

Aug. 25, 1959

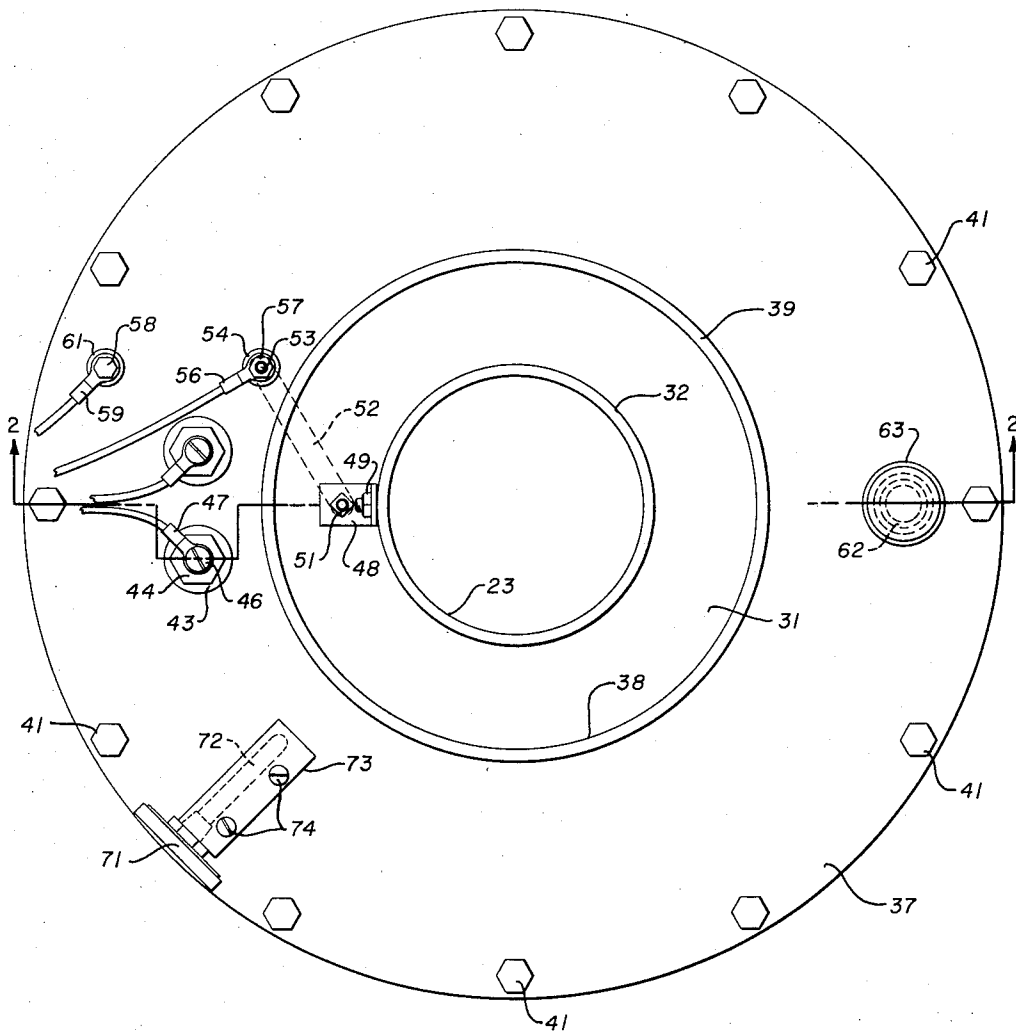
W. R. BAKER
TRANSFORMER

2,901,714

Filed Nov. 29, 1955

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Fig. 1.



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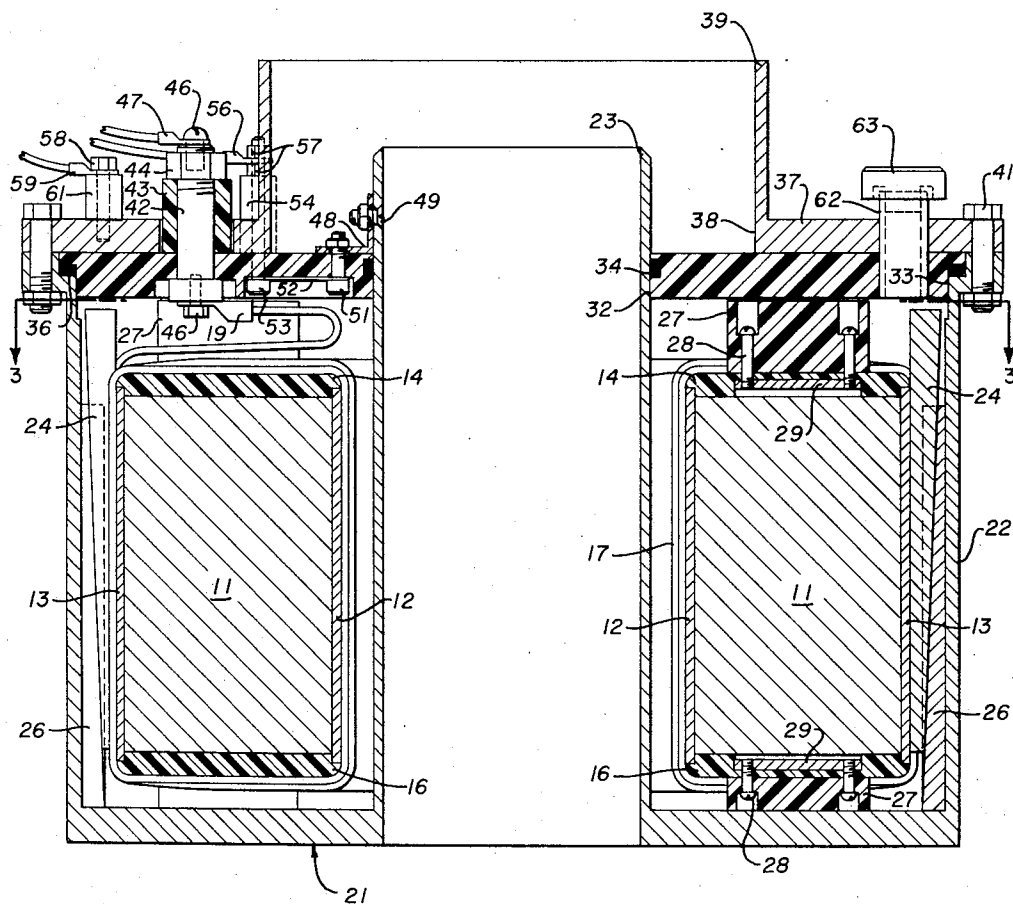
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Fig. 2.



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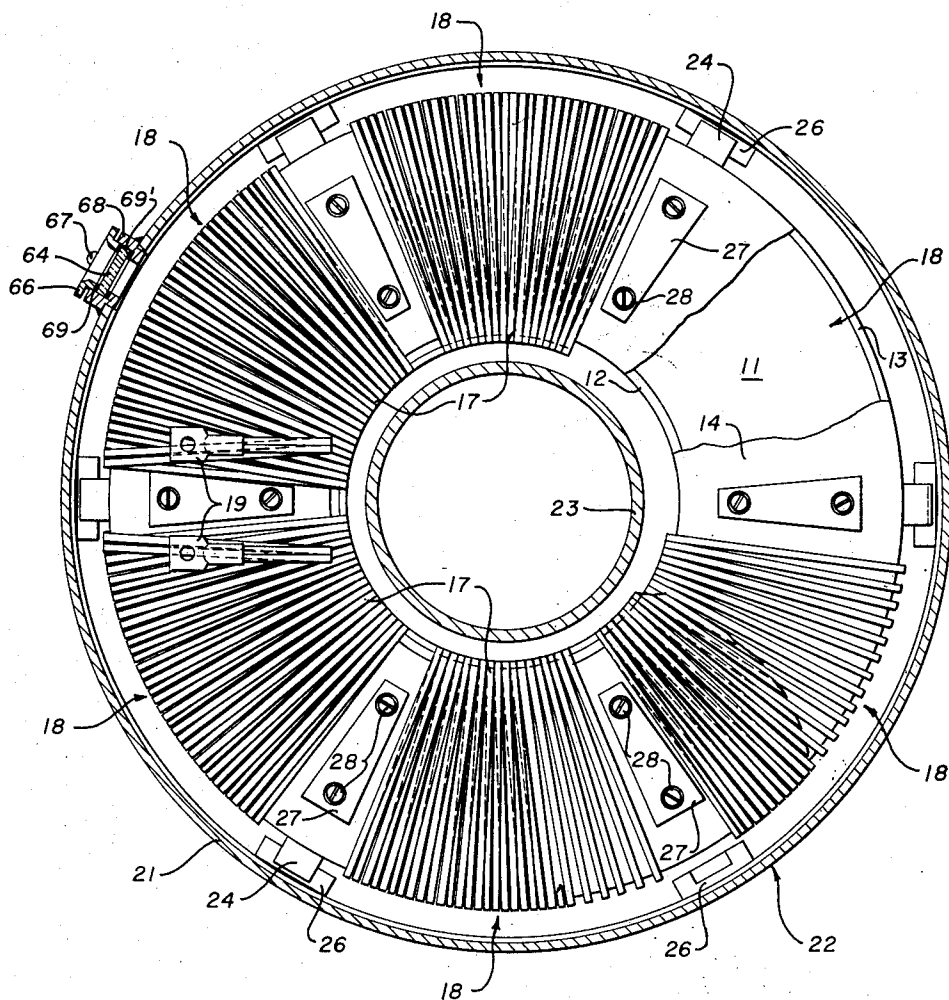
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Filed Nov. 29, 1955

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Fig. 3.



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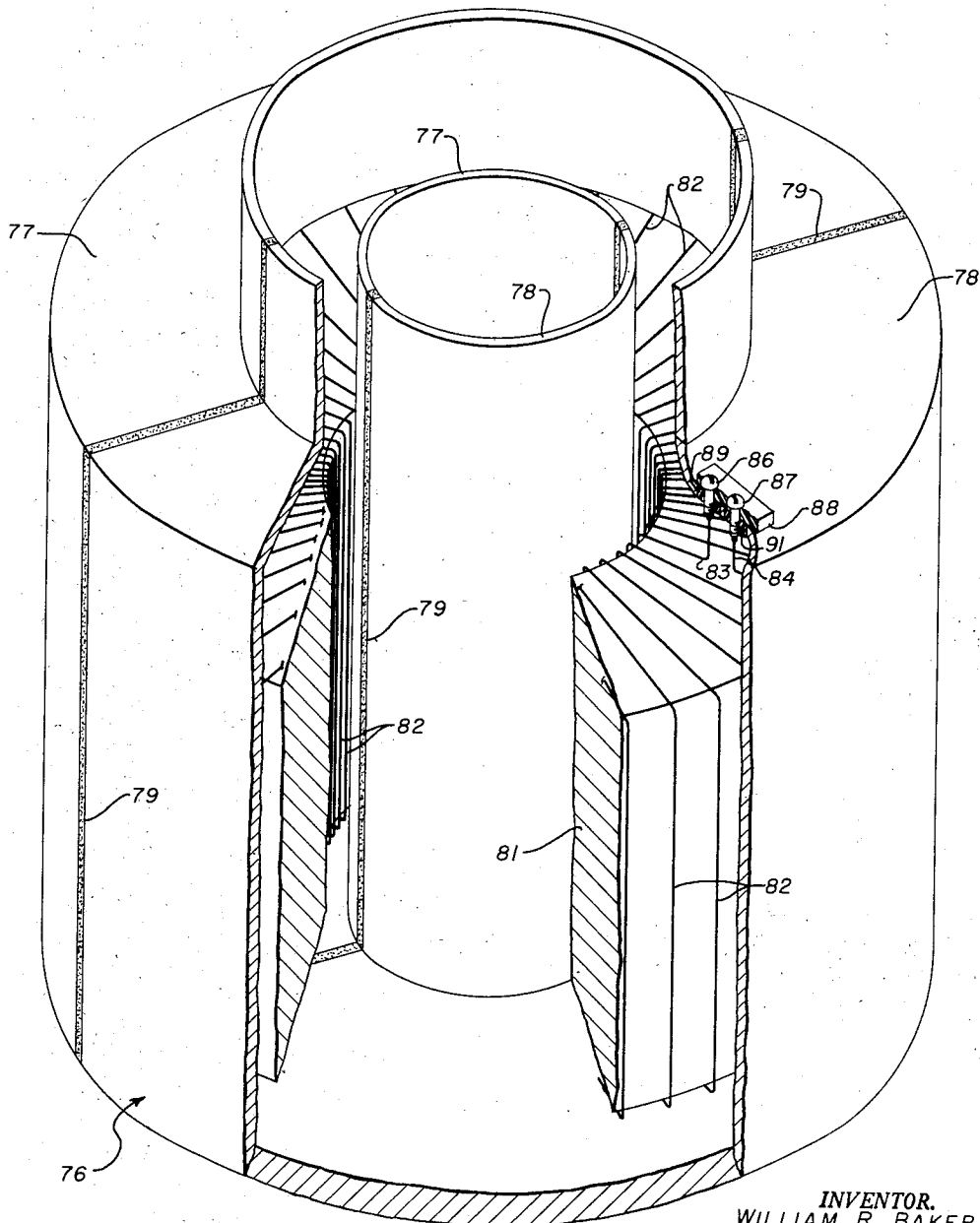
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Filed Nov. 29, 1955

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Fig. 4.



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2,901,714

TRANSFORMER

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Application November 29, 1955, Serial No. 549,900

1 Claim. (Cl. 336—82)

The present invention relates to improvements in electrical transformers, and more particularly to step-down transformers of the class used for supplying current to the filaments of high power vacuum tubes and to beam deflection devices for cyclotrons, wherein current requirements may be within and exceeding the range of 2000 to 200,000 amperes.

Undesirable characteristics usually embodied in such transformers include the very great amount of heat generated by electrical resistance in the transformer windings, and also the external magnetic flux that normally surrounds a transformer and renders difficult the operation of other magnetically sensitive instruments that may be disposed in the vicinity.

It is accordingly an object of this invention to provide a transformer supplying a very high value of current and having improved electric, magnetic, and thermal qualities.

It is another object of this invention to provide a transformer generating a reduced amount of heat in proportion to power rating.

It is still another object of this invention to provide a transformer having improved heat transfer characteristics.

It is a further object of this invention to provide a transformer having a minimum field of magnetic flux external to the physical body of the apparatus.

It is still a further object of this invention to provide a transformer of simplified and more economical construction, and of improved efficiency in operation.

The invention, both as to its organization and method of operation, together with further objects and advantages thereof, will best be understood by reference to the following specification taken in conjunction with the accompanying drawing, of which:

Figure 1 is a plan view of an embodiment of the invention;

Figure 2 is a vertical section of the transformer shown in Figure 1, taken along line 2—2 of Figure 1;

Figure 3 is a partially cut-away horizontal section of the transformer, taken along line 3—3 of Figure 2; and

Figure 4 is a cut-away perspective view of a second embodiment of the invention, in which the secondary winding may be connected as a coil of multiple turns.

Referring now to the drawing, and particularly to Figs. 1 and 2, there is shown a high current transformer having a primary winding core 11 of ferromagnetic material, in the form of an annulus which is insulatingly encased by hollow cylindrical shields 12 and 13, and by annular top and bottom plates 14 and 16, the latter being mortised to fit smoothly into the open ends of the shields.

A bifilar primary winding 17 is disposed, toroidally upon the core 11, in a plurality of spaced sectors 18 (see Fig. 3), the intervals of which define zones wherein the individual conductors of the winding are transposed for electromagnetic balance; and the paired extremities of the conductors are connected in electrically parallel manner by means of perforated clamping terminals 19.

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A novel feature of the present device is represented by the secondary winding which, instead of comprising simple loops or a loop of wire, is formed by the outside container of the apparatus. A hollow annular case 21, having an open upper end at which the exterior wall 22 is flanged and counterbored, and at which the interior wall 23 is extended in an axial direction, is disposed sheathing the primary winding assembly, the two elements being exactly spaced apart by suitable means.

In the present embodiment, the spacing means comprise a plurality of cooperating wedges 24 and 26 vertically disposed between the exposed portions of the primary core shield 13 and the exterior wall 22 of the case, and a plurality of spacing blocks 27 disposed radially upon the exposed portions of the primary core top and bottom plates 14 and 16, each block being retained to an appropriate plate by means of bolts 28, which transpierce the plate and are threaded tightly into a corresponding anchor element 29 countersunk on the inner side of the plate.

The case 21 is closed at the top by an insulating plate 31, which is adapted, by means of a central transverse bore 32 and a peripheral mortised surface 33, to fit smoothly between the walls 23 and 22 of the case; and the joints are closed against the passage of fluids by means of flexible toroidal seals 34 and 36, the first of which is seated within an appropriate recess formed in the bore 32 of the plate, and the second of which is retained between the adjacent horizontal surfaces of the plate and case. A retaining ring 37, having a central bore 38 and a coaxially disposed, upward projecting cylindrical portion 39, is disposed to cover the periphery of the insulating plate 31, and is affixed to the flanged portion of the case 21 by means of spaced fasteners 41.

A feature of importance in the inventive concept of the present device lies in the arrangement of terminals for connecting the secondary winding, or case, with an exterior circuit. It is well known that a current-conducting coil wound uniformly upon a toroidal core sets up a magnetic field contained entirely within the toroid. It is desirable, for reasons to be later explained, to have such a conformation, and such a resulting field, for the entire closed current path of the secondary winding, both internally and externally of the transformer itself; this current path being, however, in the present case comprised of only one turn; or in other words being shaped generally as the surface of an axially elongated toroid upon which the induced secondary current is constrained to circulate in a continuously re-entering direction. It is to be noted, in reference to Fig. 2, that the inside diameters of the cylinder 39 and the bore 38 of the retaining ring 37 are proportioned to be substantially greater than the outside diameter of the wall 23 of the case 21 so that the cylinder and wall are separated by an insulating space, while yet being disposed coaxially in relation to one another. The cylinder 39 and wall 23 are thus adapted to serve as exterior terminals for the secondary winding, which has the shape of half a toroid, whenever it is desired to connect that winding with an external circuit of similar conformation, such as, for instance, the filament circuit of an RCA triode tube 5831; and the consequent closed current path has the full toroidal shape described.

Exterior terminals for the primary winding are formed by a pair of bolts 42, the heads of which are countersunk on the interior surface of the insulating plate 31 to conserve space, and the body portions of which transpierce the plate 31 and the retaining ring 37, being sheathed in passage through the latter by a pair of coaxially disposed insulating tubes 43. This assembly is completed by retainers 44, threaded onto the bolts 42, and by two pairs of contact retainers 46, which are threaded coaxially into

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the extremities of the bolts 42, and which serve to affix a pair of external primary leads 47 as well as the clamping terminals 19 of the primary winding.

Take-off terminals, which are desirable for the electrical connection of monitoring instruments to the secondary winding, may be formed in a variety of ways, and in the embodiment shown in the drawing are formed as will now be described.

An angled bus bar 48 is affixed to the extended portion of the wall 23 and to the top of the insulating plate 31 by means of retainers 49 and 51, the latter of which also retains, within a recess formed on the interior face of the plate 31, a second bus bar 52. A secondary monitor terminal bolt 53, disposed at a distance from the wall 23, transpierces the bus bar 52, the plate 31, and the retaining ring 37; and an insulating tube 54 protects the upward protruding extremity in a disposition similar to that of the tubes 43. A secondary monitor lead 56 is then affixed to the bolt 53 by means of a pair of retainers 57. The other secondary monitor terminal is comprised of a terminal bolt 58, which retains a lead 59, is sheathed by an insulating tube 61, and is threaded into the retaining ring 37.

The apparatus is prepared for operation by filling the case 21 with coolant, such as oil, which is admitted by a filling pipe 62 secured transpiercing the retaining ring 37 and the insulating plate 31 at a convenient location, the pipe then being closed by means of a cup shaped cap 63. A proper level of the coolant may be verified at any time by observation through a transparent window 64 (see Fig. 3), which is retained by a ring 66, affixed by fasteners 67 into a counterbored annular frame 68, which is secured transpiercing the exterior wall 22 of the case, the joints being protected by toroidal seals 69 and 69' interposed on either side of the window. The operating temperature of the apparatus is monitored by means of a thermometer 71 (see Fig. 1), mounted with its stem sheathed in an appropriate bore 72 of a thermally conducting block 73, which is affixed to the retaining ring 37 by fasteners 74.

It will be understood that electrically conducting substances are employed in the primary winding 17, the clamping terminals 19, the primary terminals 42, the case 21, the retaining ring 37, and the monitor terminals 53 and 58; and that electrically insulating substances are employed in the core shields 12 and 13, the core top and bottom plates 14 and 16, the wedges 24 and 26, the insulating plate 31, and the insulating tubes 43, 54, and 61.

Referring now to Fig. 4, there is shown a second embodiment of the invention wherein the outside container of the apparatus is divided into insulated parts that may be connected in series with an exterior circuit, thus forming, in effect, a secondary winding having a plurality of turns. A conducting, re-entrant cylindrical case 76 is split, along an axial plane, into two halves 77 and 78, which are retained together and sealed into a fluid tight container by means of a dielectric strip 79 disposed between the facing edges. A ferromagnetic annular core member 81 is coaxially disposed within the case 76, and a primary winding in the form of a toroidal coil 82 is disposed upon the core member. The terminals 83 and 84 of the coil are secured to terminal bolts 86 and 87, which transpierce the case 76 and are insulated therefrom by insulating members 88, 89, and 91.

Now will be considered the effects of having such a transformer, formed with a secondary winding that encloses the primary winding and its magnetic circuit upon all sides, without leaving any substantial gaps except those that obtain between the exterior terminals 23 and 39, the latter being connectable with an external

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circuit to complete the enclosure desired. A consequence of this novel conformation is that the secondary winding more completely comprehends, absorbs, and is linked by, the magnetic field established in the core by action of the primary winding, so that the transformer is operated with less leakage inductance, that is, with greater work efficiency. Also, the self-induced field of the secondary winding is more completely contained within the toroidal volume embraced by that winding, and since practically no flux from either source finds passage to areas external to the physical body of the apparatus, it becomes possible to dispose in the vicinity many delicate instruments, the proper functioning of which depends on freedom from magnetic influences. Furthermore, the conformation described, when it is used for a winding having but a single turn as shown in Figs. 1 through 3, or when it is used in a winding having a suitably small number of turns in relation to the overall diameter of the toroid as shown in Fig. 4, provides a conductor having greater average surface and cross-sectional areas than a comparably disposed wire, thus more effectively dispersing the heat incident to operation of the transformer, and at the same time causing less heat to be generated, by reason of decreased electrical resistance in the conductor. And also, with this conformation, a further casing for holding coolant exterior to the windings is eliminated, thus simplifying construction of the transformer and decreasing its expense.

It will be understood that similar winding conformations may be embodied in the primary winding of a transformer, or in transformer windings having more than two turns, or in transformers which are used for either increasing or decreasing the current supplied; and while the invention has been disclosed with respect to only two embodiments, it will be apparent to those skilled in the art that numerous variations and modifications may be made within the spirit and scope of the invention, and thus it is not intended to limit the invention except as defined in the following claim.

What is claimed is:

In an electrical transformer, the combination comprising a secondary winding in the form of a fluid-impermeable, conducting, re-entrant cylinder, the outer cylindrical wall of which is inwardly directed at the open extremity thereof, said shell being divided upon at least one axial plane into a plurality of parts, dielectric means disposed in fluid tight contact between the adjacent ones of said parts, a ferromagnetic annular core member disposed within said cylinder, said core member being positioned encircling the inner cylindrical wall of said cylinder, and a primary winding in the form of a toroidal coil of rectangular cross section, the turns of which are wound helically upon spaced sectors of said core member.

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