and the square of the capacitive coupling coefficient as a function of the radial phase constant. Ordinate axes 183 is marked off with a logarithmic scale representing the square of the respective coupling coefficients and abscissa axes 184 is marked off in a linear scale representing radial phase constant which increases as the input or driving frequency increases. Curves 185 and 186 are respective plots of the square of the capacitive coupling coefficient and the square of the inductive coefficient. Since the square of the capacitive coupling coefficient, as shown by the slope of curve 185, decreases more rapidly than the square of the inductive coupling coefficient, as shown by the slope of curve 186, with an increase in frequency, helical resonators utilizing capacitive coupling provide greater attenuation to high frequency spurious signals than resonators utilizing inductive coupling.

A multi-function antenna coupler similar in mechanical form to the one shown in FIG. 2, and having a length of approximately 5 inches, a width of approximately 2 inches and a depth of approximately 2 inches has been built and tested for operation on the very high frequency (VHF) commercial communication band between 132 and 174 megahertz (MHz). Each cell of this filter has a square transverse cross-section having sides which are about $1\frac{1}{8}$ inches long. The coupling aperture is about $1\frac{1}{4}$ inches long and 0.2 inch wide. The insertion loss verses frequency characteristic for this antenna coupler is shown in FIG. 5. Solid curve 188 represents the insertion loss characteristic of the receiver filter leg and dashed curve 189 represents the insertion loss characteristics for the transmitter filter leg. Ordinate axis 190 is marked off in decibels (db) and abscissa 191 is marked off with a logarithmic scale beginning at 100 MHz and extending to 500 MHz. As shown by curve 188, the receive leg of the filter provides little attenuation, e.g., about 4.5 db, to a received signal having a center frequency of about 150 MHz but it provides a large insertion loss, e.g., about 82 db, to signals at most other frequencies including the transmitter center frequency of 155 MHz. Similarly, as shown by characteristic 188, the transmit leg provides little insertion loss to frequencies close to the transmitter center frequency, e.g. 1.5 db, but it provides a relatively large insertion loss, e.g. 80 db, at most other frequencies.

As shown in FIG. 5, third harmonic inherent spurious response or passband 192, which is centered at about 450 MHz, occurs in the receive leg, and inherent spurious passband 193 which is centered at about 465 MHz, occurs in the transmit leg. Undesired signals occurring within the frequency ranges of these spurious passbands tend to be passed through a filter to a greater extent than undesired signals having other frequencies outside of the desired passband. Since there is an ultra high frequency (UHF) commercial band located between 406 MHz and 512, there is a strong likelihood that signals at the frequencies of the spurious passbands will be applied to the filter. The novel arrangement of apertures in filter 84, which employs capacitive coupling between adjacent resonators rather than inductive coupling, in at least 20 db attenuation to signals within the spurious passbands in each leg of the antenna coupler. Prior art helical resonators having apertures opening to the low impedance end of the helical windings, present attenuations of only about 7 db to the undesired third harmonic signals. Thus, the multi-function antenna coupling circuit, which selectively couples a common antenna to a receiver and transmitter, provides a greater degree of attenuation to undesired frequencies above its passband than conventional helical resonator filters.

FIG. 6 is an end section view of output cell 136 of the receiver filter leg of antenna coupler 84. Top plate 88 is shown in its position on housing 86. Screw 194 extends through base-plate 90 to mechanically fasten coil form 195 thereto. End 196 of conductor 197 is electrically and mechanically connected to base plate 90 by solder 198. Conductor 199 is connected between a selected point on end 196 and a center conductor 200 of receiver RF connector 116. The precise point of connection of conductor 199 to coil 197 may depend upon the necessary impedance transformation for maximum power transfer from the filter into the receiver. The coupling from the transmitter output, which is connected to the center conductor of connector 114, into cell 124 may also be accomplished by utilizing a similar structure. Also, in some applications it might be desirable to include impedance transforming capacitors between either or both of RF connectors 114 and 116 and the respective coils of cells 124 and 136.

Tuning device 202, which is typical of the tuning devices associated with the other cells of the multi-function antenna coupler, is associated with cell 136. It may be formed from a threaded rod 204 having a slot 206 in one end thereof. Threaded opening 208 in top plate 88 receives tuning device 202 which extends into aperture 210 of coil form 195. The portion of adjustable member 202 extending below top plate 88 and into the interior of cell 136 forms a first plate of an adjustable tuning capacitor, endmost winding 212 of helical conductor 197 forms a second plate, and the portion of coil form 195 located between these two plates acts as a dielectric. As member 202 is turned by a blade inserted in slot 206 so that it extends either more or less into aperture 210, the effective surface area of the first plate is varied thereby changing the equivalent capacitance. The resonant frequency of the cell is thereby changed or adjusted. Thus, by adjusting the other tuning members similar to member 202 associated with each cell the resonant frequencies of the

transmitter and receiver legs of the antenna coupling circuit is determined. The resonant frequency or center of the passband of the receiver leg may be selected to be either greater than or less than the resonant frequency or center of the passband of the transmitter leg. Moreover, the tuning structure facilitates accurate alignment of the multi-function antenna coupler at high signal levels whereas prior art antenna couplers, including a plurality of different types of elements, often can only be adjusted at lower signal levels. The feature of antenna filter 86 enabling high power adjustment is particularly desirable with respect to the transmit leg, because it may be difficult to adjust the transmitter so that it generates a low level signal.

What has been described, therefore, is a multi-function filter network for allowing duplex operation through a common antenna between a transmitter and a receiver, which is inexpensive, reliable and which requires a minimum amount of space. The filter is comprised of integral homogeneous cells which facilitate an inexpensive construction. Selective positioning of the apertures between the cells cause insertion loss characteristics indicating a greater attenuation to frequencies above the passbands of the filter legs than heretofore realized with conventional helical resonator filters having the same number of cells. Furthermore, the antenna coupler can be easily and quickly aligned even with high level signals passing therethrough.

We claim:

1. Filter apparatus for selectively coupling signals from an antenna to an input stage of a radio receiver operating on a first frequency band and from an output stage of a transmitter operating on a second frequency band to the antenna, the filter apparatus including in combination:

a conductive housing including a plurality of conductive enclosures and helical windings in each of said enclosures forming a plurality of helical resonators;

a first group of said helical resonators being tuned to the first frequency band to form a receiver preselector filter having an output terminal adapted to be connected to the input stage of the radio receiver for selecting signals applied thereto;

a second group of said helical resonators being tuned to the second frequency band to form a transmitter harmonic filter having an input terminal adapted to be connected to the output stage of the transmitter for selecting only the desired components of the signal therefrom;

an antenna terminal on said housing adapted to be connected to the antenna;

first circuit means coupling said winding of said receiver filter to said antenna terminal whereby the receiver filter selects signals of the first frequency band and applies the same to the receiver stage and rejects signals of the second frequency band; and

second circuit means coupling said winding of said transmitter filter to said antenna terminal whereby the transmitter filter selects signals of the second frequency band from the transmitter stage and applies the same to the antenna terminal and rejects signals of the first frequency band.

2. The filter apparatus of claim 1 wherein said first circuit means includes capacitor means having a first plate connected to said antenna terminal and a second plate connected to said receiver filter.

3. The filter apparatus of claim 1 wherein said second circuit means includes capacitor means having a first plate connected to said antenna terminal and a second plate connected to said transmitter filter.

4. The filter apparatus of claim 1 further including:

first capacitor means having a first plate formed by a portion of said winding of said receiver filter, a dielectric formed by a first insulating member which is mechanically connected to said winding of said receiver filter, and a second plate formed by a first conductive member having first and second ends, said first end being connected to said first insulating member and said second end being connected to said antenna terminal; and

second capacitor means having a first plate formed by a portion of said winding of said transmitter filter, a dielectric formed by a second insulating member which is mechanically connected to said winding of said transmitter filter, and a second plate formed by a second conductive member having first and second ends, said first end of said second conductive member being connected to said second insulating member and said second end of said second conductive member being connected to said antenna terminal.

5. The filter apparatus of claim 1 wherein said receiver filter includes a plurality of cooperating helical resonators which tend to have a spurious passband, each of said resonators having a helical coil with first and second ends and a longitudinal axis, and a housing member enclosing said helical coil which is formed by four conductive sidewalls and first and second conductive end walls, said longitudinal axis of each of said coils being perpendicular to said first and second conductive end walls;

said resonators being juxtapositioned with respect to each other so that said housing member of each resonator has a common sidewall with the housing member of a cooperating resonator;

said first end walls of said resonators being formed by a single integral conductive member;

means electrically connecting said first end of each of said coils to said integral conductive member; and

each of said common sidewalls having an aperture formed therein, said apertures being located adjacent to said second ends of said coils to facilitate predominantly capacitive coupling between said adjacent cooperating resonators to provide attenuation to signals having frequencies lying within said spurious passband.

6. The filter apparatus of claim 1 wherein said transmitter filter includes a plurality of cooperating helical resonators which tend to have a spurious passband, each of said resonators having a helical coil with first and second ends and a longitudinal axis, and a housing member enclosing said helical coil which is formed by four conductive sidewalls and first and second conductive end walls, said longitudinal axis of each of said coils being perpendicular to said first and second conductive end walls;

said resonators being juxtapositioned with respect to each other so that said housing member of each resonator has a common sidewall with the housing member of a cooperating resonator;

said first end walls of said resonators being formed by a single integral conductive member;

means electrically connecting said first end of each of said coils to said integral conductive member; and

each of said common sidewalls having an aperture formed therein, said apertures being located adjacent to said second ends of said coils to facilitate predominantly capacitive coupling between said adjacent cooperating resonators to provide attenuation to signals having frequencies lying within said spurious passband.

7. The filter apparatus of claim 1 wherein each of said resonators has a helical coil with first and second ends, a coil form for supporting said coil and having first and second ends and an aperture extending from said second end into said coil form, and a housing member formed by four conductive sidewalls and first and second conductive end walls;

said resonators of said receiver filter being juxtapositioned so that said housing members thereof have common intermediate sidewalls;

said resonators of said transmitter filter being juxtapositioned so that said housing members thereof also have common intermediate sidewalls;

said first end walls of said housing members of each of said filters being formed by a first integral conductive member, means electrically connecting said first ends of said coils to said first conductive member;

said second end walls of said housing members of each of said filters being formed by a second integral conductive member having a surface located in a plane which is parallel to and adjacent to said second ends of said coil forms; and

a plurality of tuning means each extending through said second conductive member into said aperture of one of said coil forms, said plurality of tuning means facilitating simultaneous adjustment of said resonant frequencies of said receiver and transmitter filters.

* * * * *