May 5, 1964 G. W. ELMEN ETAL 3,132,316

TOROIDAL TRANSFORMER HAVING A CORE OF CLOSED LAMINATIONS WITH FLUID AND NON-FLUID INSULATION THEREBETWEEN

Original Filed June 20, 1945 2 Sheets-Sheet 1

Fig. 1.

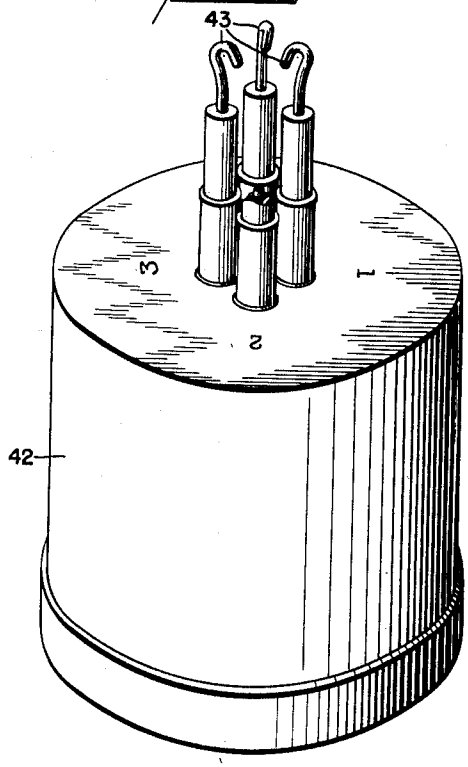


Fig. 2.

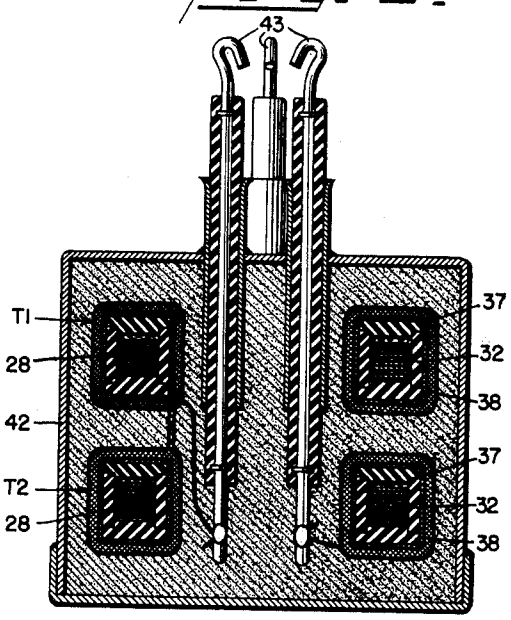


Fig. 5.

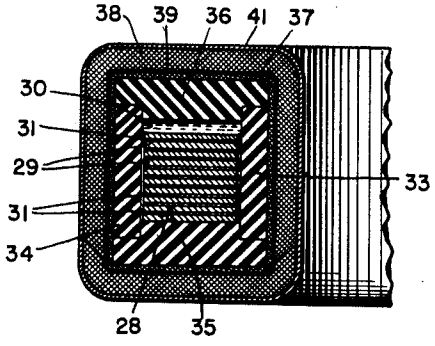
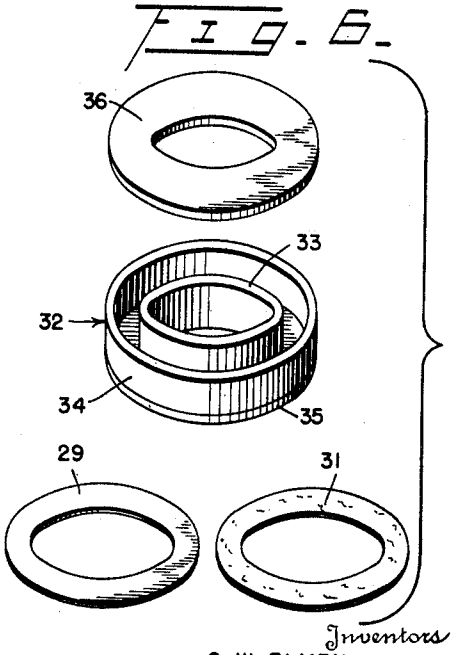


Fig. 6.



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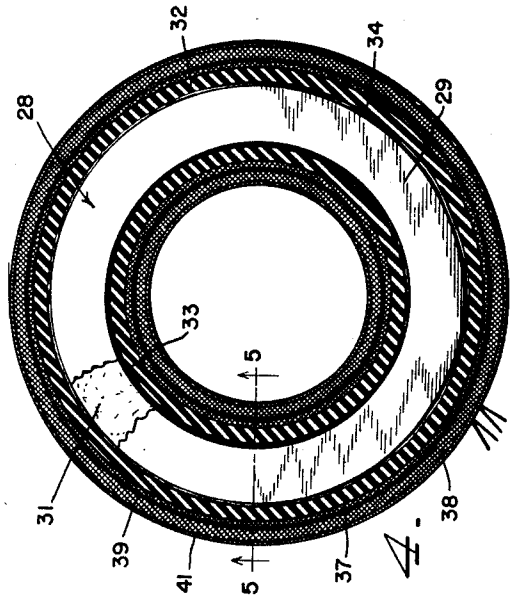


FIG. 4.

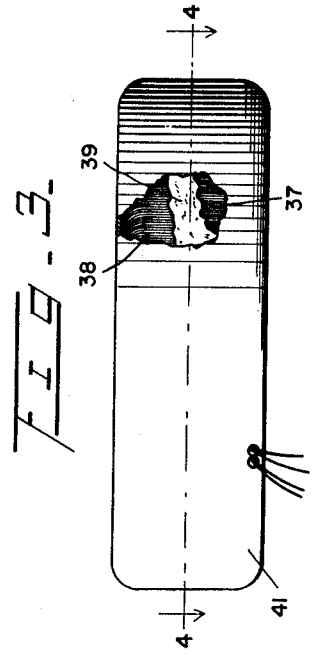


FIG. 3.

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TOROIDOL TRANSFORMER HAVING A CORE OF CLOSED LAMINATIONS WITH FLUID AND NON-FLUID INSULATION THEREBETWEEN

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Original application June 20, 1945, Ser. No. 600,629. Divided and this application Mar. 25, 1955, Ser. No. 496,960

3 Claims. (Cl. 336—94)

(Granted under Title 35, U.S. Code (1952), sec. 266)

This invention relates generally to signal amplifiers and more particularly to a highly stabilized and sensitive magnetic amplifier adapted to convert weak signal currents to electrical impulses of relatively great amplitude.

This is a division of application Serial No. 600,629, filed June 20, 1945, now abandoned.

The present invention further contemplates the provision of a stabilized magnetic amplifier having matched parts of novel construction which renders the operational characteristics of such parts substantially identical and prevents changes in the characteristics of one part relative to the other in response to variations in the operating conditions to which the amplifier may be subjected in use, or by reason of shocks received during transportation and handling and upon impact with the water when a mine employing the amplifier is launched from an aircraft in flight, or by reason of countermining shocks received through the surrounding water.

In accordance with the arrangement of the present invention, a pair of matched transformers each having a closed core preferably formed as a toroid with primary and secondary windings disposed thereabout provide the amplifying function of the magnetic amplifier.

The cores are formed of insulated laminations of magnetic material of high permeability and resistance whereby the material affords a high rate of change of total flux for small field changes and eddy current losses are reduced to a minimum. Thus, by reason of such construction a small change in the magnetization of one core relative to the other in response to a signal current in the order of one microampere causes the hysteresis loops of the cores to be shifted in phase and thereafter changed in shape relative to each other sufficiently to produce a relatively large difference in the relative rate of change of flux in the cores such that the secondary voltages are unbalanced sufficiently to cause current in the order of milliamperes to flow in an output circuit including the secondary windings.

Certain of the magnetic amplifiers heretofore devised for the purpose comprise matched transformers having ribbon or tape wound cores of magnetic material of high permeability. Such transformers have not been found to be entirely satisfactory in service for the reason that the magnetic characteristics of the cores are altered when the transformers are subjected to stresses resulting, for example, from shocks received thereby and from strains set up in the convolutions of the magnetic ribbon or tape comprising the cores as the convolutions change position relative to each other in response to variations in temperature encountered in the use of the transformers.

These difficulties have been overcome substantially in the design of the matched tarnsformers of the present invention by the provision of closed magnetic circuits comprising toroidal cores formed of ring-shaped laminations inherently rigid in construction and by the provision of containers for the laminations which permit a degree of freedom of movement therein in response to temperature changes within a range of temperatures to which the amplifier may be subjected in use. Moreover, the loose mounting of the laminations permits the use of a

suitable fluid within the containers whereby pressure on the laminations is applied uniformly thereon by way of the fluid and permanent strain therein is thus avoided.

It is a broad object of the invention, therefore, to provide a new and improved magnetic amplifier whose operational characteristics are not affected by reason of shocks received by the amplifier in the use thereof or by reason of temperature variations encountered under different conditions of use thereof.

Another object is to provide a sensitive magnetic amplifier having matched transformers in which the cores thereof are constructed so as to reduce to a minimum the deleterious effects of eddy currents therein and to render the magnetic characteristics of the cores substantially uniform and identical under all conditions of service.

Still other objects, advantages and features of the present invention not specifically stated hereinabove are those inherent in or implied from the novel combination, construction and arrangement of parts as will become more fully apparent from the following detailed description thereof taken in connection with the accompanying drawings wherein:

FIG. 1 is a view in perspective of a unit comprising a pair of matched transformers or toroids constructed in accordance with a preferred embodiment of the invention;

FIG. 2 is a sectional view of the unit shown in FIG. 1 taken substantially axially thereof;

FIG. 3 is a view in elevation of one of the toroids, certain portions thereof being broken away to illustrate the construction;

FIG. 4 is a sectional view of the toroid as seen along the line 4—4 of FIG. 3;

FIG. 5 is a fragmentary sectional view of the toroid as seen along the line 5—5 of FIG. 4;

FIG. 6 is an exploded view in perspective of several of the component parts comprising a toroid.

FIGS. 1 through 6 structurally disclose a pair of matched transformers or toroids generally designated as T1 and T2. Each of the toroids comprises a closed core 28 having a plurality of ring-shaped laminations 29. Laminations 29 are formed of a suitable magnetic material preferably of high permeability such, for example, as a material known in the trade as 4–79 Molybdenum Permalloy and composed approximately of 79% nickel, 17% iron, and 4% molybdenum. Laminations 29 preferably are selected from the same melt of permalloy and heat treated in a special manner to insure uniform magnetic characteristics. The laminations also preferably are formed of a material having a high specific resistance in order that eddy currents may be reduced to a minimum. For such latter purpose, the laminations also are made as thin as engineering practice will permit, a suitable thickness of the laminations being in the order of 6 to 10 thousandths of an inch. Adjacent laminations are separated by suitable ring-shaped strips of insulation 31 which may be formed of paper having a thickness in the order of 1 thousandth of an inch, thereby further to prevent eddy current losses in the cores.

The laminations and insulation separators therefor are loosely retained within a toroidal-shaped container 32 formed of a suitable material such, for example, as phenol fiber and fabricated into the form shown in any convenient manner. Container 32 preferably is formed of sufficient size to permit the laminations to move several thousandths of an inch both radially and axially therein and formed in such a manner as to permit a suitable semi-fluid or fluid 30 such, for example, as cable oil to seep thereinto. In the arrangement shown, container 32 comprises inner and outer annular members 33 and 34 and side members 35 and 36 which are fitted into registered

engagement with the annular members whereby the oil is permitted to seep into the container by way of the joints between the several members thereof.

Each of the cores of toroids T1 and T2 has primary and secondary windings 37 and 38 respectively disposed thereabout and insulated from each other by suitable electrical insulation 39 disposed therebetween and bound outwardly by suitable insulating tape 41. Windings 37 and 38 each preferably comprise an optimum number of turns as affects the wave form of the exciting current and matching of the secondary windings and the search coil SC.

Toroids T1 and T2 are potted as a unit in the same nonmagnetic container 42 having a quantity of potting sand disposed therein and a plurality of insulated terminals 43 brought outwardly therefrom. Primary windings 37 are connected series aiding and the free ends thereof connected to a pair of terminals 43. Similarly, secondary windings 38 are connected series opposing and the free ends thereof connected to the remaining pair of terminals 43. In practice, the sand and toroids within container 42 are vacuum dried and impregnated with cable oil which thereafter seeps into the fiber containers 32.

The magnetic characteristics of permalloy are altered when the material is strained. When this condition occurs, the magnetic amplifier is incapable of operating in the manner intended. By reason of the foregoing construction of the toroids, however, any pressure thereon resulting from shocks received thereby is uniformly distributed by the oil to the several laminations within the containers 32 therefor, thus avoiding any permanent strain therein. Moreover, freedom of movement afforded the laminations within the containers individual thereto prevents strain in the laminations by reason of contraction or expansion of the containers resulting from variations in temperature or by reason of contraction and expansion of the laminations due to magnetostriction. The insulation separators also serve as a means for conveying the oil between the laminations and further serve as cushions in preventing the transmission of shock therebetween. Furthermore, by reason of this core construction eddy current losses are held to a minimum, the oil between the laminations serving to increase the insulation therebetween.

While the invention has been described in particularity with respect to a specific embodiment thereof adapted to fulfill the aforestated objects of the invention, it will be apparent to those skilled in the art, after understanding the invention, that the same is susceptible of additional

embodiments and modifications thereof without departing from the spirit and scope of the invention as defined by the appending claims.

The invention hereindescribed and claimed may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

1. In a transformer of the character disclosed, the combination of a core comprising a plurality of closed ring-shaped laminations formed of material having high specific resistance and high permeability, a nonmagnetic container for the laminations formed so as to permit a degree of freedom of movement of the laminations radially and axially therein, and a fluid contained in and substantially filling the space between said laminations and said container and adapted to move between the laminations.

2. In a transformer of the character disclosed, the combination of a core comprising a plurality of closed ring-shaped laminations formed of material having high resistance and high permeability, a nonmagnetic container for the laminations formed so as to permit a degree of freedom of movement of the laminations radially and axially therein, a fluid within said container and adapted to move between the laminations, and a plurality of ring-shaped insulators disposed respectively between adjacent pairs of laminations and adapted to convey said fluid therebetween whereby the insulators and the fluid serve to distribute stresses applied to the container uniformly over the laminations.

3. In a transformer of the character disclosed, the combination of a core comprising a plurality of closed ring-shaped laminations formed of magnetic material of high resistance and high permeability and a plurality of insulation separators disposed respectively between adjacent pairs of the laminations, a container for loosely retaining said laminations and separators therein and having a quantity of fluid disposed therein between the laminations and separations, and a plurality of windings disposed about the container and supported thereon.

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