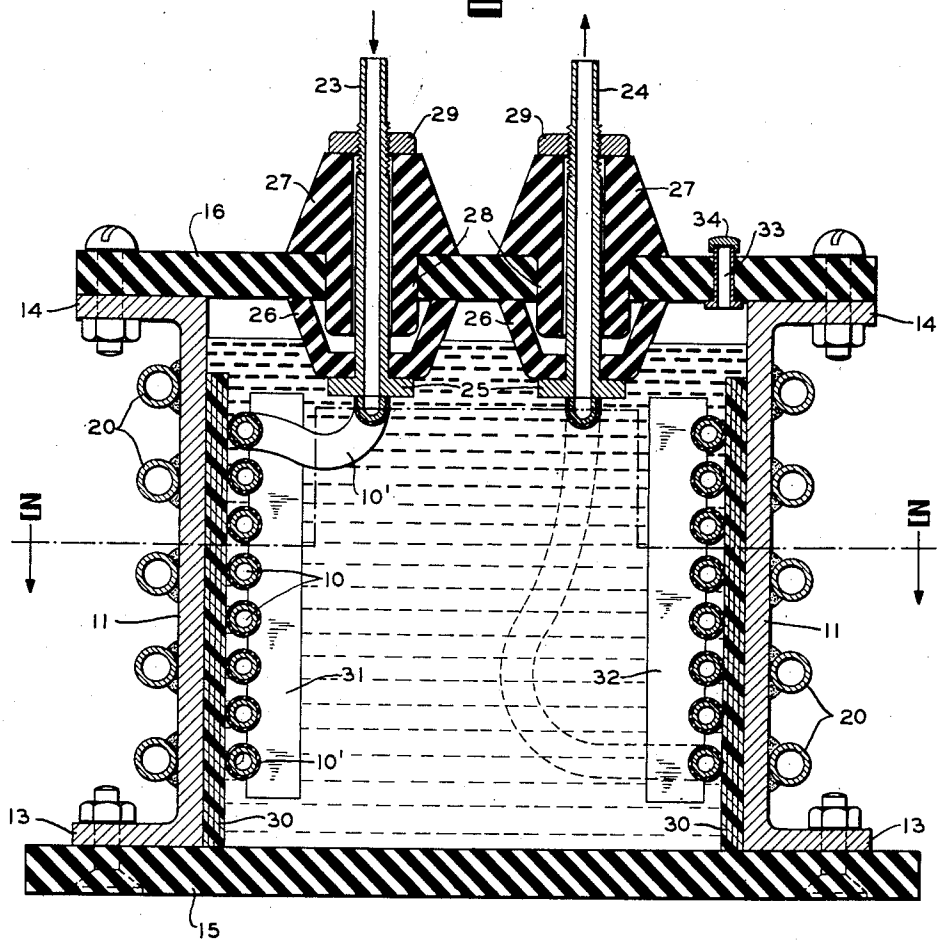
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RADIO FREQUENCY TRANSFORMER

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2 Sheets-Sheet 1

Fig. 1



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Fig. 2

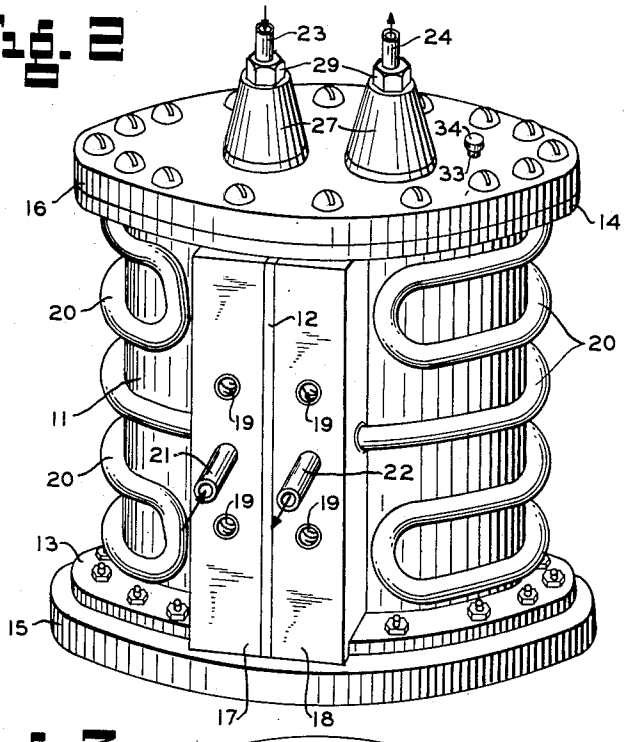
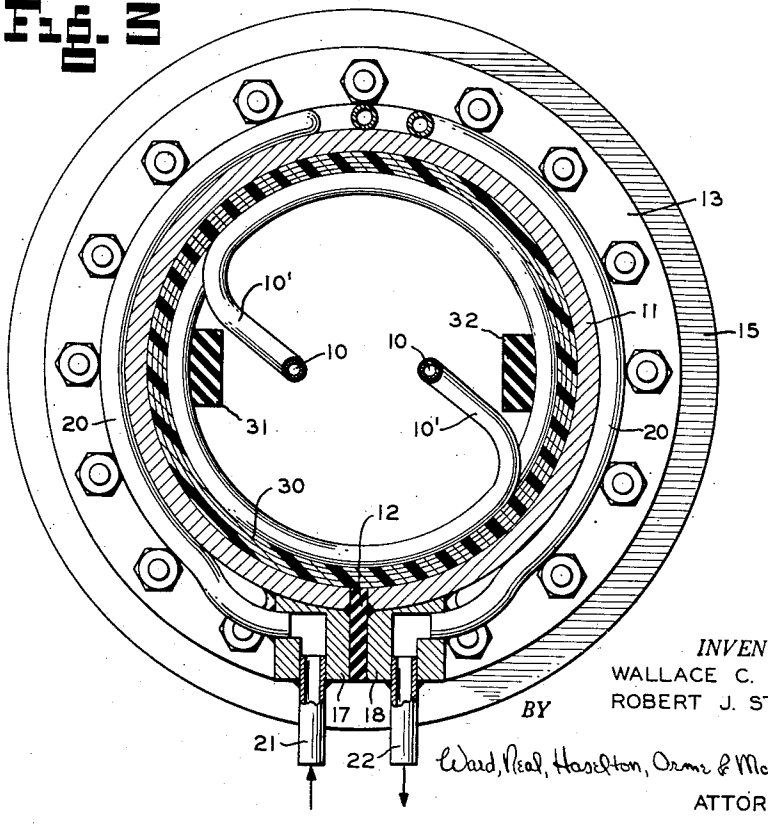


Fig. 3



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2,825,033

RADIO FREQUENCY TRANSFORMER

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Application October 18, 1955, Serial No. 541,143

1 Claim. (Cl. 336—58)

This invention relates to radio frequency transformers and more particularly to types thereof adapted to be used as output transformers for supplying high frequency current to the work circuit of induction heating means and for other purposes such as in the welding of tubing and other articles.

One of the difficulties in constructing highly efficient, inexpensive and dependable high frequency transformers heretofore of such types has involved the problem of obtaining a satisfactorily high coupling factor as between the primary and secondary windings, especially when the primary current amounts to some hundreds of amperes at thousands of volts. This difficulty arises from the problem of bringing the primary coil turns sufficiently close to the secondary while still providing safe, dependable insulation therebetween having a satisfactory dielectric constant. It has not been possible so far as is known heretofore to provide transformers for the above indicated purposes of very high efficiency and adapted for use with frequencies such as hundreds of thousands of cycles per second and the secondaries of which will be suitable for providing a load circuit of the necessary low inductance.

The present invention provides a construction which has been found quite surprisingly efficient for the purpose and which at the same time is relatively simple, easy to construct and assemble and highly reliable in operation.

Various further and more specific objects, features and advantages of the invention will appear from the description given below, taken in connection with the accompanying drawings, illustrating by way of example a preferred embodiment of the invention.

In the drawings:

Fig. 1 is a vertical sectional view of the preferred embodiment of the invention;

Fig. 2 is a perspective view of same; and

Fig. 3 is a horizontal sectional view taken substantially along line 3—3 of Fig. 1.

Referring to the drawings now in further detail, the primary winding of the transformer shown may comprise a plurality or several turns of copper tubing as indicated at **10**, covered with a glass fiber sleeve **10'** and wound to conform to a substantially cylindrical shape, whereas the secondary comprises a single turn in the form of a cylindrical casing of copper as at **11**, having (as indicated in Fig. 3) a vertical gap along one side, filled with a strip of insulation material **12**.

The secondary turn **11** is formed with upper and lower flanges as indicated at **13** and **14**, which may be bolted as shown, or otherwise secured and sealed with respect to lower and upper circular disc-like plates **15** and **16** of synthetic resinous insulating material, laminated if desired, and also embodying, if desired, flaked mica or the like.

As shown in Figs. 2 and 3, the two "ends" respectively of the secondary turn **11** may have secured thereto as by brazing, a pair of metal terminal bars as at **17, 18**, between which the insulation strip **12** is clamped and

sealed as by a suitable plastic cement. As indicated in Fig. 2, these terminal bars may be formed with taped holes as at **19** adapted for the connection of the terminals of a work circuit.

With currents of the nature with which transformers of this class are adapted to be used, it is necessary to cool both the primary and secondary windings or turns. In the construction shown, the secondary is cooled by providing a copper or other metal tube as at **20** brazed along a serpentine path providing spaced turns thereof on the exterior of the secondary **11**, such turns being suitably shaped to be relatively closely spaced over the greater part of the exterior surface of the secondary. The ends of the fluid cooling tube **20** may terminate as indicated in Fig. 3 in the terminal blocks **17** and **18** respectively, which are formed with apertures therethrough permitting cooling water or other fluid to be connected to a source thereof by a pipe **21** and to an outlet pipe **22**.

The primary winding being in the form of a copper tube, may also be similarly cooled by a stream of fluid, the inlet for which may comprise one of the primary power terminals as indicated at **23**, and the fluid outlet being provided by the other power terminal indicated at **24**. The hollow tubular terminal members **23, 24** may be flanged at their lower ends as indicated at **25** (Fig. 1) and brazed or soldered to the respective ends of the tubular primary winding, so as to provide for communication therewith. The terminal members **23, 24**, as shown, may be retained in suitable insulators shaped as indicated at **26, 27**, the latter having a depending portion **28** fitted within and extending down through an aperture in the cover **16**. The flanges **25** may be held up against the underside of insulators **26** by nuts as at **29** having threaded engagement with the upper portions of the terminal members.

The primary turns are preferably insulated from the secondary by a plurality of layers of tape **30** formed of tetrafluoroethylene or equivalent insulation tape of durable oil-resistant material and having a satisfactory dielectric constant and high dielectric strength, for example tape of polytetrafluoroethane polymer or the type fabricated from the material commercially available under the trademark "Teflon" (du Pont) has been found highly satisfactory for the purpose and has a dielectric constant of about 2.5. In case such "Teflon" tape is used, same may be of a thickness of about 0.015 inch, for example, wound around the primary in layers to form a total thickness of about ⅛ inch and so as to closely fit within the secondary.

The primary may be supported in the position shown suspended above the base plate **15** by the terminal connections therefor. However, to keep each turn in properly spaced relation and position, a plurality of vertical supporting strips as at **31, 32** formed of synthetic resinous or plastic material such as commercially available under the trade name "Mycalex" for example, which same material also may be used for the top piece **16**, if desired. These strips such as at **31, 32** may be formed on the faces thereof which engage the primary turns, with scalloped-out areas, if desired, to partially fit between adjacent turns, and the turns may be tied in place with respect to such strips as by the use of glass fiber thread.

After the parts are assembled in the positions shown in Fig. 1, the casing or container comprising the secondary and the bottom plate, is substantially filled with a good grade of transformer oil, for example one which will have a dielectric constant of about 2.5. Thereupon the whole assembly is placed in a vacuum chamber so as to withdraw any entrapped air which may exist between the layers of the tape **30** or around the primary

turns or at other places within the casing. The air may be withdrawn as through a nipple 33 passing through the top cover and after the assembly has been removed from the vacuum chamber, this outlet may be covered by a cap or screw plug 34 which need not be airtight as it is desirable for the casing interior to "breath" as the result of temperature changes. Nevertheless the subjection of the assembly to the above-described vacuum treatment amply insures that the areas around and between the interior surface of the secondary turn and the primary turns will all be free of entrapped air and the interstices around and between these parts and the insulation tape will be filled with oil having about the same dielectric constant as the insulation tape.

This conjoint use of oil thoroughly freed of gas bubbles, in conjunction with the tape layers 30, contributes greatly to the success of the transformer and its high coupling factor. It should be pointed out that either the layers of plastic tape or the use of oil alone would not be satisfactory for achieving the desired results. The combination of the two is essential for high dielectric strength and the prevention of corona discharges around the primary turns. With a typical example of the construction shown and above described, the transformer was supplied with current of a frequency of 450 kilocycles per second and used with a 50 kilowatt output induction heating unit. The primary voltage was about 8000 and the primary current about 400 amperes. The kilovolt-ampere rating of the transformer was over 3000. The coupling factor by measurement was about 80%, thus providing a transformer of surprisingly remarkable rating under the conditions.

Transformers as shown may be made of different sizes to provide transformers of different impedances for feeding various ranges of inductance load circuits, but preferably with the primaries all such that they have the same inductance. To that end for example a relatively small sized transformer may be made with an inside diameter of the secondary equal to 4½ inches and with a primary having about eleven turns. Another with an inside diameter of 6 inches has, for example, about 8½ turns of

quarter inch copper tubing forming the primary. Other larger sizes with the same primary inductance may be made with corresponding smaller numbers of primary turns.

What is claimed and desired to be secured by Letters Patent is:

A radio frequency power transformer comprising in combination: a closed casing having upper and lower insulation plates and a cylindrical metal wall portion the ends of which are secured to and covered by said plates, the metal of such wall portion being interrupted along one side by a strip of insulation; output terminals attached to said metal wall portion at either side of said interruption whereby such wall portion is made to constitute a single-turn secondary of the transformer; terminal means for connection of the terminals respectively of a work circuit directly to said secondary at opposite sides of said insulation strip; a primary coil of several turns mounted within said casing coaxially therewith and with its turns each extending circumferentially close to the interior surface of said cylindrical metal wall portion, said primary coil being covered with tetrafluorcethylene tape substantially filling the space between said primary and the inner surface of said cylindrical metal wall portion; insulation means for supporting and positioning the primary turns respectively in spaced relation; a gas-free filling of oil contained in said casing and permeating the interstices about said primary turns and the insulation tape thereon, said primary being formed of hollow tubing adapted to contain a stream of cooling fluid; and conduit means adapted to contain a stream of cooling fluid in heat exchange relation with the outside of said single-turn secondary.

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