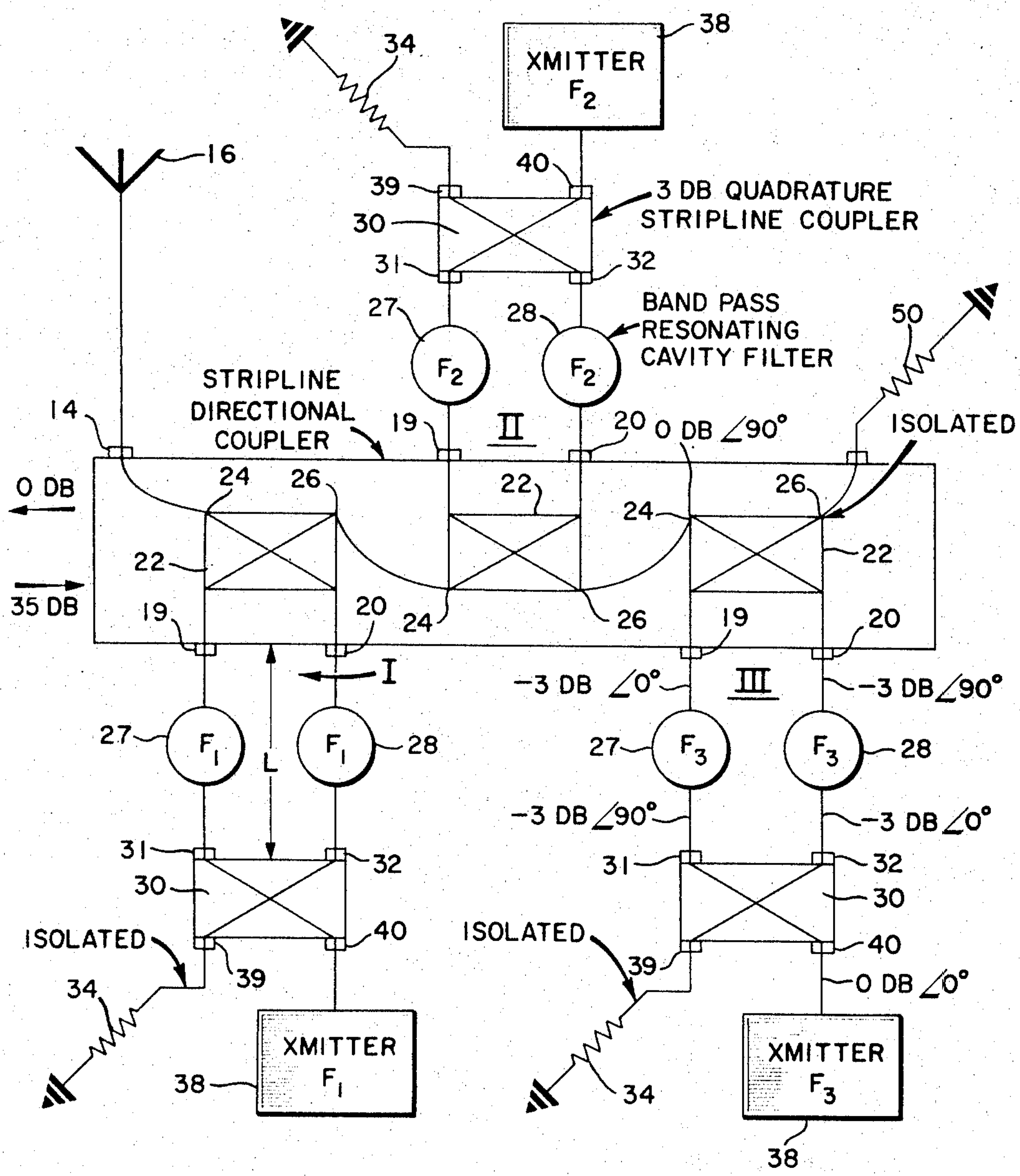
FIG. I.



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July 1, 1969 W. S. HOOVLER 3,453,638
MULTIPLEX PACKAGE
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FIG. 2.

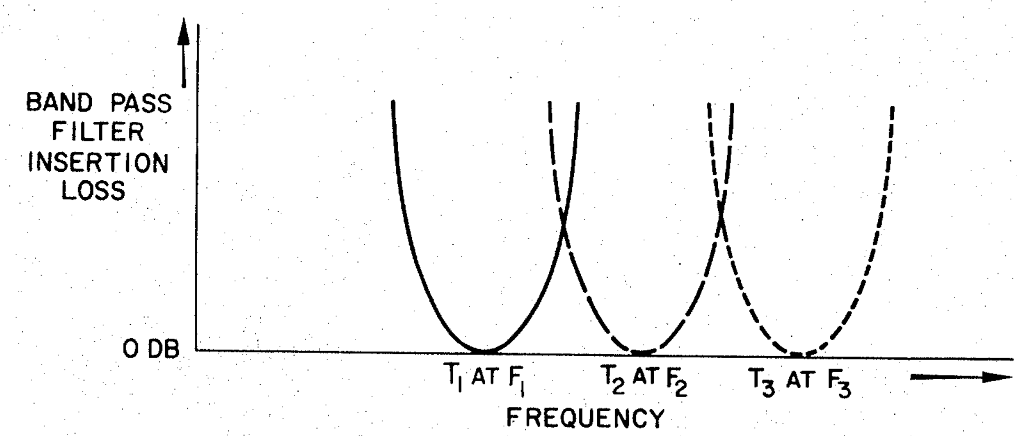
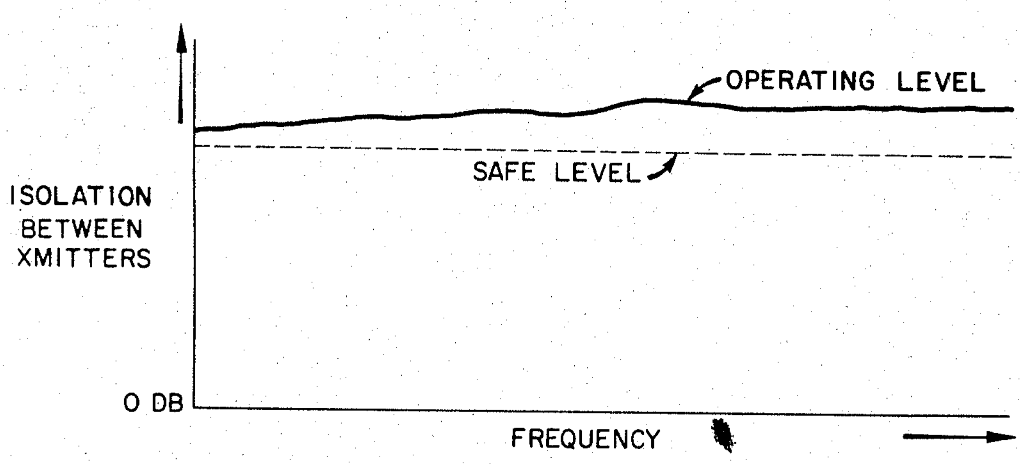


FIG. 3.



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ABSTRACT OF THE DISCLOSURE

A multiplex package for coupling a plurality of transmitters to an antenna including a stripline directional coupler having a plurality of stages and a package output connected to said antenna is shown. Each stage includes a quadrature coupler means having an output terminal and an isolated output terminal as well as first and second input terminals. A quadrature coupler having first and second output terminals is associated with each stage. A first bandpass filter is coupled from the first output terminal to the first input terminal, and a second bandpass filter is coupled from the second output terminal to the second input terminal. Each quadrature coupler is provided with a transmitter input terminal for receiving a signal. Each pair of first and second bandpass filters have a selected bandpass and are tuned to the respective input signal frequencies. Each of the tuned frequencies are separated from one another by about 500 kilocycles. The stage of said stripline coupler closest to said package output has its coupler means output terminal connected to the package output. The isolated terminal of each quadrature coupler means is connected to the coupler means output terminal of the adjacent stage next removed from the package output. A matched load means is connected to the isolated terminal of the stage furthest removed from the package output.

The present invention relates to a coupling system which couples a number of transmitters to one transmitting antenna without experiencing intermodulation problems, excess signal power loss and other interference difficulties. More particularly, the present invention relates to a multiple package which comprises an arrangement of directional stripline couplers and a number of resonant cavity bandpass filters for coupling the transmitter signal of a particular carrier frequency to the stripline which in turn feeds the same to the antenna.

Due to the expense of a transmitting tower, it is desired to have as many transmitters coupled to one transmitting antenna as possible. However, impedance matching, insertion loss and intermodulation between transmitters has heretofore limited the number of transmitters that can be used with a single transmitting antenna.

Many techniques have been employed in an attempt to solve this problem and increase the number of transmitters per tower. Use of resonant cavities have been employed but it has been found that cavities connected by conventional coaxial cable cannot effectively isolate two transmitters operating at a frequency difference of 500 kilocycles in the 450 megacycle region because the line length connections are critical and the cavities tend to load each other which causes excess line loss. Moreover, safe intermodulation levels are difficult to achieve.

Other couplers including ferrite circulators have been used but these systems are expensive and introduce unacceptable insertion losses.

Diplex systems have also been employed, but a diplexer enables but one user per antenna.

It is the purpose of the present invention to provide a new and improved multiplex package which is inexpensive to make, which requires practically no maintenance and

which has a capability of increasing tenfold the number of users (channels) for each transmitting antenna without the need of additional antenna or towers.

It is also the purpose of the present invention to provide a multiplex package that couples a plurality of transmitters, capable of operating at a frequency difference of 500 kc. at 150 megacycles and above to a single transmitting antenna without operating below the safe isolation level between transmitters and without experiencing excess power loss between transmitter and antenna. Moreover, the present invention can be used with standard antenna, and it need only have a power rating of 1000 watts with a 10 channel capability of 100 watts per channel. The package of the present invention is flexible within the frequency band of operation (150 mc.–1000 mc. and above, if desired) and field tune-up is easily performed with conventional multimeters.

Basically, the package of the present invention comprises an elongated directional stripline coupler having a plurality of input stages and a single output connected to the transmitting antenna, each input stage of the stripline having a pair of input connectors connected internally to a 3 db quadrature coupler, a resonant cavity bandpass filter connected to each said input stage connector, a transmitter operating at a predetermined carrier frequency, and a quadrature stripline coupler coupled between the transmitter and the pair of cavities associated with each input stage, said cavities being tuned to its associated transmitter carrier frequency.

It is therefore an object of the present invention to provide a new and improved multiplex package which comprises an arrangement of striplines and resonant cavities which couple to a transmitting antenna a plurality of transmitters operating at different carrier frequencies without experiencing intermodulations and excessive insertion loss problems.

Other and further objects of the present invention will become apparent with the following detailed description when taken in view of the drawings in which:

FIG. 1 is an illustration of the package of the present invention.

FIG. 2 graphically illustrates the characteristics of the resonant cavity used in the present invention.

FIG. 3 is a graphic illustration of the isolation between transmitters of the present invention as compared with a predetermined safe level.

Referring to the drawings in detail, the multiplex package shown in FIG. 1 comprises a conventional stripline directional coupler with a single output **14** connected to transmitting antenna **16** and having a series of spaced input stages I, II and III. Each input stage has a pair of spaced connectors **19** and **20** which is internally connected with a 3 db quadrature coupler **22**. Each coupler **22** is internally connected in series with adjacent couplers. The characteristics of the connected couplers **22** in the stripline are such that signals appearing at the output terminal **24** of each coupler **22** are propagated toward output **14** with 0 db attentuation and propagated away from output **14** with approximately 35 db attenuation. Any signal appearing at terminals **26** of couplers **22** are effectively isolated for reasons more fully described below.

A resonant cavity bandpass filter (**27** and **28**) is coupled to each connector (**19** and **20**) of each input stage. Another four terminal 3 db quadrature stripline coupler **30** has two output connectors **31** and **32** feeding the inputs of filters **27** and **28**. The lengths L for the cavity lines between coupler **30** and the stripline directional coupler are the same for each input stage, but these lengths for one stage need not be equal to that of any of the other stages. In order to maintain the efficiency of the package, 50 ohm connectors are used on cavities **27** and **28**. For the purpose of isolation, a matched load **34** is connected to one input connector **39** and a transmitter **38** operating at a predetermined carrier frequency is connected to input connector **40**. As is apparent from FIG. 1, each pair of cavity filters **27** and **28** are tuned to the carrier frequency of the associated transmitter **38** and the bandpass characteristics of filters **28** can be seen in FIG. 2. Specifically, for any given filter, any signal removed from the set resonant frequency experiences high attenuation. Resonant cavity filters **27** and **28** are conventional and readily available on the market. A matched load **50** is connected to the last coupler terminal **26** and absorbs signals arriving thereat.

Although only three transmitting channels are shown in FIG. 1, it is to be understood that the stripline directional coupler can continue to the right and receive as many channel transmitter signals as desired with ten channels being a practical limit for a package operating in the 150 to 1000 megacycle range (and above if desired) with a minimum frequency difference of 500 kc.

In operation, when any one transmitter such as F3 is turned on, it delivers the signal to be transmitted to the input connector **40** of coupler **30**, this signal being defined at a 0 db level and a 0° phase shift for the purposes of discussion. The signal emitted from connector **31** is at minus 3 db and 90° phase shift, and the signal emitted from connector **32** is at minus 3 db and at 0° phase shift. Connector **39** is isolated from its associated transmitter.

The F3 signal through filter **27** is shifted 90° to minus 3 db at 0° and the F3 signal through filter **28** is shifted 90° to minus 3 db at 90°. These signals are then delivered to input stage III. Upon passing through coupler **22**, the signal appearing at terminal **26** is isolated and the signal appearing at terminal **24** is at 0 db and a 90° phase shift. Although the signal at terminal **24** is at a theoretical 0 db there is some insertion loss by filters **27** and **28** and this may range from ¼ to 3 db.

The signal at terminal **24** is then propagaed toward the output connector **14** and is delivered to antenna **16** with only the ¼ to 3 db filter insertion loss.

With reference to intermodulation signals, a signal at the 0 db level appearing, for example, at terminal II–**24** also appears at terminals II–**26** and III–**24** at the minus 35 db level.

From terminal III–**24**, the F2 signal passes through filters III–**27** and III–**28** (which impart an 18 db loss) into transmitter F3. The F2 signal in transmitter F3 experiences a 6 to 13 db mixing loss after which it is again fed toward the antenna through filters III–**27** and III–**28** which again impart an 18 db loss. Thus, the F2 signal fed to stage III reappears at terminal III–**24** with about a 78 to 84 db loss which is well above the safe isolation level for systems of this type.

At the same time, the F2 signal at terminal II–**24** also appears at terminal I–**26** at full strength. From terminal I–**26** it splits and approaches filters I–**27** and I–**28**, but since these filters are tuned to F1, 99 percent of the F2 split signal is reflected and the components recombine and appear at terminal I–**24** at about the 0 db level. This F2 signal at terminal I–**24** is then fed to antenna **16**. The other 1 percent of the F2 signal passes through filters I–**27** and I–**28**, but is almost entirely absorbed by load I–**34**. That signal part which passes through filters I–**27** and I–**28** but is not absorbed enters transmitter F1 with an additional 35 db loss. Transmitter F1 imparts a 6 to 13 db mixing loss and filters I–**27** and I–**28** impart an additional 18 db loss before the unwanted intermodulation F2 signal component reaches terminal I–**24**. Thus, it can be seen that transmitter F2 is safely isolated from transmitter F1 as well as transmitter F3.

It should also be understood that other and further modifications can be made to the present invention without departing from the spirit and scope of the present invention.

What is claimed is:

1. A multiplex package for coupling a plurality of transmitters to an antenna comprising a stripline directional coupler having a plurality of stages and a package output connected to said antenna, each stage comprising quadrature coupler means having a coupler means output terminal and an isolated output terminal and having a first input terminal and a second input terminal, a separate quadrature coupler associated with each of said stages having a first output terminal and a second output terminal, a first bandpass filter having a given bandpass coupled from said first output terminal to said first input terminal, and a second bandpass filter having a given bandpass coupled from said second output terminal to said second input terminal, each said quadrature coupler further comprising a transmitter input terminal for receiving a signal at a predetermined different transmitting frequency, each pair of first and second bandpass filters being tuned to a respective input transmitting signal frequency, the stage of said stripline directional coupler closest to said package output having its coupler means output terminal connected to said package output, the isolated terminal of each quadrature coupler means being connected to the coupler means output terminal of the adjacent stage next removed from the package output, and a matched load means connected to the isolated terminal of the stage furthest removed from the package output.

2. A package as set forth in claim **1**, wherein each of said quadrature couplers has an additional terminal, separate matched load means connected to each of said additional terminals for absorbing signals propagated thereto from the isolated terminals of the respective stages.

3. A package as set forth in claim **1**, wherein the signal paths through the bandpass filters between said quadrature couplers and said stripline directional coupler are, for each stage, of equal length.

4. A package as set forth in claim **1**, wherein each quadrature coupler comprises a stripline coupler.

References Cited

UNITED STATES PATENTS

3,056,096	9/1962	Vane	333—11 XR
3,094,677	6/1963	Theriot	333—84 XR
3,310,748	3/1967	Putnam.	
3,311,850	3/1967	Podell	333—84 XR
3,315,182	4/1967	Woolley	333—10
3,327,255	6/1967	Bolljahn et al.	333—84 XR

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