Sept. 9, 1958 J. G. McCANN 2,851,665

LOSSLESS RADIO FREQUENCY POWER MIXER

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Fig. 1

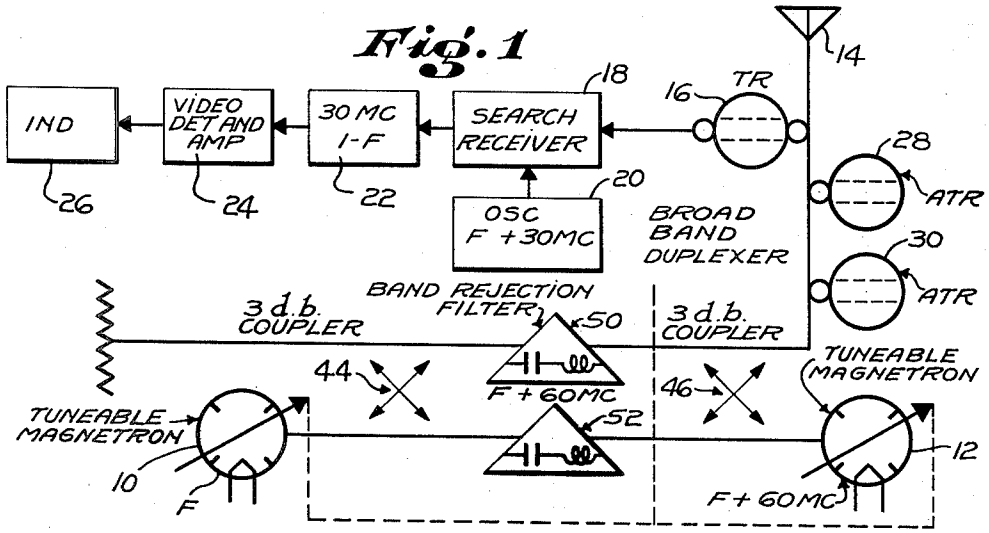


Fig. 2

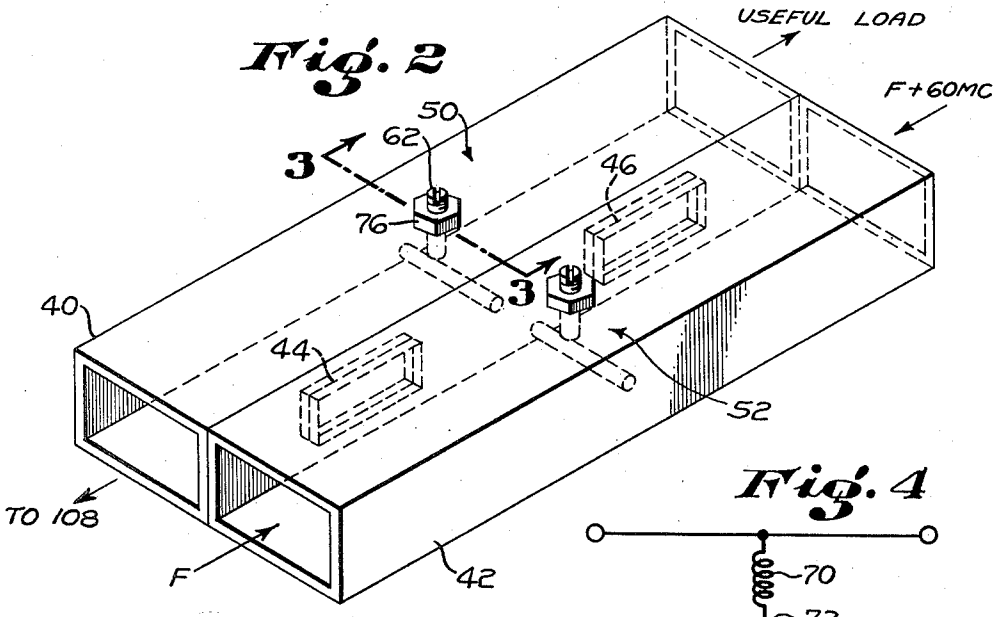


Fig. 3

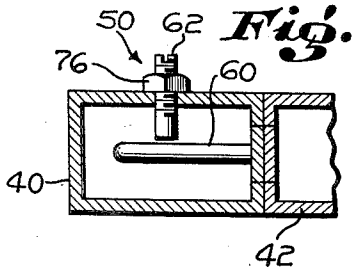


Fig. 4

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Fig. 5

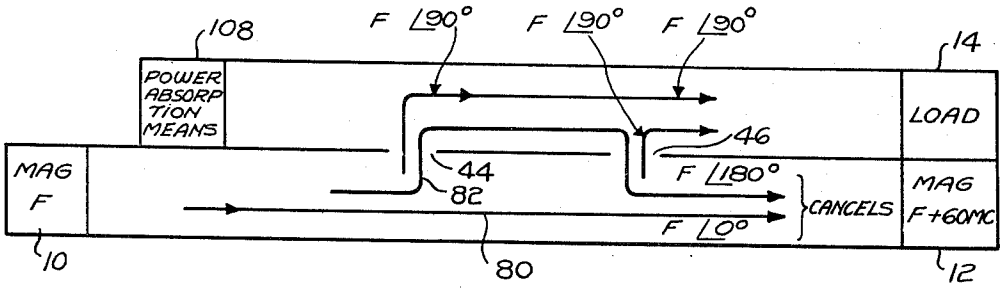


Fig. 6

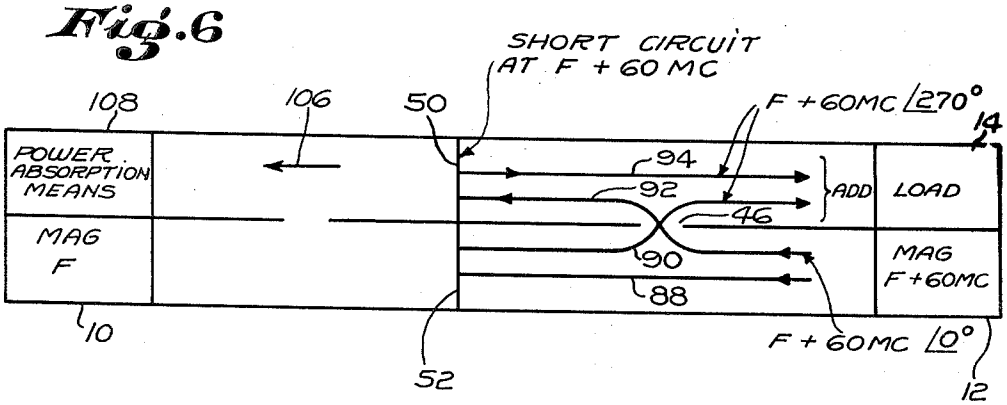
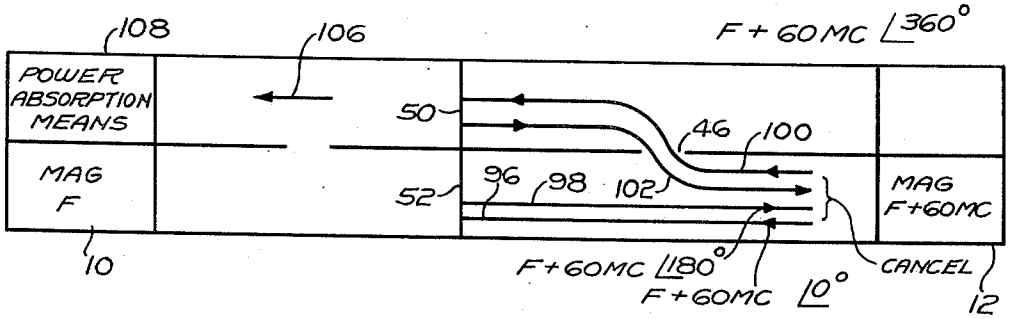


Fig. 7



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LOSSLESS RADIO FREQUENCY POWER MIXER

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5 Claims. (Cl. 333—9)

The present invention relates to the improved means and techniques for coupling efficiently a pair of sources of different frequency to a common load such as a radar antenna.

Oftentimes it is desirable to mix energies from a pair of sources of different frequencies and to apply the energies so mixed to a common load. This result is desirably accomplished without appreciable loss in energy and without one source inter-acting on the other source in such a manner that the frequency oscillations developed in the sources is not altered by virtue of the interconnection. This is particularly true when microwave energy developed by the use of magnetrons is mixed and applied to common antenna. In other words, it is desirable that not only should there be an efficient transfer of energy from each of the sources to the common load but also there should be no undesirable inter-action between the sources which may otherwise result, for example, in undesirable shifting of frequency or inefficient operation of the magnetrons. It is, therefore, a general object of the present invention to provide improved means and techniques whereby the abovementioned desideratum is obtained.

A specific object of the present invention is to provide an improved arrangement of wave guides, coupling between the same and associated filters for efficiently transferring energy from a pair of magnetrons operating at different frequencies to a common load.

Another specific object of the present invention is to provide improved means and techniques for mixing energy of different microwave frequencies.

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

Figure 1 represents a system embodying features of the present invention.

Figure 2 shows apparatus incorporating features of the present invention used in the system illustrated in Figure 1.

Figure 3 is a sectional view taken substantially on the line 3—3 of Figure 2.

Figure 4 illustrates the electrical equivalent of the mechanical arrangement illustrated in Figure 3.

Figure 5 illustrates the manner in which the energy developed by the magnetrons operating at frequency F is applied to the common load.

Figure 6 illustrates the manner in which energy developed by the magnetrons operating at a frequency $F+60$ megacycles as applied to the common load.

Figure 7 illustrates the manner in which some of the energy developed by the magnetron operating at a frequency $F+60$ megacycles is prevented from having deleterious effects on the magnetron.

As shown in Figure 1, the system includes a pair of

sources having different oscillation frequencies supplying energy to a common load. One of such sources is represented by the magnetron 10 developing energy of frequency F. The other or second source is represented by the magnetron 12 operating at a frequency of $F+60$ megacycles. The common load is represented by the radar antenna 14. The energy transferred to the antenna 14 is in the nature of short pulses and causes reflections from reflecting objects thus illuminated by the energy transmitted from the antenna 14. These reflections, in the form of echo signals, are applied through a conventional tune-receive switch 16 and applied to the input terminal of the so-called search receiver 18 having a local oscillator 20 operating at a frequency $F+30$ megacycles. Due to superheterodyne action, a 30 megacycle signal is produced and applied to the intermediate frequency amplifier 22. The video is detected in the stage 24 and applied to a cathode ray tube type of indicator 26. The energy in these received echo signals, as received on the antenna 14, is prevented from being appreciably dissipated using conventional techniques involving the ATR devices 28 and 30.

In accordance with improved features of the present invention, the energy developed using the magnetrons 10 and 12 is applied to a mixing or coupling arrangement illustrated in Figure 2.

The structure illustrated in Figure 2 comprises essentially a pair of rectangular wave guide elements 40 and 42 in side by side relationship, with their axes extending parallel. Apertured portions 44 and 46 serve to allow the transfer of microwave energy from one wave guide 40 to the other wave guide 42, and vice versa. These apertured portions 44 and 46 are spaced along the length of the wave guides 40 and 42 and comprise energy coupling means. One end of the wave guide 42 is in communication with the magnetron 10 so as to receive energy of frequency F therefrom as indicated in Figure 2, while the other end of the wave guide 42 is in communication with the other magnetron 12 to receive energy having a frequency $F+60$ megacycles.

Band rejection filter means 50 and 52 are disposed between the apertured portions 44 and 46, the filter means 50 being disposed in the wave guide 40 and the filter means 52 being disposed in the other wave guide 42. Such filter means is preferably adjustable and is of the form illustrated in Figure 3, it being understood that, while the drawings show only one filter element, preferably each filter means 50 and 52 comprises a plurality of structures of the character illustrated in Figure 3, with the elements in each filter means 50 and 52 spaced relatively close to each other and between, of course, apertured portions 44 and 46. As shown in Figure 3, each of the filter elements comprises a cantilever supported rod 60 affixed to one vertical wall of the wave guide 40 with an adjusting screw 62 threaded into horizontal extending wall, using suitable bushing means if desired, so as to adjustably position the lower end of the screw or bolt 62 above and in alignment with the rod 60. The electrical equivalent of the mechanical arrangement shown in Figure 3 is illustrated in Figure 4 and it is observed that it is considered to be a series tuned circuit comprising inductance 70 and condenser 72, such tuned circuit being resonant at the frequency $F+60$ megacycles. Such adjustment being effected by positioning the screw or bolt 60 after which it is locked in place by the locking nut 76.

The apertured portions 44 and 46 provide for the transfer of one-half the power from the one wave guide 40, to the other wave guide 42 and the energy thus transferred through the apertured portions 44 and 46 may be considered to have its phase shifted by an angle of 90

degrees as represented in Figure 5. Furthermore, energy of frequency $F+60$ megacycles which is reflected from the band rejection filter means **50** and **52** may be considered to have its phase shifted or reversed by an angle of 180 degrees. Thus, considering the energy of frequency F developed using the magnetron **10**, the energy may be considered to flow along the different paths illustrated in Figure 5. It is considered that the energy from the magnetron **10** has a zero phase angle. The energy of such phase may travel as indicated by the line **80** in the direction of the other magnetron **12**, but this energy is effectively cancelled out by the energy which travels in the direction indicated by the line **82**, extending through the apertured portions **44** and **46** where the two phase reversals of 90 degrees result in energy having a phase of 180 degrees so as to effectively cancel the energy having zero phase. In this respect, it is observed that the band rejection filter means **50** and **52** is considered not to have any effect on the transfer of energy at frequency F. The load **14** receives energy which, on the one hand passes through the apertured portion **44**, and which passes on the other hand through the apertured portion **46**, and these two energies are additive in that they both have the same phase, namely, a 90 degree phase. The result is, thus, that substantially none of the energy of frequency F is transferred to the source represented by the magnetron **12** but all of the energy theoretically, at least, developed by the magnetron **10** is transferred to the load **14**. The same result is obtained considering the source **12**, as now described in connection with Figures 6 and 7.

The energy of frequency $F+60$ megacycles developed in the source **12** is prevented from having deleterious effects on the source **10** or of being dissipated by source **10** by virtue of the filter means **50** and **52** serving to prevent transfer of energy having a frequency $F+60$ megacycles. The energy of frequency $F+60$ megacycles is transferred to the load **14** after reflection from the filter means **50** and **52** so that the energy arriving at the load **14** is considered to have a phase of 270 degrees, i. e., 90+180 degrees. A first path for such energy is indicated by the lines **88** and **90** in Figure 6 and a second path is represented by the lines **92** and **94**. Each of said paths involve a reflection, i. e., a phase shift of 180 degrees, and on passage through the apertured portion **46** undergoes an additional phase shift of 90 degrees. Likewise, as shown in Figure 7, some of the energy from source **12** is considered to be directed as indicated by the lines **96** and **98** so that the energy after reflection from the filter **52** returns with a phase of 180 degrees. On the other hand, as indicated by the paths **100** and **102**, some of the energy is considered to pass through the apertured portion **46**, be reflected from the filter means **50**, pass again through the apertured portion **46** and return to the source **12** with a phase of 360 or zero degrees, i. e., 90+180+90. The result, thus, is that there is cancellation and all the energy supplied from the source **12** is applied to a useful purpose, namely, to the load **14**.

Due to mechanical inaccuracies, lack of sufficient sharpness in the filter means **50** and **52**, as well as other factors, some energy may flow in the direction indicated by the arrow **106** in Figures 6 and 7, and in order to absorb such energy or power, considered to result from unbalanced or imperfect elements, suitable power absorption means **108** is disposed in communication with one end of the wave guide **40**, the other end of the wave guide **40**, of course, being in communication with the load or antenna **14**.

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

I claim:

1. For use in an arrangement wherein it is desired to couple sources of different frequencies to a common load, the subcombination comprising a first wave guide, a first and a second source in direct communication respectively at opposite ends of said first wave guide, a second wave guide, said load being directly in communication with said second wave guide, first coupling means between first points on said first and second wave guides, second coupling means between second points on said first and second wave guides and band rejection frequency selective filter means disposed in each one of said wave guides and between said first and second points on each wave guide said first and second sources having different frequencies, said filter means being tuned to the frequency of said second source.

2. In an arrangement of the character described, a first source of electrical oscillations, a second source of electrical oscillations having a frequency different from the frequency of oscillations of said first source, a common load adapted to receive energy from said first and second sources, means coupling said first and second sources to said load, said means comprising, a pair of wave guides, coupling means coupling first and second points of each of said first and second wave guides, band rejection frequency selective filter means disposed in each of said guides between said first and second points of each guide, one of said guides having one of its ends in direct communication with said first source and having the other one of its ends in direct communication with said second source, and the other one of said wave guides being in communication with said load, said filter means being tuned to the frequency of said second source.

3. In a system of the character described, a first source of electrical oscillations, a second source of electrical oscillations having a frequency different from the oscillations of said first source, a load, first band rejection frequency selective filter means, second band rejection frequency selective filter means, a first wave guide, a second wave guide, first coupling means between said wave guides, second coupling means between said wave guides, said filter means being tuned to the frequency of said second source, each of said sources being directly coupled to said one wave guide at opposite ends thereof, said load being coupled to said other wave guide, and said filter means in each wave guide being disposed between said first and second coupling means.

4. In an arrangement of the character described, a first source of electrical oscillations, a second source of electrical oscillations having a frequency different from the oscillations of said first source, a common load adapted to receive energy from said first and second sources, means coupling said first and second sources to said load, said means comprising a pair of wave guides, spaced coupling means coupling spaced points of the wave guides for the transfer of energy from one to the other and vice versa, one of said wave guides having one of its ends in direct communication with said first source and having the other one of its ends in direct communication with said second source, first band rejection frequency selective filter means in one of said wave guides disposing between said spaced coupling means, second band rejection frequency selective filter means in the other one of said wave guides disposed between said spaced coupling means, each of said filter means being tuned to the frequency of said second source and said load being in communication with said second wave guide.

5. In an arrangement of the character described, a first source of electrical oscillations, a second source of electrical oscillations having a frequency different from the oscillations of said first source, a common load adapted to receive energy from said first and second sources, means coupling said first and second sources to said load,

said means comprising, a pair of hollow generally rectangular wave guides extending generally parallel in side by side relationship, a pair of apertured portions interconnecting said pair of wave guides at spaced points along the length of the same for the transfer of energy from one to the other and vice versa, one of said wave guides having one of its ends in direct communication with said first source and having the other one of its ends in direct communication with said second source, first band rejection frequency selective filter means in one of said wave guides disposing between said apertured portions, second band rejection frequency selective filter means in the other one of said wave guides disposing between said apertured portions, each of said filter means being tuned to the frequency of said second source, and said load being in communication with said second wave guide.

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