Dec. 1, 1953 I. E. GOLDSTEIN 2,661,424

DIPLEXER ARRANGEMENT

Filed Jan. 22, 1951 4 Sheets-Sheet 1

Fig_1

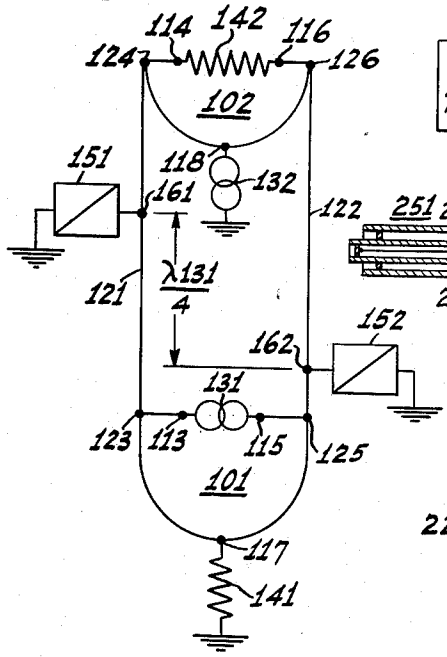
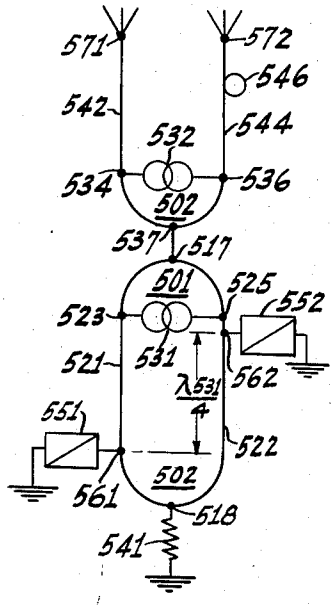


Fig_5



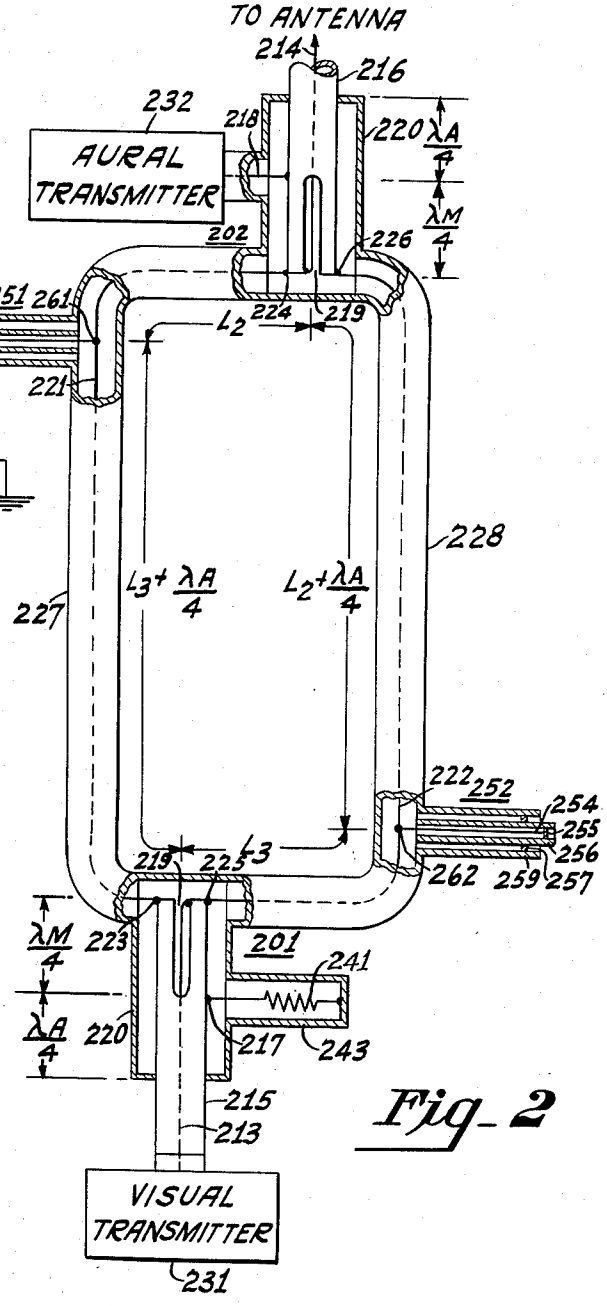


Fig_2

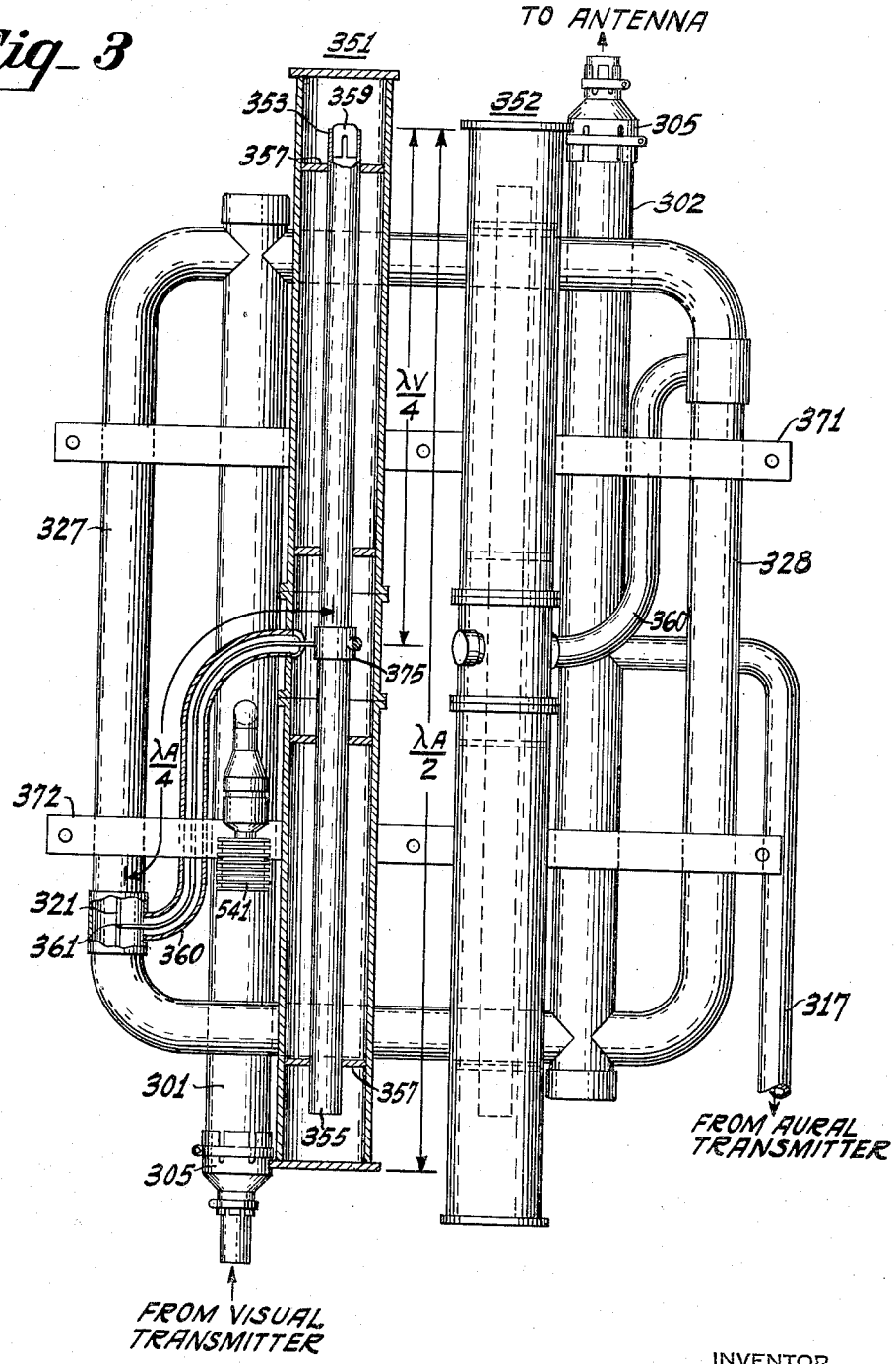
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Dec. 1, 1953 I. E. GOLDSTEIN 2,661,424

DIPLEXER ARRANGEMENT

Filed Jan. 22, 1951 4 Sheets-Sheet 2

Fig. 3



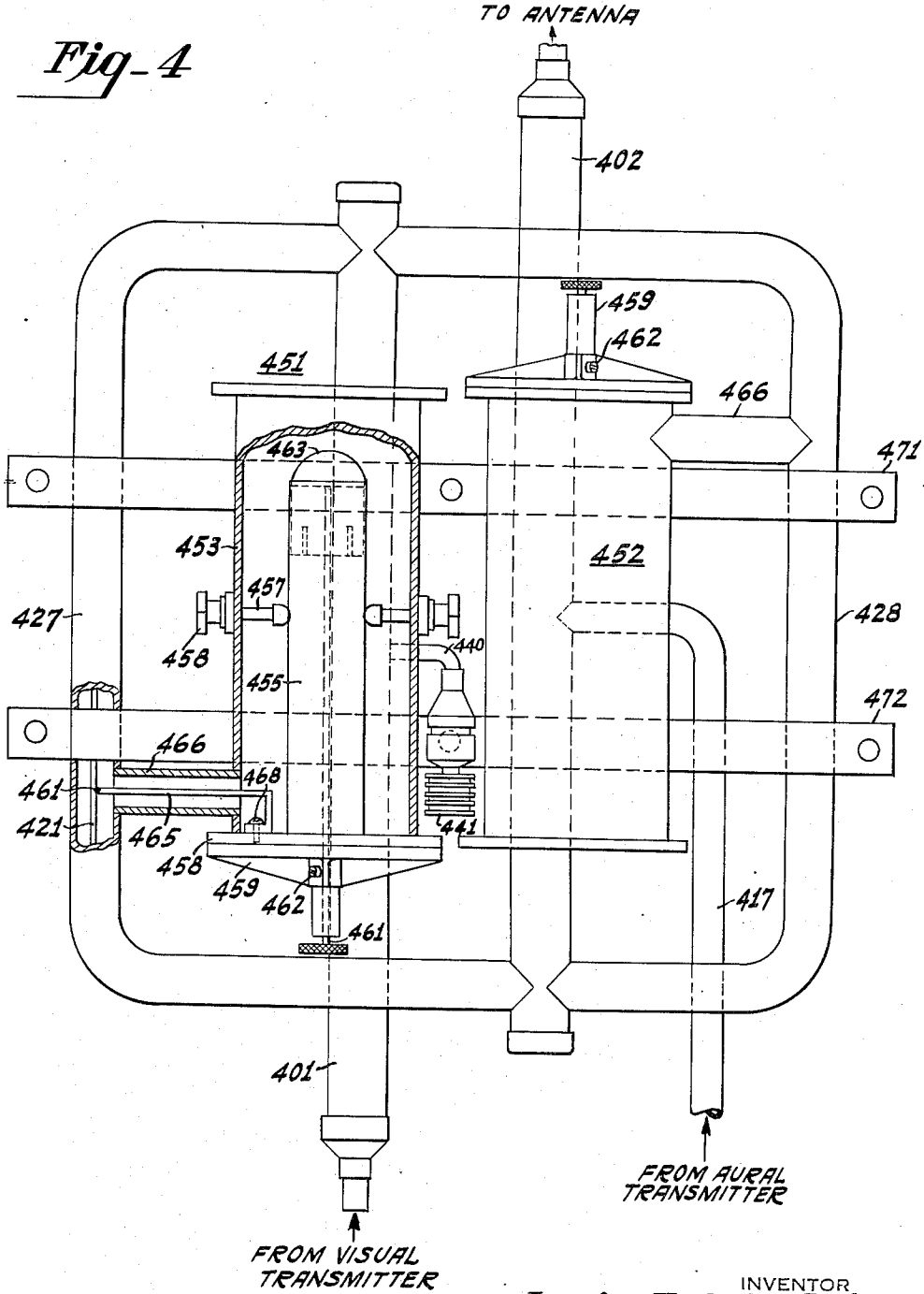
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DIPLEXER ARRANGEMENT

Filed Jan. 22, 1951 4 Sheets-Sheet 3

Fig. 4



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DIPLEXER ARRANGEMENT

Filed Jan. 22, 1951 4 Sheets-Sheet 4

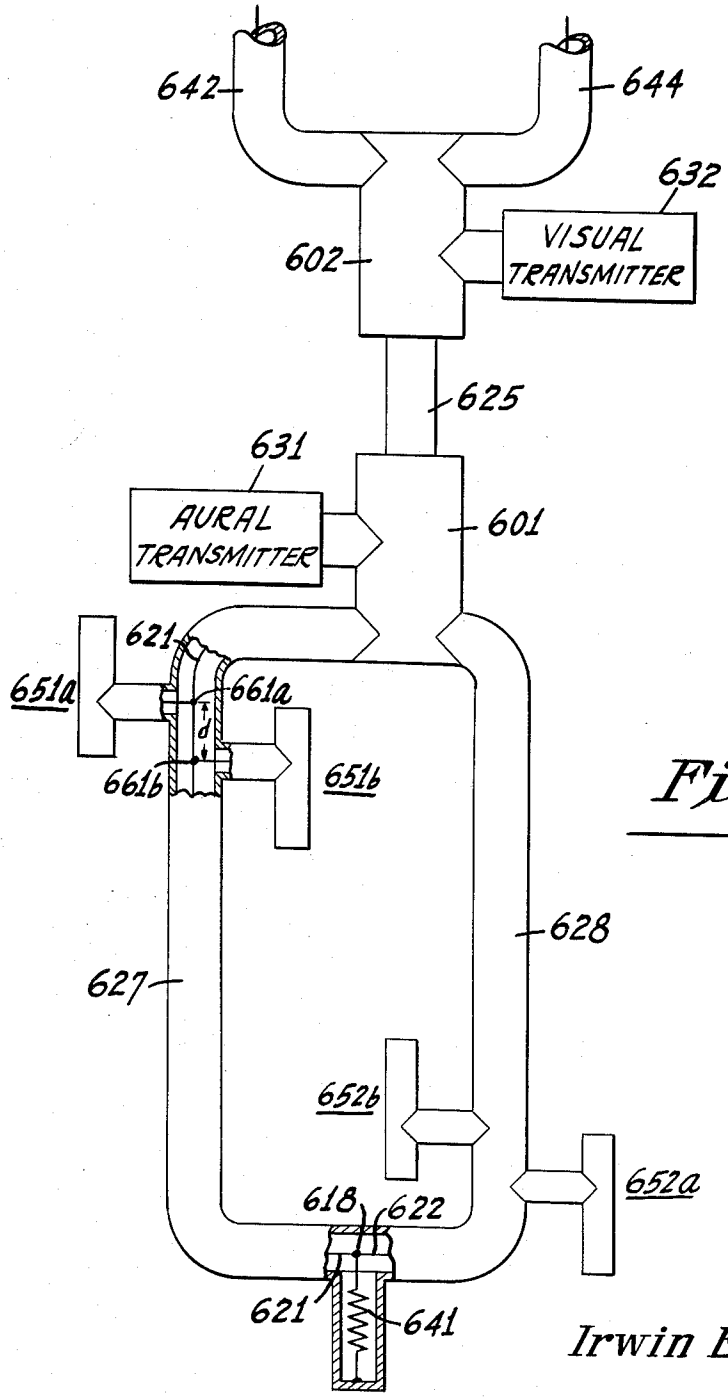


Fig. 6

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2,661,424

DIPLEXER ARRANGEMENT

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Application January 22, 1951, Serial No. 207,071

24 Claims. (Cl. 250—33.69)

1

The invention relates to antenna feed systems and it particularly pertains to diplexing and reflection absorbing circuitry for television program broadcasting installations.

Diplexing two program-modulated radio frequency signals, such as television aural and visual signals, for application to a common radiating system is well known in the art. In general, there are two methods of introducing visual and aural signal-modulated carriers to one antenna. The first method is popularly known as notch diplexing. In essence, the notch diplexer is constituted by a transmission feed line circuit arrangement having auxiliary frequency-selective circuit elements, usually reflection filters of known type, interconnected at proper points to provide a low impedance to R. F. energy over a wide band of frequencies except for one or more very narrow frequency ranges in which the impedance is extremely high. The term "notch" circuit is readily suggested by one form of impedance-frequency diagram popularly used which illustrates a relatively narrow depression in a rather uniform plateau-like curve. When using a notch diplexer, a notch is placed in the picture pass-band centered about the aural carrier and the elements of the reflection filter are so constructed and located that there is negligible mutual interaction between the aural and visual carriers. A basic notch diplexer is shown and described in U. S. Patent 2,128,400 issued August 30, 1938 to P. S. Carter. The second arrangement is known as a bridge diplexer, an example of which is shown and described in U. S. Patent 2,318,237 issued May 4, 1943, to N. E. Lindenblad. In this patent, a single output transmission line is shown. An arrangement similar to the latter, except that a pair of output transmission lines for use primarily with a two-element radiator is shown and described in U. S. Patent 2,341,408 issued February 8, 1944, to N. E. Lindenblad. The latter is also shown in U. S. Patent 2,495,589 issued January 24, 1950 to R. W. Masters. Bridge diplexing is so called because it suggests a Wheatstone bridge from the manner in which it is schematically shown and also from the relationship of the component circuit impedances. Still another effective diplexing arrangement is shown and described in U. S. Patent 2,454,907 issued November 30, 1948, to G. H. Brown.

While perfectly satisfactory at the time of conception, such arrangements are not inherently capable of meeting present-day standards and desires with respect to the constancy of impedance level over the desired frequency band and absence

2

of reflections due to unavoidable mismatching of circuit components. Circuit arrangements have been proposed for improving the overall operation by absorbing energy reflected by the antenna back toward the transmitter. A thorough discussion of this problem is to be found in the Proceedings of the Institute of Radio Engineers for July 1949, pages 735–738, entitled "A Power-Equalizing Network for Antennas." The term "power equalizing" has been suggested because in the operation of antennas having two separated radiator elements such as are found in turnstile antennas the power radiated by one element becomes greater than that radiated by the other element due to the fact that the phase relationship of reflections travelling over the quadrature incremental feed line and those travelling over the other line will be altered in such fashion as to provide cancellation at certain points of the system and addition at other points, one of the latter points being one radiator element only of the antenna. Where the radiator elements are not identical, a bridge arrangement must be interposed in the circuit to correct for the disparity in impedance level. An example of such an arrangement will be found in U. S. Patent 2,465,843 issued March 29, 1949, to G. H. Brown and D. W. Peterson. Where the radiator elements for all practical purposes are or can be made symmetrical so that the reflection from both radiator elements will be equal and by providing a 180 degree path difference for energy going to one element over that going to the other element, the reflected components are thrown out of phase and prevented from reentering the visual transmitter. Because of the frequency difference between the aural and visual transmitters, the reflected energy can be trapped out by a suitable notch circuit. Examples of such additional notch circuitry for this purpose can be found in U. S. Patent 2,495,589 above-mentioned, and co-pending U. S. application Serial No. 714,620, filed December 6, 1946, by R. W. Masters issued October 9, 1951, as U. S. Patent 2,570,579.

When the antenna itself has been made as wide band as possible, greater band widths are obtained by absorbing all reflected energy and a circular radiation pattern is inherently maintained.

The prior art diplexers and reflection absorbing arrangements have been found unsatisfactory in that a poor voltage standing wave ratio is obtained in the vicinity of the filter cut-off. The arrangements of the prior art are also expensive to build and wasteful of space in the final installation. Furthermore, tuning and adjustment

of the prior art arrangements is entirely too critical and complicated for the purpose. With the advent of the use of relatively narrow band antennas and power equalization by means of a bridge-type diplexer, a need has developed for a diplexing and reflection absorbing circuit having the output delivered over a single unbalanced transmission line, which need is not adequately filled by the prior art arrangements. For high power operation, the known arrangements also tend to larger power losses, which reduce the efficiency, both electrical and economical, to an undesirable level.

It is an object of the invention to provide an antenna feed system having more constant input impedance over a wider frequency band than heretofore obtained.

It is another object of the invention to provide an antenna feed system having higher power capability with lower losses than heretofore possible.

It is a further object of the invention to provide a circuit arrangement incorporating an improved arrangement for diplexing a plurality of high frequency energy sources to a common load without interaction.

It is still another object of the invention to provide a simpler circuit arrangement by means of which two transmitters are coupled to a single antenna by means of a single unbalanced transmission line.

It is still a further object of the invention to provide a transmission line reflection filter circuit having a substantially unitary voltage standing wave ratio in the vicinity of the cut-off frequency of the filter.

It is yet another object of the invention to provide a network for a reflected energy absorber or a diplexer arrangement which is simpler, lower in cost and more readily adjusted than those heretofore known.

It is yet a further object of the invention to provide an improved circuit arrangement by means of which two transmitters are coupled to a single antenna by means of a single unbalanced transmission line.

It is a more specific object of the invention to provide an arrangement whereby two programs may be diplexed onto a single transmission line with greater fidelity than heretofore obtainable.

It is another specific object of the invention to provide a diplexer and reflection absorber network employing cavity-resonator type reflection filters.

It is a further specific object of the invention to provide a diplexer and reflection absorber network employing series-parallel tuned-circuit type reflection filters.

It is still another and more specific object of the invention to provide a combined diplexer and reflection absorber arrangement which is more compact and more readily accessible than heretofore available.

It is a still further and more specific object of the invention to provide a television bridging and reflection absorber arrangement for coupling aural and visual modulated carrier waves to a common antenna by means of a single unbalanced transmission line.

These and other objects of the invention which will appear as the specification progresses are attained by an arrangement comprising a pair of balanced-to-unbalanced transmission line bridging networks having the balanced terminals interconnected by a pair of transmission lines of equal length and a reflection filter network connected across each of the transmission lines at points differing in location with respect to each of the bridging networks by a quarter wavelength at a predetermined frequency.

One of the sources of energy is coupled to one set of unbalanced terminals and a terminating resistance element having a resistance equal to the characteristic impedance value determined by the associated transmission lines is connected to the other set of unbalanced terminals of one of the bridging networks. The other source of energy is connected to one set of unbalanced terminals of the other one of the bridging networks and the transmission line to the antenna is coupled to the remaining set of unbalanced terminals of the other of the bridging networks.

One of the sources of energy is coupled to the unbalanced terminals providing push-pull output at the balanced terminals of the bridging networks and the terminating resistance element is connected to the unbalanced terminals obtaining push-push input at the balanced terminals.

The invention will be described in detail with reference to the accompanying drawing forming a part of the specification and in which:

Fig. 1 is a schematic diagram of the basic principles of a diplexing arrangement according to the invention;

Fig. 2 is a suggested embodiment of the diplexing arrangement illustrated in Fig. 1;

Fig. 3 is an illustration of a practical embodiment of the arrangement shown in Fig. 1;

Fig. 4 is an illustration of another practical embodiment of the invention;

Fig. 5 is a schematic diagram of an alternative reflection absorbing network according to the invention; and

Fig. 6 is another embodiment of the invention.

Referring to Fig. 1, the basic principles of an arrangement according to the invention applicable to both open wire and coaxial transmission lines are shown by a schematic diagram drawn for the most part according to well-known practice to represent the structure of the center conductor of a concentric transmission line arrangement. A pair of bridging networks 101 and 102 having unbalanced connection terminals 113, 115, 117 and 114, 116, 118 respectively are joined by transmission line sections 121, 122 interconnecting balanced terminals 123, 125 and 124, 126 of networks 101, 102 respectively. Each of the unbalanced connection terminals 113, 115 and 117, and 114, 116 and 118 is adapted to have connected thereto either a radio frequency generator or a load which is single-sided or unsymmetrical with respect to ground or reference potential. These connections are made (usually by shielded or coaxial lines) at some point external to the structure of the bridging networks 101, 102 and, by virtue of the line lengths and structural connections in the bridging networks themselves, the voltage across the unbalanced terminals 113, 115 or 114, 116 appears in push-pull, that is to say, symmetrical balanced relation across the balanced terminals 123, 125 or 124, 126.

A radio frequency generator 131 is connected to unbalanced terminals 113, 115 to present energy in push-pull relationship to balanced connection terminals 123 and 125 and a second generator 132 is connected to unbalanced connection terminal 118 to present energy in push-push relationship at balanced connection ter-

minals 124 and 126. A resistive terminating element 141 is connected to unbalanced terminal 117 effective to couple element 141 in the same sense to terminals 123 and 125. A load element, shown here as resistor 142, is connected to unbalanced connection terminals 116 and 116 to obtain energy in push-pull relationship from balanced connection terminals 124 and 126. Elements 141 and 142 have electrical values interrelated in known manner determined from the characteristic impedances of the associated transmission lines. Or stated from another view point, the characteristic impedance of the associated transmission lines and the value of terminating element are arranged to match the impedance relationship of the load and the sources in known manner. Transmission line reflection filter elements 151 and 152 are connected to transmission lines 121 and 122 at points 161 and 162 respectively. Filters 151 and 152 are identical and are tuned to present a low impedance or a short circuit to energy at the operating frequency of generator 132 and a high impedance or open circuit to energy at the operating frequency of generator 131 across the transmission lines to which they are connected. Terminals 161 and 162 are located with respect to bridging networks 101 and 102 so that there is a difference in path length of a quarter wavelength from terminals 161 and 162 to either source. Signal energy from generator 131 is presented to transmission lines 121 and 122 in push-pull relationship by the action of bridging network 101 and is transmitted to load element 142 substantially without reflection there being a high impedance presented to terminals 161 and 162 at the operating frequency of generator 131. In operation signal energy from generator 132 is presented in push-push relationship to transmission lines 121 and 122 by bridging network 102 and is totally reflected by the operation of reflection filters 151 and 152 presenting a short circuit to energy of the operating frequency of generator 132 at terminals 161 and 162. The energy flowing in transmission line 122 travels over a path distance greater by twice a quarter wavelength or a half-wavelength at the operating frequency of generator 132 than is travelled by eneryy flowing in line 121 whereby the reflected energy at terminals 123 and 125 is then transferred in push-pull relationship to load element 142. None of the reflected energy will reenter generator 132 because the phase relationship is such as to effect cancellation at terminals 118. Any signal energy from generator 132 which is not reflected for any reason by filters 151 and 152 will continue in push-push relationship along lines 121 and 122 to terminals 117 from which it will be directed to resistive terminating element 141 and absorbed. Likewise any signal energy from generator 131 which is reflected by the action of filters 151 and 152 for any reason will be transformed in phase to push-push relationship and absorbed in the sink constituted by terminating element 141. Push-push energy arriving at terminals 123, 125 will not be introduced to generator 131 no matter what the frequency since the terminals are at the same instantaneous potential with respect to the arriving energy. Thus diplexing of two signals onto a single unbalanced transmission line is accomplished in simple manner without any interaction between sources of the signals.

Referring to Fig. 2, there is shown a suggested practical embodiment of an improved diplexer according to the principles of the invention as hereinbefore described. Bridging networks 201 and 202, corresponding to the schematic illustrations of bridging networks 101 and 102 respectively, are of the type shown and described in above-mentioned U. S. Patent 2,454,907. It will be obvious to one skilled in the art, however, that bridging networks of the type shown and described in above-mentioned U. S. Patent 2,341,408 or any known bridge arrangement for connecting two unbalanced input transmission lines to two balanced output transmission lines in balanced push-push and balanced push-pull relationship will serve equally as well.

Bridging networks 201 and 202, are constituted by structures comprising sections of coaxial transmission line having inner conductors 213, 214 and outer conductors 215, 216 respectively. Conductors 215, 216 are each bifurcated at one end by means of diametrically opposed slots 219, 219 which are approximately a quarter of a wavelength long at a predetermined frequency. The length of slots 219, 219 theoretically should be equal to a quarter wavelength at the frequency at which balanced-to-unbalanced transformation is desired. However, it has been found that a considerable degree of variation is permissible, so that in practice, slots 219, 219 are made a quarter wavelength long at a mid-band frequency. Such construction then allows diplexers according to the invention to be made up for stock rather than for each specific order, which feature is of no little importance to the art. Outer conductors 215, 216 are surrounded by sheath conductors 220 for a distance of approximately a half wavelength at the desired operating frequency, the actual length being determined by constructing the sheath to extend a quarter wavelength at the aural frequency beyond the bottom of slots 219, 219. Sheath conductors 220 are connected to conductors 215, 216 at the end of the sheath remote from slots 219. Inner conductor 213 is connected to outer conductor 215 at one side of slots 219, 219 to establish terminal 225. The branches of bifurcated conductor 215 forming terminals 223 and 225 are then balanced with respect to conductors 213 and 215 at the other end of the transmission line section. Similarly, terminals 224 and 226 of bridging network 202 are balanced with respect to conductors 214, 216 as seen from the end remote from the terminals. A visual signal transmitter 231 is connected to bridging network 201 at the end of the transmission line comprising coaxial conductors 213, 215. A terminating resistor 241 is connected between conductor 215 at terminal 217 and sheath conductor 220. An aural signal transmitter 232 is coupled to bridging network 202 by means of a length of transmission line 218 having the outer conductor thereof connected to sheath conductor 220 and the inner conductor connected to conductor 216 at terminal 218 which is located at the bottom of notch 219 whereby energy from transmitter 232 is presented at terminals 224, 226 in push-push relationship. Terminals 223 and 225 are interconnected to terminals 224 and 226 respectively by inner conductors 221 and 222 respectively of transmission line sections whose outer conductors 227 and 228 are connected at the ends to sheath conductors 220, 220. Reflection filters 251 and 252 are connected at terminals 261

and 262. These filters are constructed substantially as described and shown in co-pending U. S. application Serial No. 102,498 of R. W. Masters, filed July 1, 1949. Reflection filters 251 and 252 in brief comprise a first resonant circuit including an inner conductor 254, a shorting member 255 and a tubular conductor 256 surrounding inner conductor 254 coupled in circuit with a further shorting member 257 interconnecting conductor 256 and another tubular conductor 259 surrounding conductor 256 to form a further resonant circuit. Inner conductor 254 and sheath conductor 259 are connected to the inner and outer conductors of the transmission lines respectively. The first resonant circuit is adjusted to provide series resonance, or in other words to present a short circuit, at the frequency of the aural transmitter, and the further resonant circuit is tuned to provide parallel resonance, or to present an open circuit at the frequency of the visual transmitter. By means of this arrangement operating as described hereinbefore with reference to the arrangement of Fig. 1, energy from aural transmitter 231 and visual transmitter 232 may be transmitted over the single unbalanced line comprising conductors 213 and 215 to an antenna or any other useful load circuit.

Referring to Fig. 3, there is shown a practical embodiment of a diplexer according to the invention as hereinbefore described arranged for compact installation in existing television transmitting stations on support members 371 and 372 which in practice are preferably rigid metal channel members. Bridging networks 301 and 302 are arranged in folded relationship with respect to transmission lines 327 and 328 in order to save space. Bridging networks 301, 302 are constructed along the lines illustrated in connection with bridging networks 201 and 202, the end caps 305 being made adjustable so that the relationship between the outer conductor and the sheath conductor may be accurately set. A conventional reflection energy absorber unit 341 is connected to bridging network 301 and is supported on members 372. Reflection filters 351 and 352 are constituted by T-filter structures as shown and described in U. S. Patent 2,570,579 previously mentioned. Essentially, filters 351 and 352 comprise a length of open-ended coaxial transmission line 353 the conductors of which have diameters providing the optimum ratio for obtaining a substantially high "Q" circuit. The overall length of transmission line 353 is a half wavelength at the aural frequency. At a point a quarter wavelength at the visual transmitter frequency from one end of each of the lines a connection is made to a section of coaxial transmission line 360 a quarter wavelength long at the aural frequency for connection to transmission line sections 327 and 328 at terminals 361 and 362, the latter not being shown. The characteristic impedance of the various sections of line are of course determined in known manner to provide optimum impedance matching throughout the system. At terminals 361 and 362 the desired impedance relationship is obtained as previously described. However, the exact lengths of the transmission line sections of filters 351 and 352 are varied in practice to alter the reactance relationships of the system. Such variations are described in co-pending U. S. application Ser. No. 723,317 filed January 21, 1947, by L. J. Wolf, now Pat. No. 2,600,949 granted June 17, 1952. Such variations are made feasible by varying the length of inner conductor 351 by adjustment of an end cap 359 constructed in accordance with the teaching of copending application Ser. No. 114,400 filed September 7, 1949, by O. O. Fiet. In all other respects, the diplexer arrangement of Fig. 3 is similar in construction and operation to that shown structurally in Fig. 2 and schematically in Fig. 1.

Referring to Fig. 4, there is shown another practical embodiment of a diplexer according to the invention which is similar in construction to that shown in Fig. 3 except that reflection filters 451 and 452 are constituted by cavity resonator members of the type shown and described in U. S. Patent 2,266,501 issued December 16, 1941, to N. E. Lindenblad. Reflection filters 451 and 452 comprise a large conductor cylinder 453 closed at both ends and having an inner conductor 455 arranged therewithin and rigidly supported at one end thereof by connection to one end cap 459. The end of inner conductor 455 remote from end cap 459 is preferably made adjustable by means of an end cap 463 connected to a threaded rod member 461 arranged to permit the adjustment of the length of the inner conductor to be made during operation. A screw 462 is employed to lock rod 461 in the adjusted position. Insulated probe members 457 are preferably provided at the midpoints of cylinder 453 to fix inner conductor 455 rigidly in place. Cavity resonators 451 and 452 are coupled to transmission lines 427 and 428 by means of a short length of transmission line 466, the inner conductor 465 of which is formed into a coupling loop element 468 and fastened to end plate 459.

While the suggested embodiments of reflection filters have been shown as comprising a single unitary set of elements, it should be understood that if more effective filtering is required, a plurality of such filters may be employed in accordance with known practice. Such an arrangement is shown on the drawing of Fig. 6 which is described below. These filters are spaced at some prearranged distance d apart along the transmission line, for example $\frac{1}{6}$ wavelength has been found to be a convenient value. It is also suggested that band pass filters such as described and illustrated in U. S. Patent 2,532,993 issued December 5, 1950, to P. S. Carter can be used to advantage.

Referring to Fig. 5, there is shown in schematic form an arrangement wherein the structure of the diplexer according to the invention may be employed as a power equalizer in a television broadcasting installation having a two-element radiator system such as the well known turnstile antenna. A source of R. F. energy 531 is connected by means of bridging network 501 in push-pull relationship to a pair of transmission lines 521 and 522 corresponding to transmission lines 121 and 122 of Fig. 1 for transmitting energy in push-push relationship to transmission lines 542 and 544 by operation of reflection filters 551 and 552 connected to transmission lines 521 and 522 at terminals 561 and 562 respectively. A diplexing network 592 which may be a diplexer of the type shown and described in aforementioned U. S. patents, 2,341,408, 2,495,589, or 2,454,907, the connections being made by a length of transmission line interconnecting terminals 517 and 537 of networks 501 and 502 respectively. A visual frequency generator 532 is coupled in push-pull relationship to terminals 534 and 536 to excite antennas 571 and 572 in phase quadrature relationship due to the interposition of a quarter

wavelength phase shifting transmission line section 546 in transmission line 544.

Assuming antenna elements 571, 572 are properly matched to the transmission lines 542 and 544, transfer of energy thereto from generators 531 and 532 will take place as described without reflection. However, if there is mismatch to any substantial degree, reflection of energy will take place back along transmission lines 542 and 544 to bridging network 502. Energy of the frequency of generator 532 will be reflected to terminals 534 and 536 in push-push relationship due to the effect of the additional quarter wavelength section 546 and will not affect the operation of generator 532. This energy will instead be directed to terminals 537, 517 and then to a terminating element 541 connected to terminal 518 of the arrangement. No interaction will be had with generator 531 because of the push-push relationship and no reflection will take place at terminals 561 and 562 because filter elements 551 and 552 are open circuit for energy of this frequency. Some reflection of energy at the frequency of generator 531 may take place from radiator elements 571 and 572. This energy will arrive at terminals 534 and 536 in push-pull relationship, in which case however, there will be little ill effect on generator 532 from a practical stand point. Cancellation of the push-pull energy will occur at terminals 537 and 517 and no interaction will be had with generator 531. Also any loss in circularity that might occur at the aural frequency is of no practical importance with the arrangement shown.

A practical embodiment of the arrangement schematically shown in Fig. 5 may be constructed as shown in Fig. 6 along the lines of Figs. 3 and 4. A pair of balanced-to-unbalanced converters 601—602 are arranged to present push-pull outputs from both the aural and visual signal transmitters 631 and 632, respectively and the other input terminals are interconnected by a length of coaxial transmission line 625. The turnstile antenna transmission lines 642—644 are connected to the balanced output terminals of the converter 602. The reflection filter system comprising filters 651*a*, 651*b*, 652*a* and 652*b* is connected to the balanced output terminals of the aural signal bridging network 691 by means of coaxial transmission lines 627 and 628. A resistive absorber unit 641 is connected in parallel to the resulting loop of transmission line on which the reflection filters are connected, formed by joining lines 627 and 628 together at point 618. No balanced-to-unbalanced line converter is necessary at this point, since the absorber device 641 is connected in push-push to the circuit.

The invention claimed is:

1. A transmission line circuit arrangement for selective transmission of radio frequency energy within a wide band of frequencies, including a balanced-to-unbalanced transmission line converter having a pair of balanced terminals, a pair of transmission lines connected to said balanced terminals of said converter, a resistive element coupled to both of said transmission lines at the ends thereof remote from said converter, each of said transmission lines having a reactance network coupled thereacross at a prearranged point, the distances from said converter to said prearranged points differing by a quarter wavelength at a predetermined frequency, and said reactance network presenting a low impedance across said lengths of transmission line at said predetermined frequency and a high impedance at substantially all other frequencies within said band of frequencies.

2. A transmission line circuit arrangement for selective transmission of radio frequency energy within a wide band of frequencies, including a balanced-to-unbalanced transmission line converter having a pair of balanced terminals and two pairs of unbalanced terminals, one pair of said unbalanced terminals being coupled in push-pull to said balanced terminals and the other pair being coupled to the balanced terminals in push-push, a pair of transmission lines connected to balanced terminals of said converter, a resistive element coupled to both of said transmission lines at the ends thereof remote from said converter, each of said transmission lines having a reactance network coupled thereacross at a prearranged point, the distances from said converter to said prearranged points differing by a quarter wavelength at a predetermined frequency, and said reactance network presenting a low impedance across said lengths of transmission line at said predetermined frequency and a high impedance at substantially all other frequencies within said band of frequencies.

3. A transmission line circuit arrangement for selective transmission of radio frequency energy within a broad band of frequencies, including a pair of balanced-to-unbalanced transmission line converters each having a pair of balanced terminals, equal lengths of transmission line interconnecting the balanced terminals of one of said converters to the corresponding terminals of the other of said converters, each of said lengths of transmission line having a reactance network connected thereacross at a predetermined point, the distances from one of said converters to said predetermined points differing by a quarter wavelength at a desired operating frequency, and said reactance network presenting a low impedance across said lengths of transmission line at said desired frequency and a high impedance at substantially all other frequencies within said band of frequencies.

4. A transmission line circuit arrangement for selective transmission of radio frequency energy within a broad band of frequencies, including a pair of balanced-to-unbalanced transmission line converters, each of said converters having a pair of balanced terminals and two pairs of unbalanced terminals, one of said pairs of unbalanced terminals being coupled in push-push to said balanced terminals and the other pair being coupled in push-pull to said balanced terminals, equal lengths of transmission line interconnecting the balanced lines of one of said converters to the corresponding balanced lines of the other of said converters, each of said lengths of transmission line having a reactance network connected thereacross at a predetermined point, the distances from one of said converters to said predetermined points differing by a quarter wavelength at a desired operating frequency, and said reactance network presenting a low impedance across said lengths of transmission line at said desired frequency and a high impedance at substantially all other frequencies within said band of frequencies.

5. A transmission line circuit arrangement for selective transmission of radio frequency energy within a broad band of frequencies, including a pair of balanced-to-unbalanced transmission line converters, each of said converters having a pair of balanced terminals and two pairs of unbalanced terminals, one of said pairs of unbalanced

terminals being coupled in push-push to said balanced terminals and the other pair being coupled in push-pull to said balanced terminals, equal lengths of transmission line interconnecting the balanced terminals of one of said converters to the corresponding balanced terminals of the other of said converters, each of said lengths of transmission line having a reactance network connected thereacross at a predetermined point, the distances from one of said converters to said predetermined points differing by a quarter wavelength at a desired operating frequency, and said reactance network presenting a low impedance across said lengths of transmission line at said desired frequency and a high impedance at substantially all other frequencies within said band of frequencies, means to couple a source of energy to the pair of unbalanced terminals coupled in push-pull to balance terminals of one of said converters, means to couple a utilization device to corresponding unbalanced terminals of the other of said converters, means to couple a further source of energy of said desired frequency to the remaining unbalanced terminals of said other converter and means to couple an absorber device to the remaining terminals of said one converter.

6. A notch filter circuit arrangement, including an unbalanced output transmission line, an unbalanced input transmission line, a balanced-to-unbalanced transmission line converter coupled to said transmission lines and having balanced terminals coupled in push-push relationship to said output transmission line and in push-pull relationship to said input transmission line, lengths of transmission line connected to said balanced terminals, said lengths differing by a quarter wavelength at the frequency of energy applied to said input transmission line, and reflection filters coupled to said lengths of transmission line, said filters being tuned to present a short circuit to said lengths of transmission line at said frequency.

7. A transmission line arrangement for coupling two sources of energy to a given unbalanced transmission line substantially without interaction, including a length of unbalanced transmission line, means to couple a source of energy to said length of unbalanced transmission line at one end thereof, said given unbalanced transmission line and said length of unbalanced transmission line each being terminated in a balanced terminal arrangement, equal lengths of transmission line interconnecting the balanced terminals of said terminating arrangements to couple said length of unbalanced transmission line to said given unbalanced transmission line for said source of energy, means to couple another source to energy to said given transmission line to present energy at the balanced terminals of the balanced terminal arrangement terminating said given unbalanced transmission line in a phase relationship preventing transmission over said given unbalanced transmission line, means to transform the phase of energy from said other source to enable transmission over said given unbalanced transmission line, said means comprising a pair of reflection filters connected to said equal lengths of transmission line at points spaced from both of said terminal arrangements by distances differing by a quarter wavelength at the frequency of said other source of energy, said reflection filters presenting a substantially short circuit at the frequency of said other source of energy to said equal lengths of transmission line, and an absorber network coupled to the balanced terminal arrangement terminating said length of unbalanced transmission line.

8. A notch filter circuit arrangement, including an unbalanced output transmission line, an unbalanced input transmission line, a balanced-to-unbalanced transmission line converter coupled to said transmission lines and having balanced terminals coupled in push-push relationship to said output transmission line and in push-pull relationship to said input transmission line, lengths of transmission line connected to said balanced terminals, said lengths differing by a quarter wavelength at the frequency of energy applied to said input transmission line, reflection filters coupled to said lengths of transmission line, said filters being tuned to present a short circuit to said lengths of transmission line at said frequency, further lengths of transmission line intercoupling the first said lengths of transmission line, and means to couple an absorber device across said further lengths of transmission line, said further lengths of transmission line differing by a quarter wavelength at said frequency.

9. A transmission line circuit arrangement for selective transmission of radio frequency energy within a wide band of frequencies, including a balanced-to-unbalanced coaxial transmission line converter having a pair of balanced terminals, a pair of coaxial transmission lines connected to said balanced terminals of said converter, a resistive element coupled to both of said transmission lines at the ends thereof remote from said converter, said resistive element having a value determined by the characteristic impedance of said transmission lines, each of said coaxial transmission lines having a reactance network coupled thereacross at a prearranged point, the distances from said converter to said prearranged points differing by a quarter wavelength at a predetermined frequency, and said reactance network presenting a low impedance across said lengths of coaxial transmission line at said predetermined frequency and a high impedance at substantially all other frequencies within said band of frequencies.

10. A transmission line circuit arrangement for selective transmission of radio frequency energy within a broad band of frequencies, including a pair of balanced-to-unbalanced coaxial transmission line converters, each of said converters having a pair of balanced coaxial transmission line terminals and two pairs of unbalanced coaxial transmission terminals, one of said pairs of unbalanced terminals being coupled in push-push to said balanced terminals and the other pair being coupled in push-pull to said balanced terminals, equal lengths of coaxial transmission line interconnecting the balanced terminals of one of said converters to the corresponding balanced terminals of the other of said converters, each of said lengths of coaxial transmission line having a reactance network connected thereacross at a predetermined point, the distances from one of said converters to said predetermined points differing by a quarter wavelength at a desired operating frequency, said reactance networks each comprising a tuned transmission line circuit having an inner conductor substantially a quarter wavelength long at said desired operating frequency, an outer conductor surrounding said inner conductor and a length of coaxial transmission line having one end of the central

conductor thereof arranged as a coupling loop within said outer conductor to present a low impedance across said lengths of transmission line at said desired frequency and a high impedance at substantially all other frequencies within said band of frequencies, means to couple a source of energy to the pair of unbalanced terminals coupled in push-pull to balanced terminals of one of said converters, means to couple a utilization device to corresponding unbalanced terminals of the other of said converters, means to couple a further source of energy of said desired frequency to the remaining unbalanced terminals of said other converter and means to couple a resistive absorber device to the remaining terminals of said one converter.

11. A transmission line circuit arrangement for selective transmission of radio frequency energy at given and predetermined frequencies, including a balanced-to-unbalanced coaxial transmission line converter having a pair of balanced terminals and two pairs of unbalanced terminals, one pair of said unbalanced terminals being coupled in push-pull to said balanced terminals and the other pair being coupled in push-push to said balanced terminals, a pair of coaxial transmission lines connected to balanced terminals of said converter, a resistive element coupled to both of said coaxial transmission lines at the ends thereof remote from said converter, each of said coaxial transmission lines having a reactance network coupled thereacross at a prearranged point, the distances from said converter to said prearranged points differing by a quarter wavelength at said predetermined frequency, and said reactance networks comprising a length of transmission line a half wavelength long at said predetermined frequency and a further length of transmission line a quarter wavelength long at said predetermined frequency coupling the point on said coaxial transmission line to a point on said length of transmission line a quarter wavelength from one end at said given frequency to present a low impedance across said lengths of coaxial transmission line at said predetermined frequency and a high impedance at substantially all other frequencies within said band of frequencies.

12. A notch filter arrangement for use in selectively transmitting energy over a wide band of frequencies, including a balanced-to-unbalanced transmission line converter having a pair of balanced transmission line terminals coupled in push-push to unbalanced output transmission line terminals and in push-pull to unbalanced input transmission line terminals, a loop of coaxial transmission line having the ends thereof connected to the balanced terminals of said converter, means to couple an absorber device across the transmission line forming said loop at substantially the midpoint of the loop, and a pair of reflection filter circuits coupled across the transmission line forming said loop at further points on either side of said midpoint, the distances from said midpoint to each of said further points differing by a quarter wavelength at the frequency of the energy applied to said unbalanced input transmission line terminals, said filter circuits being tuned to provide a substantially short circuit at the frequency of energy applied to said unbalanced input transmission line terminals and a high impedance at substantially all other frequencies within said band of frequencies.

13. A transmission line circuit arrangement for selective transmission of radio frequency energy at given and predetermined frequencies, including a pair of balanced-to-unbalanced coaxial transmission line converters, each of said converters having a pair of balanced coaxial transmission line terminals and two pairs of unbalanced coaxial transmission line terminals, one of said pairs of unbalanced terminals being coupled in push-push to said balanced terminals and the other pair being coupled in push-pull to said balanced terminals, equal lengths of coaxial transmission line interconnecting the balanced terminals of one of said converters to the corresponding balanced terminals of the other of said converters, each of said lengths of coaxial transmission line having a reactance network connected thereacross at a predetermined point, the distances from one of said converters to said predetermined points differing by a quarter wavelength at said predetermined frequency, said reactance networks each comprising a tuned transmission line circuit having concentric inner, outer and sheath conductors interconnected by shorting members to tune the network to series resonance at said given frequency and to parallel resonance at said predetermined frequency, thereby to present a low impedance across said lengths of transmission line at said predetermined frequency and a high impedance at said given frequency, means to couple a source of energy to the pair of unbalanced terminals coupled in push-pull to balanced terminals of one of said converters, means to couple a utilization device to corresponding unbalanced terminals of the other of said converters, means to couple a further source of energy of said desired frequency to the remaining unbalanced terminals of said other converter and means to couple a resistive absorber device to the remaining terminals of said one converter.

14. A transmission line structure, including a loop of coaxial transmission line having an inner and an outer conductor, said inner conductor being in two parts effective to divide said loop into two equal length sections, a pair of balanced-to-unbalanced transmission line converters having four coaxial transmission line connectors each, two of said connectors having the center conductors thereof in balanced relationship, another of said connectors having the center conductor arranged in push-pull relationship to said balanced center conductors and the remaining connector having the center conductor arranged in push-push relationship to said balanced center conductors, adjacent ends of the parts of said inner conductors being connected to balanced conductors of said converters, and reflection filters connected to each section of said transmission line loop at points located at distances differing a quarter wavelength at the desired operating frequency from either of said converters.

15. A transmission line structure for selective transmission at given and prearranged frequencies, including a loop of coaxial transmission line having an inner and an outer conductor, said inner conductor being in two parts effective to divide said loop into two equal length sections, a pair of balanced-to-unbalanced transmission line converters having four coaxial transmission line connectors each, two of said connectors having the center conductors thereof in balanced relationship, another of said connectors having the center conductor arranged in push-pull relationship to said balanced center conductors and the remaining connector having the center con-

ductor arranged in push-push relationship to said balanced center conductors, adjacent ends of the parts of said inner conductors being connected to balanced conductors of said converters, and reflection filters connected to each section of said transmission line loop at points located at distances differing a quarter wavelength at said prearranged frequency from either of said converters, said filters comprising lengths of open-ended coaxial transmission line a half wavelength long at said prearranged frequency, further lengths of transmission line a quarter wavelength long at said prearranged frequency coupled at one end to said length of open-ended transmission line at a point one quarter wavelength at said given frequency from one end, the other ends of said further lengths of transmission line being connected to said loop of coaxial transmission line at said spaced points.

16. A transmission line structure for selective transmission at given and prearranged frequencies, including a loop of coaxial transmission line having an inner and an outer conductor, said inner conductor being in two parts effective to divide said loop into two equal length sections, a pair of balanced-to-unbalanced transmission line converters having four coaxial transmission line connectors each, two of said connectors having the center conductors thereof in balanced relationship, another of said connectors having the center conductor arranged in push-pull relationship to said balanced center conductors and the remaining connector having the center conductor arranged in push-push relationship to said balanced center conductors, adjacent ends of the parts of said inner conductors being connected to balanced conductors of said converters, and reflection filters connected to each section of said transmission line loop at points located at distances differing a quarter wavelength at said prearranged frequency from either of said converters, said filters comprising lengths of coaxial transmission line a half wavelength long at said prearranged frequency and short circuited at one end, further lengths of transmission line coupled at one end to said length of transmission line near one end thereof, the other ends of said further lengths of transmission line being coupled to said loop of coaxial transmission line at said spaced points.

17. A transmission line structure, including a loop of coaxial transmission line having an inner and an outer conductor, said inner conductor being in two parts effective to divide said loop into two equal length sections, a pair of balanced-to-unbalanced transmission line converters having four coaxial transmission line connectors each, two of said connectors having the center conductors thereof in balanced relationship, another of said connectors having the center conductor arranged in push-pull relationship to said balanced center conductors and the remaining connector having the center conductor arranged in push-push relationship to said balanced center conductors, adjacent ends of the parts of said inner conductors being connected to balanced conductors of said converters, and reflection filters connected to each section of said transmission line loop at points located at distances differing a quarter wavelength at the desired operating frequency from either of said converters, said filters comprising concentric conductor assemblies having an inner conductor connected at one end to the inner conductor of said loop, an intermediate conductor and a sheath conductor connected at one end to the sheath of said loop, the inner and intermediate conductors and the intermediate and the sheath conductors being interconnected at the ends thereof remote from the connections to said coaxial transmission line loop to form series connected circuits, one of said circuits being tuned to series resonance at said given frequency and said other circuit being tuned to parallel resonance across said coaxial transmission line loop at said prearranged frequency.

18. A transmission line structure, including a loop of coaxial transmission line having an inner and an outer conductor, said inner conductor being in two parts effective to divide said loop into two equal length sections, a pair of balanced-to-unbalanced transmission line converters having four coaxial transmission line connectors each, two of said connectors having the center conductors thereof in balanced relationship, another of said connectors having the center conductor arranged in push-pull relationship to said balanced center conductors and the remaining connector having the center conductor arranged in push-push relationship to said balanced center conductors, adjacent ends of the parts of said inner conductors being connected to balanced conductors of said converters, and reflection filters connected to each section of said transmission line loop at points located at distances differing a quarter wavelength at the desired operating frequency from either of said converters, said filters each having two sections, the sections of each of said filters being connected to said coaxial transmission line loop at intervals of substantially one-tenth of a wavelength at said desired operating frequeny.

19. A power equalizing notch diplexer circuit arrangement for a two-element radiator antenna system, including first and second balanced-to-unbalanced transmission line converters each having a pair of balanced transmission line connections, a set of unbalanced transmission line connections coupled in push-pull to said balanced connections and a set of unbalanced transmission line connections coupled in push-push to said balanced transmission line connections, means to couple sources of energy of prearranged and predetermined frequency to said push-pull connections, said push-push connections being coupled together, means to couple the radiator elements of said antenna system to the balanced coaxial transmission line connections of one of said line balance converters, a loop of coaxial transmission line having the ends thereof connected to the balanced coaxial transmission line terminals of the other of said line balance converters, means to connect an absorber device across said coaxial transmission line loop at substantially the midpoint thereof, and reflection filter circuits connected across said coaxial transmission line loop at points spaced from said midpoint by distances differing by a quarter wavelength at the frequency of the source connected to the same line balance converter, said reflection filters presenting a substantially short circuit impedance to energy of the last said frequency.

20. A transmission line circuit arrangement for selective transmission of radio frequency energy within a wide band of frequencies, including a balanced-to-unbalanced transmission line converter having a pair of balanced terminals and at least one pair of unbalanced terminals coupled to the balanced terminals in push-push relationship, a pair of transmission lines connected to

said balanced terminals of said converter, a resistive element coupled to both of said transmission lines at the ends thereof remote from said converter, each of said transmission lines having a reactance network coupled thereacross at a prearranged point, the distances from said converter to said prearranged points differing by an odd multiple including unity of a quarter wavelength at a predetermined frequency, and said reactance network presenting a low impedance across said lengths of transmission line at said predetermined frequency and a high impedance at substantially all other frequencies.

21. A transmission line circuit arrangement for selective transmission of radio frequency energy within a broad band of frequencies, including a pair of balanced-to-unbalanced transmission line converters, each of said converters having a pair of balanced terminals and at least one pair of unbalanced terminals coupled in push-push to said balanced terminals, equal lengths of transmission line interconnecting the balanced lines of one of said converters to the corresponding balanced lines of the other of said converters, each of said lengths of transmission line having a reactance network connected thereacross at a predetermined point, the distances from one of said converters to said predetermined points differing by an odd multiple including unity of a quarter wavelength at a desired operating frequency, and said reactance network presenting a low impedance across said lengths of transmission line at said desired frequency and a high impedance at substantially all other frequencies.

22. A notch filter circuit arrangement, including an unbalanced output transmission line, an unbalanced input transmission line, a balanced-to-unbalanced transmission line converter coupled to said transmission lines and having balanced terminals coupled in push-push relationship to said output transmission line and in push-pull relationship to said input transmission line, lengths of transmission line connected to said balanced terminals, said lengths differing by an odd multiple including unity of a quarter wavelength at the frequency of energy applied to said input transmission line, and reflection filters coupled to said lengths of transmission line, said filters being tuned to present a short circuit to said lengths of transmission line at said frequency.

23. A diplexer for the selective transmission of radio frequency energy within a band of frequencies, comprising two physically parallel transmission line sections, conducting means bridging said line sections at the ends thereof, means for cophasally feeding said line sections with radio frequency energy near one end thereof, means for feeding said line sections out-of-phase with radio frequency energy near the other end thereof, and a cavity type reflection filter adapted to have a periodically repeating electromagnetic field therein connected to each line section, the distances along said line sections as measured from one of said feed points to said filters differing by approximately an odd multiple of a quarter wave at the frequency of the radio frequency energy fed by one of said means.

24. A circuit arrangement for diplexing two waves of radio frequency energy, one wave having a wider frequency band than the other and extending into the narrower frequency band of the other, comprising two electric circuit paths, means to apply energy of said wave of the narrower frequency band to said two paths in push-push relationship, means connected in said two paths at given points for reflecting a major portion of said last energy from said points on said paths in push-pull relationship, means to apply energy of said wave of the wider frequency band to said two paths in push-pull relationship, said reflecting means also reflecting a major portion of those components of said wider frequency band whose frequencies center about or are close to the narrower frequency band from said points on said paths in push-push relationship, means connected to said two paths for dissipating said push-push energy, and means coupled to said two paths for utilizing said push-pull energy.

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