

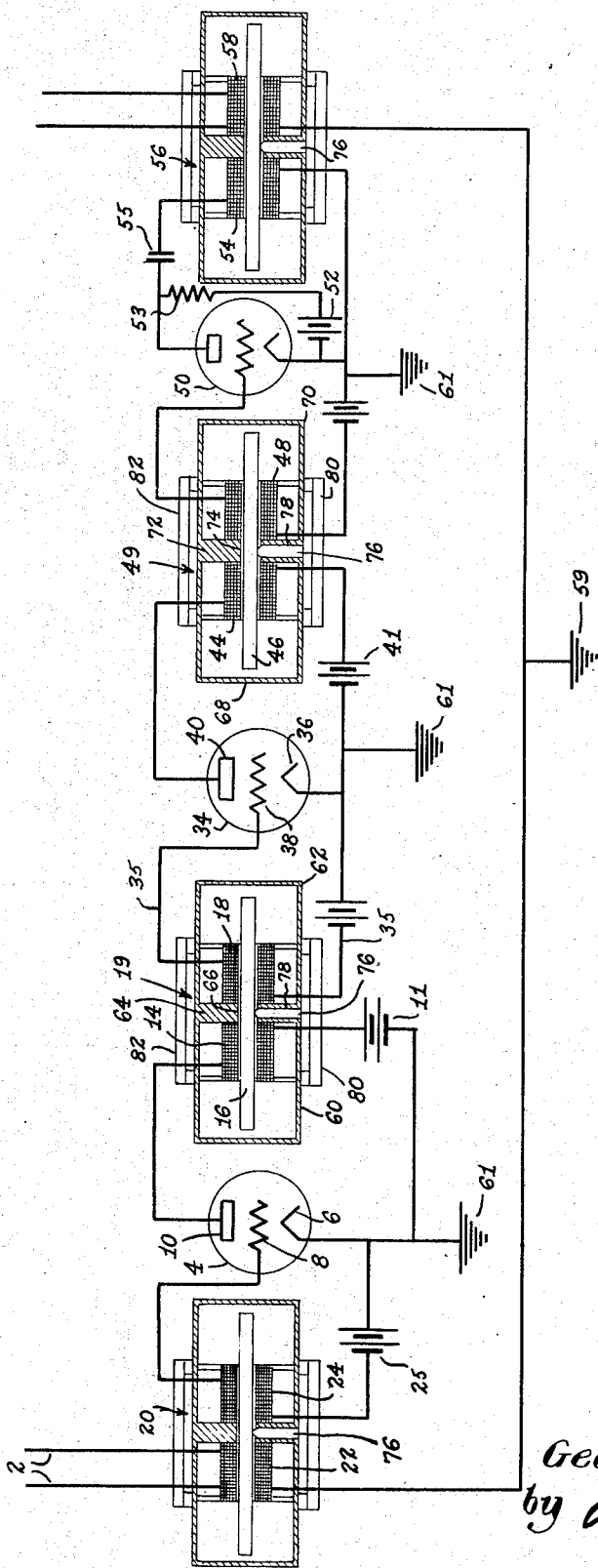
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ELECTRIC FILTER

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ELECTRIC FILTER

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The present invention relates to vibratory systems and apparatus, and more particularly to electrical systems and apparatus employing electromechanical vibrators, particularly magnetostrictive devices. From a more limited aspect, the invention relates to magnetostrictive filters.

An object of the invention is to provide a new and improved filter operating by magnetostriction.

A further object is to provide a new and improved magnetostrictive transformer.

Another object is to provide an electromagnetic shielding between two coils so that electrical energy transferred from one coil to the other may be largely limited to the frequency of mechanical vibration.

Other further objects will be explained hereinafter and will be particularly pointed out in the appended claims.

The invention will be explained in connection with the accompanying drawing, the single figure of which is a diagrammatic view of circuits and apparatus constructed and arranged according to a preferred embodiment of the present invention, for filter purposes.

An amplifier tube 4, such as a vacuum tube of the UY 227 type, is shown provided with an input circuit and an output circuit. The leads 2 are provided for connecting to a source of alternating current of complex wave form from which a narrow band of frequencies is to be selected and amplified. To this end, the source may be directly connected in the input circuit of the amplifier 4, between the filament 6 and the grid 8, but it is preferred, as illustrated, to lead the energy from the source into the input circuit of the amplifier 4 through the medium of an input transformer 20, the primary winding 22 of which is connected with the source and the secondary winding 24 of which is connected in the said input circuit. The input circuit may be provided with a grid-biasing battery 25. The output circuit of the amplifier 4, connected between the filament 6 and the plate 10, comprises a plate battery 11 and a winding 14 within which is axially positioned a magnetostrictive core 16. The core 16 may be of any form desired, as a rod or a tube, and may be of any desired magnetostrictive material, as Monel metal. A second winding 18, also positioned over the core 16, forms with the winding 14 and the core 16 a magnetostrictive transformer 19. The elements thus far described constitute a magnetostrictive filter, the transformer 20 constituting the input of the filter and the transformer 19 the output,

with but a single stage of amplification. The transformer 20 may be connected to the source by means of the leads 2; and the transformer 19 may be connected to a suitable load or indicating device by means of the leads 35 of the winding 18. The transformer 20, as hereinafter stated, may be an ordinary electromagnetic transformer, or preferably may itself be a magnetostrictive transformer as is shown in the figure.

If it is desired to enhance the filter effect, the winding 18 may be connected, by means of the leads 35, in the input circuit of a second amplifier 34; between the filament 36 and the grid 38. The magnetostrictive transformer 19 thus couples the output circuit of the first amplifier 4 with the input circuit of the second amplifier 34. A coil 44, within which is positioned a magnetostrictive core 46, is connected in the output circuit of the tube 34, between the filament 36 and the plate 40, in series with a plate battery 41. The core 46 may be provided with a second winding 48, and forming therewith and with the winding 44 a magnetostrictive transformer 49. The transformer 49 may constitute the output of the filter for connecting to the load, with two stages of amplification.

If a still further enhanced filter action is desired, the winding 48 may be disposed in the input circuit of a third amplifier 50, the output circuit of which is provided with the primary winding 54 of a transformer 56, the secondary winding of which, for connecting to the said load or indicating device is shown at 58. A plate battery 52 and a resistor 53, say of 40,000 Ω , may be connected in parallel with the winding 54, separated therefrom by a condenser 55.

As before stated, one or more of the amplifying tubes may be omitted, in which event the resistor 53 and the condenser 55 will be disposed in the output circuit of the last amplifier tube employed.

The input and the output transformers shown at 20 and 56 of Fig. 1 may themselves be magnetostrictive transformers of the type illustrated at 19 or 49, or they may be of the ordinary form. The drawing also shows certain effective methods of applying ground connections to the apparatus. Thus, the coils 22 and 58 may be connected to a common ground 59, and the various plate batteries, which may be a common battery, are preferably grounded at 61. The shielding, hereinafter mentioned, is preferably also grounded.

Current of the various frequencies present in the source connected with the leads 2, after am-

plification by the amplifier 4, will flow through the coil 14. That component of current that has the frequency of the core 16 will vibrate the core 16 by magnetostriction, and the vibration of the core 16 will communicate an electromotive force of the same frequency to the coil 18 by magnetostriction. Where a second stage of amplification is employed, the resonant frequency will be further amplified by the amplifier 34, and the amplified current will flow into the winding 44. Assuming that the core 46 is similarly tuned to the same frequency, the amplitude of the desired frequency will be further enhanced in relation to undesired frequencies and be magnetostri-actively transmitted to the winding 48, and so forth. A very effective magnetostrictive filter is thus provided, that will yield, in the output winding 58 of the transformer 56, a sharply narrow range of frequency near the frequency of the cores 16 and 46.

The sensitiveness and effectiveness of the apparatus may be further improved by electrical tuning of the circuits, as by a condenser (not shown) shunted about one or more of the coils of the magnetostrictive transformers and properly adjusted.

There is the possibility, however, that energy of undesired frequencies may pass from the winding 14 to the winding 18, and from the winding 44 to the winding 48, otherwise than magnetostri-actively, as by direct electromagnetic induction. To prevent this, each winding is electromagnetically shielded from all the other windings by enclosing it in a metal tube or housing which, at the same time, may seal the winding. The metal tube for the winding 14 is illustrated at 60 and that for the winding 18 at 62, the tubes 60 and 62 being disposed end to end and separated from each other by a metal wall 64, provided with an opening 66 for the magnetostrictive core 16. The windings 44 and 48 are similarly respectively enclosed in metal tubes 68 and 70, separated by a metal wall 72 provided with an opening 74 for the magnetostrictive core 46. The energy transferred between the windings 14 and 18, as between the windings 44 and 48, will thus be limited to that transferred by the magnetostrictive vibration of the cores 16 and 46.

Preferably, the coils of the magnetostrictive transformers are positioned as near the center of the magnetostrictive core as possible. The coils are preferably so mounted as to allow only sufficient clearance to permit free vibration of the core. The coils may each be about one-fourth the length of the core, and the thickness of the coils may be about one-seventh or one-eighth the length of the coil. The core, in the form of a rod, is mounted on a pin 76, which passes through an opening 78 in the central wall 64 or 72 and supports the magnetostrictive core so that it is mechanically free. However, slight friction caused by one end of the core accidentally touching the inside of the coil when mounted in this way is found to be without deleterious effect upon the operation. Two permanent magnets 80 and 82 are mounted outside the shields to produce a sufficient permanent field.

The magnetostrictive devices need not necessarily be of the form shown. The magnetostrictive vibrators may, for example, each be in the form of a tube in which the associated winding is enclosed, as disclosed in a copending application, Serial No. 592,320, filed February 11, 1931. Indeed, the tubes 60, 62, 68 and 70, if of suitable magnetostrictive material, may themselves be

the magnetostrictive cores. As is further explained in the said application, one magnetostrictive winding 14, in the output circuit of the tube 4, may be placed inside of the vibrator housing 60, and the other winding 18 placed outside. The vibrator housing 60 will in this case also act as an electromagnetic shield, so that action of one of the windings on the other may be prevented to any desired extent, except at or near the frequency or frequencies which cause the vibrator housing 60 to vibrate. By suitably positioning one or both of the coils, which may be adjustably movable along the direction of their axes, the intensity and sharpness of frequency selection may be adjusted. This arrangement is an important element in a magnetostrictive filter structure.

It will be understood that the invention is not restricted to the illustrated embodiment thereof, but is susceptible to further modifications and change within the skill of the artisan, and all such modifications and changes are considered to fall within the spirit and scope of the invention as defined in the appended claims.

What is claimed is:

1. An electric filter comprising an input circuit for connecting to a source of electromotive force, an output circuit, means for magnetostri-actively coupling the circuits, and means preventing coupling of the circuits except by the said magnetostrictive means.

2. An electric filter comprising an input circuit having a winding for connecting to a source of electromotive force, an output circuit having a winding, a magnetostrictive core magnetostri-actively coupling the windings together, and means for shielding the windings.

3. An electric filter comprising a vacuum tube having an input circuit and an output circuit, a second vacuum tube having an input circuit and an output circuit, means for magnetostri-actively coupling the first-named output circuit and the second-named input circuit, and means for preventing coupling of the said first-named output circuit and the said second-named input circuit except by said magnetostrictive means.

4. An electric filter comprising a vacuum tube having an input circuit and an output circuit having a winding, a second vacuum tube having an input circuit having a winding and an output circuit, a magnetostrictive core magnetostri-actively coupling the windings together, and means for shielding the windings.

5. An electric filter comprising a plurality of vacuum tubes each having an input circuit and an output circuit, and means magnetostri-actively coupling selected output circuits of various tubes with selected input circuits of other tubes, the magnetostrictive means being operable at substantially the same frequency.

6. An electric filter comprising a plurality of vacuum tubes each having an input circuit and an output circuit, a plurality of the circuits each having a winding, and magnetostrictive cores magnetostri-actively coupling windings of selected output circuits of various tubes with windings of selected input circuits of other tubes, the cores being operable at substantially the same frequency.

7. An electric system comprising a space-current device having an input circuit and an output circuit, means for connecting with the input circuit a source of alternating current or voltage of a plurality of frequencies, a second space-current device having an input circuit and an output

circuit, the input circuit of the second space-current device being coupled to the output circuit of the first-named space-current device, means for magnetostrictively transmitting selectively alternating-current quantities of predetermined frequencies to the input circuit of the second space-current device, a third space-current device having an input circuit and an output circuit, the input circuit of the third space-current device being coupled to the output circuit of the second space-current device, and means for magnetostrictively suppressing from the input circuit of the third space-current device all alternating-current residual quantities except those of the predetermined frequencies.

8. An electric system comprising a space-current device having an input circuit and an output circuit, magnetostrictive means for connecting with the space-current device a source of alternating voltage of a plurality of frequencies, and means for magnetostrictively suppressing from the circuit all alternating-current quantities of the source except those of predetermined frequencies.

9. An electric filter comprising a space-current device having an input circuit and an output circuit, means for magnetostrictively connecting the input circuit to a source of electromotive force, and means for magnetostrictively connecting the output circuit to a load.

10. A magnetostrictive transformer comprising two shielding housings, a winding in each housing, and a magnetostrictive core common to the windings, said core being designed for relatively free mechanical vibration by magnetostrictive action.

11. A magnetostrictive transformer comprising a plurality of metallic tubular compartments, a winding in each compartment, and a magneto-

strictive core common to the windings, said core being designed to vibrate mechanically with only such restraint as is essential for effective support.

12. A magnetostrictive transformer comprising two shielding housings separated by a wall having an opening, an energizing winding in each housing, and a magnetostrictive core for the windings disposed in the housings and extending through the opening.

13. A magnetostrictive transformer comprising two shielding housings separated by a wall having two openings, an energizing winding in each housing, a magnetostrictive core for the windings disposed in the housings and extending through one of the openings, and a pin for supporting the core disposed in the other opening.

14. A magnetostrictive transformer comprising two shielding housings, a winding in each housing, and a magnetostrictive core coupling the windings.

15. A magnetostrictive vibrator comprising a winding for alternating current and having a magnetostrictive field, a magnetostrictive core in the magnetostrictive field, and a shielding housing in which the winding and the core are disposed.

16. A magnetostrictive vibrator comprising a winding for alternating current, and means for sealing the winding and for magnetostrictively reacting upon the current in the winding.

17. A magnetostrictive device comprising a plurality of circuits, and means operating magnetostrictively to transfer electrical energy from one circuit to another solely at frequencies near a natural frequency of vibration of the magnetostrictively operating means and to shield the circuits from each other.

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