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FREQUENCY SELECTIVE SYSTEM

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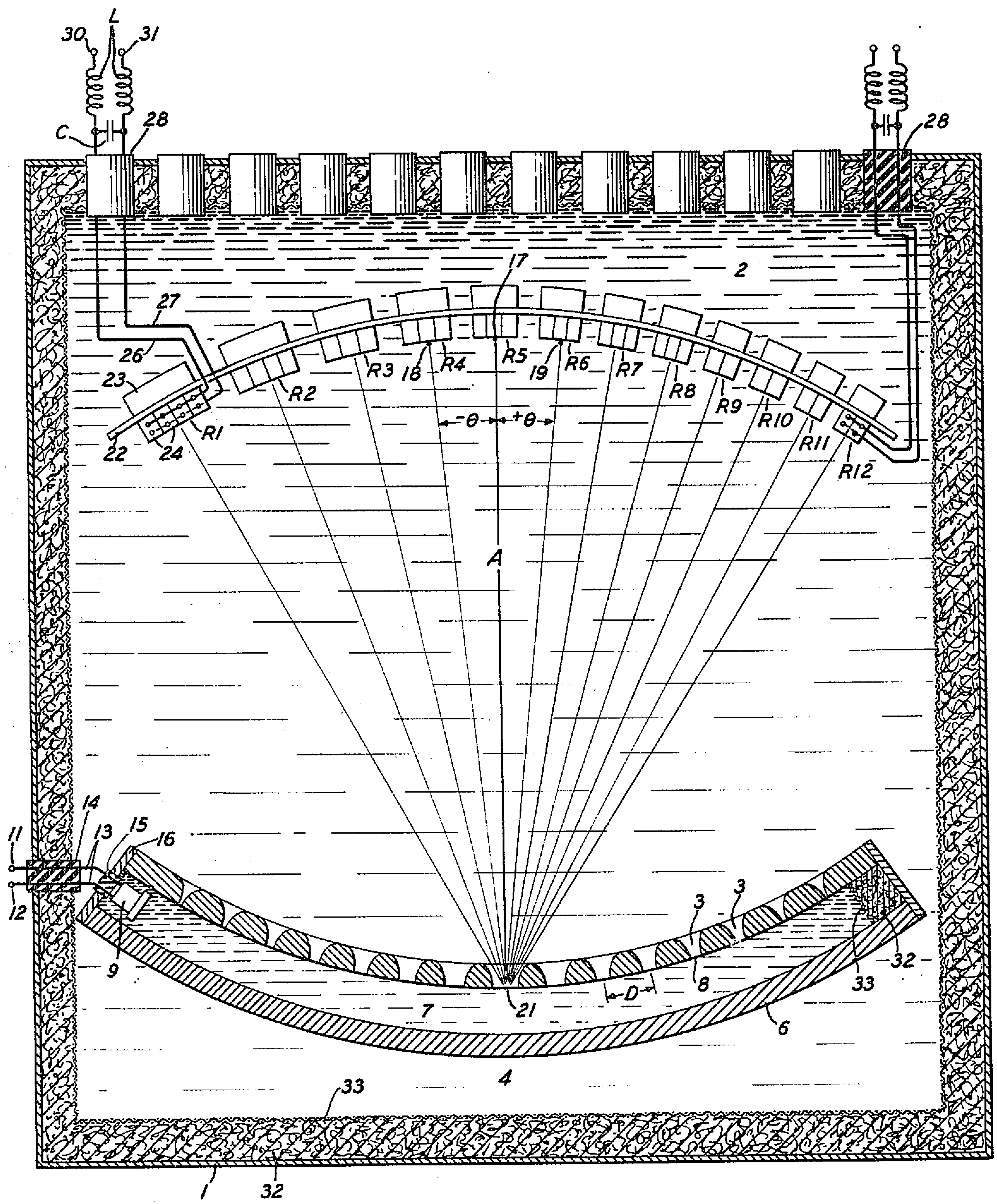

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FREQUENCY SELECTIVE SYSTEM

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This invention relates to frequency selective systems and more particularly to a system for separating compressional waves propagated in an elastic medium.

An object of the invention is to direct compressional waves into separate channels on a frequency basis.

Other objects are to improve the efficiency, simplify the construction, and reduce the size and cost of multichannel frequency selective systems.

The compressional wave frequency selective system in accordance with the invention comprises an elastic medium in which are positioned a number of compressional wave radiators, equally spaced along a uniform compressional wave transmission line, and a number of compressional wave collectors. The radiators are so arranged that waves of different frequencies are focused at different points and the collectors are located at these focal points. For example, the radiators may be arranged in an arc and the collectors in a second arc, the arcs having equal radii and facing each other on their concave sides. The radiators may, for example, be orifices in the side of a tube which is filled with a second elastic medium and supplied with energy from a multifrequency compressional wave source. The collectors may be piezoelectric devices which are responsive over the band to be transmitted by the particular channel. The elastic mediums may be liquids and the first-mentioned preferably has a higher velocity of propagation than the second.

The nature of the invention will be more fully understood from the following detailed description and by reference to the accompanying drawing, the single figure of which shows in horizontal section a multichannel compressional wave frequency selective system in accordance with the invention.

As shown, the system comprises a liquid-tight container 1 filled with a liquid 2 in which are disposed a number of compressional wave radiators 3 and twelve compressional wave collectors R1 to R12. The radiators 3 are spaced at equal distances D along a uniform compressional wave transmission line 4 in the form of a closed tube 6 filled with a second liquid 7. The radiators are constituted by horn-shaped orifices in the side of the tube 6 and are covered at the base by a thin membrane 8 to keep the liquids 2 and 7 separated. A multifrequency compressional wave source 9, having input terminals 11 and 12, supplies energy to one end of the line 4. The lead wires 13 connecting the input terminals 11 and 12 to the source 9 pass through a liquid-tight plug 14 in the side of the container 1 and through a similar plug 15 in the end plate 16 of the tube 6.

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The tube 6 follows the arc of a circle of radius A centered at the point 17. Now, at the frequency f_0, for which the spacing D is equal to one wavelength in the liquid 7, that is, when

$$D=\frac{V_2}{f_0} \tag{1}$$

where V_2 is the velocity of compressional wave propagation in the liquid 7, the energy radiated from all the radiators 3 will be in phase and will be focused on the point 17. The frequency f_0 is preferably chosen as approximately the geometric mean frequency of the multifrequency source 9. However, because of the successive phase differences between the successive radiators 3, the radiated energy of other frequencies will be focused at different points. Thus, waves of a certain frequency lower than f_0 will be focused at a point such as 18 to the left of the point 17 and those of a certain frequency higher than f_0 will be focused at a point such as 19 to the right of the point 17. All of the points 17, 18 and 19 fall on the arc of a second circle having a radius 17—21 also equal to A, with its center at the point 21 lying on the arc of the radiators 3. The collectors R1 to F12 are, therefore, arranged along the arc of this second circle. The two arcs preferably lie in the same plane and preferably have a common radius 17—21. Also, preferably, the point 21 is at the center of the arc of the radiators 3 and the point 17 is at the center of the arc of the collectors R1 to R12.

For waves of any frequency f, the angle θ between the common radius 17—21 and the line connecting the focal point such as 19 and the point 21 is given by the formula

$$\theta=\sin^{-1}\frac{(f-f_0)V_1}{fV_2} \tag{2}$$

where V_1 is the velocity of compressional wave propagation in the liquid 2. For frequencies above f_0 the angle θ will be positive and for frequencies below f_0 it will be negative, as indicated on the drawing. It is seen from Equation 2 that the frequencies are spread out more as the ratio of V_1 to V_2 is increased. Therefore, the liquid 2 preferably has a higher velocity than the liquid 7. The discrimination between frequencies may be increased by increasing the number of radiators 3 and by making the cross-sectional areas of the orifice progressively smaller from the central orifice at 21 to the end orifices.

As shown, the compressional wave collectors R1 to R12 are of the piezoelectric type, each comprising a number of piezoelectric crystal elements, with the usual electrodes, arranged side by side to form a mosaic. The crystals are attached at their ends to a supporting member 22 and backed by a metallic resonator 23. The collector R1, for example, employs four crystals 24. Each crystal 24 and the associated resonator 23 has a radial length approximately equal to a quarter wavelength at the geometric mean frequency of the band to be picked up. The angular extent of the mosaic of crystals is determined by the width of the desired band. The width of each crystal 24, however, should not materially exceed a quarter wavelength.

The lead wires 26 and 27 are connected, respectively, to the upper and lower electrodes of the crystals 24. The wires 26 and 27 pass out of the container 1 through a liquid-tight plug 28 to a pair of output terminals 30 and 31 to which a suitable load impedance may be connected. In order to simplify the drawing, connections are shown only for the end collectors R1 and R12. It is to be understood, however, that the other collectors R2 to R11 will also have lead wires similar to 26 and 27 connecting the crystal electrodes to output terminals similar to 30 and 31, thus forming twelve separate channels. A series inductance L and a shunt capacitance C may be included in each channel to improve the discrimination between channels.

In order to prevent undesired reflection of waves the inner side of the container 1 and the end of the tube 6 are preferably provided with vibration absorbing material. This may, for example, comprise a layer of copper shavings or foil 32 retained in place by a screen 33.

What is claimed is:

1. A frequency selective system comprising a source of multifrequency compressional waves, a compressional wave transmission line upon one end of which said waves are impressed, a plurality of compressional wave radiators connected to said line with a spacing equal to a wavelength in said line at a frequency of said source, a plurality of compressional wave collectors, and an elastic medium interposed between said radiators and said collectors, said radiators being arrayed in an arc whereby waves of different frequencies are focused at different points and said collectors being located, respectively, at said points.

2. A system in accordance with claim 1 in which said collectors are arrayed in a second arc.

3. A system in accordance with claim 1 in which said collectors are arrayed in a second arc, said arcs having the same radius and facing each other on their concave sides.

4. A system in accordance with claim 1 in which said collectors are arrayed in a second arc, said arcs lying in the same plane, having the same radius, and facing each other on their concave sides.

5. A system in accordance with claim 1 in which said collectors are arrayed in a second arc, said arcs having a common radius.

6. A system in accordance with claim 1 in which said collectors are arrayed in a secod arc, said arcs lying in the same plane and having a common radius.

7. A system in accordance with claim 1 in which said radiators are arrayed along the arc of a circle and said collectors are positioned some to one side and some to the other side of the center of said circle.

8. A system in accordance with claim 1 in which said spacing is approximately equal to a wavelength in said line at the geometric mean frequency of said source.

9. A system in accordance with claim 1 in which said medium is a liquid.

10. A system in accordance with claim 1 in which said line comprises a tube filled with liquid.

11. A system in accordance with claim 1 in which the velocity of propagation in said medium is higher than the velocity in said line.

12. A system in accordance with claim 1 in which said medium is a liquid and said line comprises a tube filled with a second liquid, said first-mentioned liquid having a higher velocity of propagation than said second liquid.

13. A system in accordance with claim 1 in which said line comprises a tube filled with liquid and said radiators are constituted by orifices in the side of said tube.

14. A system in accordance with claim 1 in which said line comprises a tube filled with liquid and said radiators are constituted by horn-shaped orifices in the side of said tube.

15. A system in accordance with claim 1 in which said radiators have radiating areas which progressively decrease in size from the central radiator to the end radiators.

16. A system in accordance with claim 1 in which said line comprises a tube filled with liquid and said radiators are constituted by orifices in the side of said tube, the cross-sectional areas of said orifices progressively decreasing in size from the central orifice to the end orifices.

17. A system in accordance with claim 1 in which each of said collectors is responsive to a band of frequencies.

18. A frequency selective system comprising a tube formed into an arc and filled with a first liquid, a source of multifrequency compressional waves at one end of said tube, a plurality of orifices in the side of said tube with a spacing equal to a wavelength in said first liquid at a frequency of said source, a plurality of compressional wave collectors arrayed in a second arc, and a second liquid interposed between said orifices and said collectors, said arcs lying in the same plane, having the same radius, and facing each other on their concave sides.

19. A system in accordance with claim 18 in which said arcs have a common radius.

20. A system in accordance with claim 18 in which the spacing of said orifices is approximately equal to a wavelength in said first liquid at the geometric mean frequency of said source.

21. A system in accordance with claim 18 in which said second liquid has a higher velocity of propagation than said first liquid.

22. A system in accordance with claim 18 in which said orifices are horn-shaped.

23. A system in accordance with claim 18 in which the cross-sectional areas of said orifices progressively decrease in size from the central orifice to the end orifices.

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