Feb. 14, 1956 D. D. GRIEG 2,735,073

BANDPASS FILTER SYSTEM

Filed Aug. 2, 1952

Fig. 1

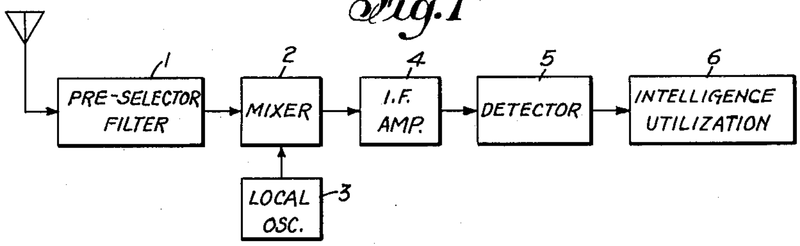


Fig. 2

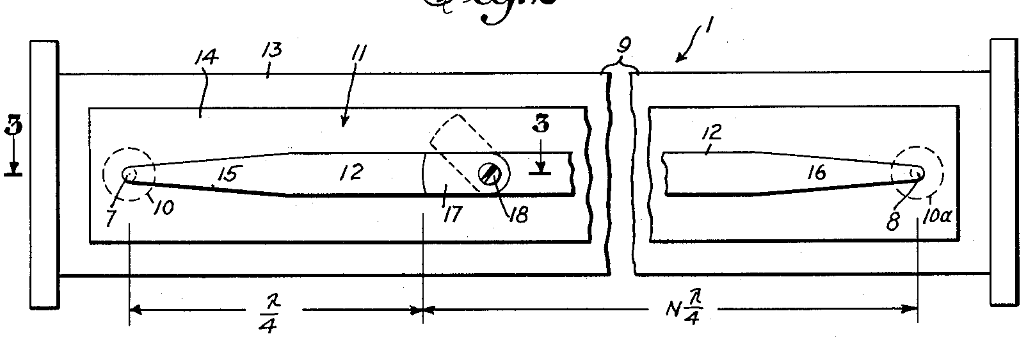


Fig. 3

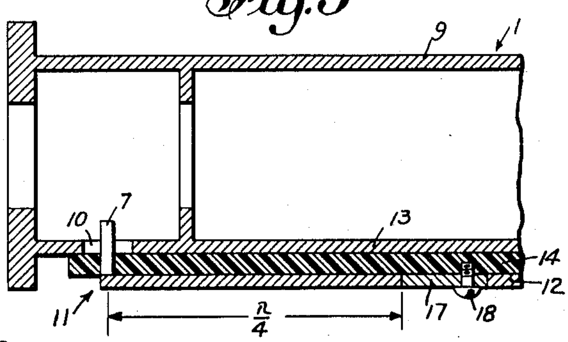
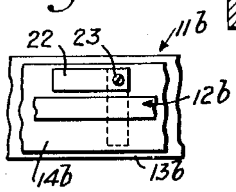


Fig. 5



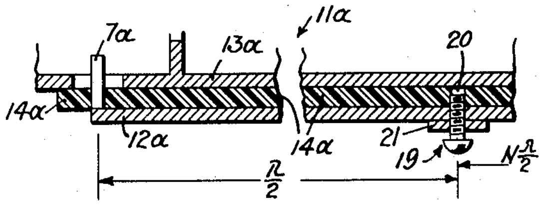


Fig. 4

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BANDPASS FILTER SYSTEM

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Application August 2, 1952, Serial No. 302,293

16 Claims. (Cl. 333—73)

This invention relates to microwave bandpass filter systems employing means to bypass a portion of received signal energy about a microwave filter to afford ease of tuning the filter and associated equipment over a wide-band of microwave frequencies.

In my copending application, Serial No. 302,292, filed August 2, 1952, entitled "Bandpass Filter," I disclose a microwave band pass filter system comprising a filter, signal input means and output means for the filter in combination with means to provide a by-pass communication about the filter directly between the input and output means. The purpose of this by-pass connection is to by-pass a small portion of the signal energy about the filter to reduce the selectivity of the filter during tuning adjustments of the filter and associated circuitry over a wide band of microwave frequencies. The by-pass connection is provided with means for controlling the by-pass communication so that it may be terminated after the tuning operation thereby introducing the selectivity characteristics of the filter. The by-pass communication is provided with means for controlling the coupling of such lines with respect to the input and output portions of the filter or by interrupting the line or by effecting a short at the point of coupling.

The object of the present invention is to provide a further specie of the bandpass filter and by-pass control system disclosed in the aforesaid copending application.

One of the features of the present invention is the provision of a transmission line of parallel strip form, wherein one of the conductors may comprise a wall of the filter. Another feature comprises the simple means for controlling the by-pass communication, one form of which may comprise means in the by-pass line which produces either an opening or a short, as the case may be, in the line at a point such as to produce an effective short at the point of coupling, and in another form to provide an attenuator movable to a line attenuating position such as to absorb the small portion of energy coupled to the by-pass transmission line.

The above mentioned and other features and objects of this invention and the manner of attaining them will become more apparent by reference to the following description taken in conjunction with the accompanying drawings, in which:

Fig. 1 is a block diagram of a heterodyne receiver employing a bandpass filter system according to the principles of this invention;

Fig. 2 is a side view of a bandpass filter system employed in the receiver of Fig. 1;

Fig. 3 is a fragmentary sectional view taken along line 3—3 of Fig. 2;

Fig. 4 is a fragmentary sectional view illustrating another embodiment of the means controlling the by-pass communication which may be incorporated with the transmission line of Fig. 2; and

Fig. 5 is a plan view of a further embodiment of the means controlling the by-pass communication which may be incorporated with the transmission line of Fig. 2.

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Referring to Fig. 1, a simple block diagram of a microwave heterodyne receiver is illustrated comprising a preselector filter **1**, a mixer **2**, and local oscillator **3**, an IF amplifier section **4**, a detector **5**, and an intelligence utilizing circuit **6**. The units illustrated therein employ conventional microwave circuits arranged in a manner to perform the desired results with the exception of the shunting line included as a portion of filter **1**. The frequency employed may be over any large frequency range in such a system, for instance the range of 4400 to 5000 mc., which is employed herein for descriptive purposes. A signal in this range received by the antenna is coupled to the preselector filter **1**, beat with the local oscillator **3**, such as a klystron oscillator in the mixer **2**. The local oscillator may also operate in the above mentioned frequency range to provide a predetermined intermediate frequency, for instance, in the range of 30 mc. to 100 mc. The remaining circuits **5** and **6** may be arranged in a predetermined manner to recover and utilize the intelligence signals of the audio type, or as more often employed, may be employed in any of the many types of pulse communication links.

Filters employed in the prior art systems inherently made the alignment and tuning of the receiver burdensome and difficult particularly where the filter was extremely selective. Furthermore, the number of tuning adjustments necessitated for the prior art filters are numerous making the tuning procedure of that unit alone very difficult. Therefore, I propose to shunt the filter portion of preselector filter **1** with a by-pass line **7** as shown in Fig. 2 to provide simpler tuning of the filter as well as the overall receiver.

Referring to Figs. 2 and 3, an embodiment of the by-pass means is illustrated wherein the probes **7** and **8** are inserted permanently into the first and last filter sections of a waveguide filter **9** through openings **10** and **10***a*, respectively. Filter **9** comprises a plurality of intercoupled filter sections having signal input means and signal output means associated with the first and last of said sections, respectively. Signal input means and signal output means may comprise in part the first and last sections of the filter, or may comprise a waveguide or coaxial coupling section preceding and succeeding the first and last filter sections of said filter. The transmission line **11** interconnecting probes **7** and **8** is of the "line-above-ground" type including therein a means to control the by-pass communications having conductive segments substantially identical to the transmission line conductors. The details of this type of transmission line incorporating controlling means, substantially as herein illustrated and including other embodiments applicable to the present invention, are disclosed in copending applications, Serial Nos. 227,896, filed May 23, 1951; 234,503, filed June 30, 1951; 280,106, filed April 2, 1952; and 286,764, filed May 8, 1952.

Transmission line **11** is of the printed circuit type comprising a first or "line" conductor **12** and a second or "ground" conductor **13** which herein comprises the wall of the microwave filter **9**, with a layer **14** of dielectric material therebetween.

The so-called "ground conductor," which may be at ground potential or some other given potential, is preferably wider than the line conductor so that the surface thereof provides in effect a mirror image reflection of the line conductor, whereby microwaves can be propagated in substantially the TEM mode therealong. While the ground conductor may be insulated separate from the wall of this filter it can and is shown as comprising a wall of the filter.

The tapered sections **15** and **16** of line conductor **12** provide a means to match the transmission line characteristic impedance to the characteristic impedance of the probe system including probes 7 and 8 extending through layer 14 and openings 10 and 10*a* in wall 13 to couple signal energy from filter 9, establishing the desired by-pass communication whereby easy tuning of the circuitry associated with said filter in a microwave system may be achieved. This small variation in the width of the line conductor may produce variations in the characteristic impedance of transmission line 11 as desired, but the field distribution with respect to the ground conductor is not materially disturbed, or if disturbed it quickly stabilizes itself to provide the desired by-pass communication under the new line conductor conditions.

The means to control the bypass communication shown in Figs. 2 and 3 comprises a pivoted segment 17 substantially identical to the line conductor 12, the segment being pivoted as indicated by pin 18 which may comprise conductive metal or dielectric material. Where the pin 18 is of conductive material it is made short so as not to extend to the wall 13. By keeping such a pin small in diameter and spaced from wall 13 it has substantially no effect on the flow of high frequency energy along the line. For other types of switches that may be used as the means to control the by-pass communication reference may be made to the aforementioned copending application, Serial No. 280,106.

The location of switch 17 in relation to the coupling probes 7 and 8 is important herein to provide proper impedance terminations for the probes when the switch is in open position. To assure in effect a short circuit condition at the probes it is necessary that the open terminals of the switch be located a distance

$$N\frac{\lambda}{4}$$

from each of the probes 7 and 8, where N is equal to an odd integer. Preferably, the opening in conductor 12 caused by switch 17 occurs one quarter wavelength from either one of the probes while the remaining probe may be located any odd number of quarter wavelengths from the switch.

Employing the by-pass means as herein illustrated the probes 7 and 8 remain in the path of signal propagation at all times with the by-pass communication being controlled by means of switch 17, which when opened produces an effective short at the probes. By leaving the coupling probes in the path of signal energy during opening of the switch 17 does not disturb appreciably any alignment and tuning accomplished during by-pass communication.

Referring to Fig. 4, a shorting means 19, shown herein to be a screw, may replace switch 17 of Figs. 2 and 3 to provide means for controlling the by-pass communication. Line conductor 12*a* and dielectric material 14*a* are provided with an aperture 20 which may be threaded for reception of shorting means 19. A stiffening member 21 is also provided contiguous to conductor 12*a* to reduce possible stresses set up in conductor 12*a* upon transverse movement of shorting means 19. To interrupt by-pass communication shorting means 19 is moved transversely into contact with ground conductor 13*a*, thereby shorting line conductor 12*a*. The shorting means 19 is located a distance

$$N\frac{\lambda}{2}$$

from each of probes 7*a* and 8*a*, where N is equal to an integer, thus providing proper impedance termination for each probe when the shorting means is in the interruption position to introduce the selectivity characteristics of the filter to the system. The location of shorting means from the probes as outlined hereinabove assures an effective short circuit at the probes. Preferably, the short in conductor 12*a* caused by shorting means 19 when in its interruption position occurs one half wavelength from either of the probes while the remaining probe may be located any integral number of one half wavelength from the shorting means. Instead of a shorting screw other shorting arrangements may be provided, such a shorting arrangement, for example, may comprise a key slidable in a keyway formed in the dielectric transversely of the line conductor whereby the key may be moved to a shorting position between the conductors.

Fig. 5 illustrates an attenuator which may replace switch 17 of Figs. 2 and 3 to provide means to control the by-pass communication. Line conductor 12*b* will be continuous from one coupling probe to the other in this embodiment. Pivoted segment 22 comprises a lossy conductive material, the segment being pivoted by means of pin 23. To disrupt the by-pass communication attenuator portion 22 is pivoted to the position shown by the dotted lines such that the by-pass energy will be absorbed by said attenuator. When employing this by-pass means the coupling probes extend into the path of the signal energy just sufficient to by-pass the minimum amount of energy required to align and tune preliminarily the circuitry associated with a given preselector filter in a microwave system. Upon termination of the by-pass communication by means of attenuator 22 a certain amount of energy will be absorbed by said attenuator. This absorbed energy will substantially equal that energy previously present in the by-pass communication. Therefore, when the selectivity characteristics of the filter is introduced to the system by means of attenuator 22 the amplitude of the signal passing through the system will decrease by an amount equal to the energy absorbed by the attenuator 22.

While I have described above the principles of my invention in connection with specific apparatus, it is to be clearly understood that this description is made only by way of example and not as a limitation to the scope of my invention as set forth in the objects thereof and in the accompanying claims.

I claim:

1. A microwave bandpass filter system comprising a filter which includes a section of a waveguide, signal input means and signal output means for said filter, and a transmission line to provide a filter bypass communication between said signal input means and said signal output means to bypass a portion of the signal energy about said filter to reduce the selectivity of said filter during tuning adjustments, and means to interrupt the bypass communication after tuning to introduce the selectivity characteristics of said filter, said transmission line including first and second conductors disposed in spaced substantially parallel relation a small fraction of a quarter wavelength apart wherein the second of said conductors comprises a wall of said waveguide section.

2. A filter according to claim 1, wherein said interrupting means comprises a segment of said first conductor movable between line opening and closing positions.

3. A filter according to claim 1, wherein said interrupting means comprises a portion of said first conductor pivoted at one end thereof.

4. A filter according to claim 3, wherein said interrupting means is located an odd number of quarter wavelengths away from each of said input means and said output means.

5. A filter according to claim 1, wherein said interrupting means comprises an attenuator including a body of lossy material with at least a section of said body being adapted to be disposed in the electromagnetic path of said transmission line.

6. A filter according to claim 5, wherein in at least a part of said body is disposed closely adjacent one of said conductors.

7. A filter according to claim 6, wherein said body is pivoted at one end for movement relative said one of the conductors.

8. A filter according to claim 1, wherein said interrupting means comprises a body of lossy material and

means pivotally supporting said body on said wall for movement relative said first conductor.

9. A filter according to claim 1, wherein said interrupting means comprises a line shorting element and means for moving said element into conductive relation with respect to both said conductors.

10. A filter according to claim 9, wherein said interrupting means is located an integral number of half wavelengths away from each of said input means and said output means.

11. A combination filter and bypass system comprising a filter having a housing of conductive material, said housing having a signal input at one end thereof and a signal output at the other end thereof, a wall of said housing having an opening therethrough adjacent the input end of said housing and another opening adjacent the output end of said housing, a conductor disposed in spaced parallel relation to said wall and extending between said openings, and means coupling said conductor through said openings to the interior of said housing to form a bypass communication directly between the input and output ends of said filter.

12. A system according to claim 11, wherein said conductor is ribbon shaped and has the end portions thereof tapered, and the means for coupling said conductor to the interior of said housing includes a probe disposed in each of said openings in conductive relation to the tapered end portion of said ribbon conductor.

13. A system according to claim 11, wherein a layer of dielectric material is disposed between said ribbon conductor and said wall to maintain said ribbon spaced a small fraction of a quarter wavelength from said wall.

14. A system according to claim 11, wherein said conductor is provided with a section movable between conductor closing and conductor opening positions, said section being located a distance from said coupling means to provide when in open position an effective short at said coupling means.

15. A system according to claim 11, wherein said conductor has associated therewith a body of lossy material movable relative thereto for attentuating the line when it is desirable to interrupt the bypass communication.

16. A system according to claim 11, wherein said conductor is provided with a conductive member movable between bypass communication position and bypass interrupting position, said member being located at a distance from said coupling means to provide when in its interrupting position an effective short at said coupling means.

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