

Aug. 4, 1925.

1,548,388

W. J. SHACKELTON
TRANSFORMER

Filed April 26, 1923

Fig. 1.

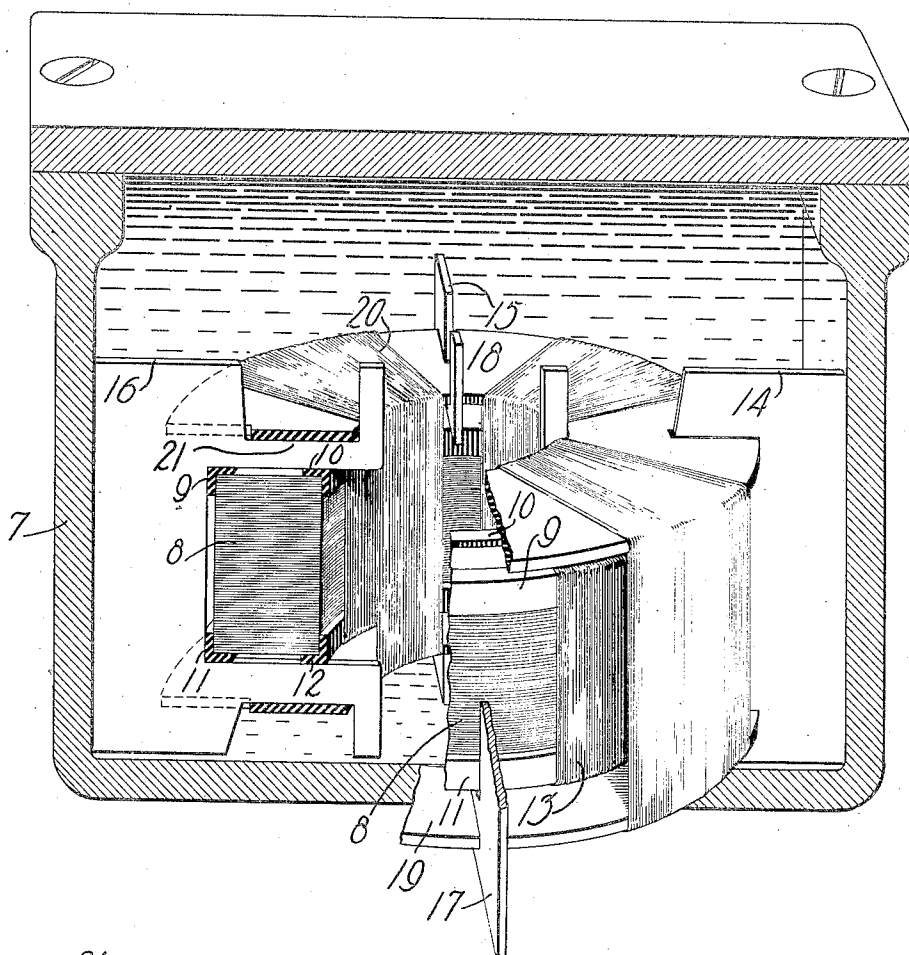
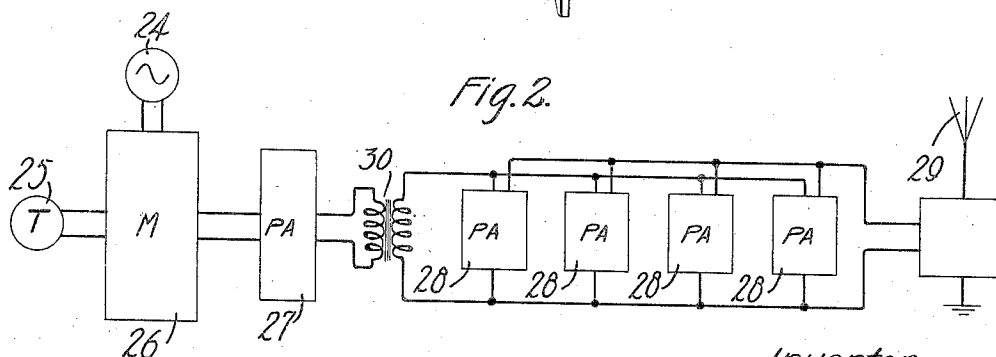


Fig. 2.



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UNITED STATES PATENT OFFICE.

WILLIAM J. SHACKELTON, OF SCOTCH PLAINS, NEW JERSEY, ASSIGNOR TO WESTERN ELECTRIC COMPANY, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

TRANSFORMER.

Application filed April 26, 1923. Serial No. 634,652.

To all whom it may concern:

Be it known that I, WILLIAM J. SHACKELTON, a citizen of the United States, residing at Scotch Plains, in the county of Union, State of New Jersey, have invented certain new and useful Improvements in Transformers, of which the following is a full, clear, concise, and exact description.

This invention relates to transformers.

10 An object of this invention is to provide a power transformer for use in high frequency circuits.

The particular modification of this invention hereinafter described in detail comprises a toroidal coil on which the two windings are uniformly distributed, one being superposed on the other. Suitable means comprising insulating material are employed for separating the two windings and for separating the inner winding from the core to allow the free circulation of a cooling fluid between and around the windings. This structure has been found particularly efficient in high voltage high frequency circuits because of the low magnetic leakage obtained.

Referring to the drawings, Fig. 1 represents one form of this invention particularly adapted for use in a high power radio transmitting station, and Fig. 2 is the schematic showing of a radio transmitting circuit in which a transformer of this invention may be employed.

Referring to the form of this invention shown in Fig. 1, a casing 7 is disclosed containing a toroidal core structure 8 made of any suitable magnetic material. Four annular rings 9, 10, 11 and 12, having an angular cross section are provided to fit over the four edges of the toroid in order to provide a framework of insulating material on which the transformer winding 13 may be wound. After the winding 13 has been applied four upright pieces 14, 15, 16 and 17 are fitted over the annular rings 9 to 12, and two annular plates 18 and 19 are fitted in the notches in the upright pieces in order to form a framework of insulating material on which the second winding 20 may be mounted.

It will be noted that the four annular rings 9 to 12 serve to space the winding 13 away from the core 8 while still allowing sufficient space between the winding and

the core into which the oil or other suitable insulating liquid contained in the casing 7 may circulate. The height of the cross arms 21 of the upright members also insures that plenty of space is available between the primary and secondary windings for the circulation of the cooling and insulating fluid.

Such a transformer has been found particularly useful in a high power radio frequency transmitting system such as that disclosed schematically in Fig. 2 in which a suitable high frequency source 24 and a low frequency signaling source 25 are shown working into a modulator 26. The high frequency modulated in accordance with the low frequency signal is impressed upon a power amplifier 27 and then upon a bank of power amplifiers 28 after which the amplified modulated high frequency may be impressed upon the radiating antenna or conductor 29. A transformer 30 employed between the first power amplifier 27 and the banking amplifiers 28 is preferably constructed in accordance with the embodiment of this invention shown in Fig. 1 since at that point in the circuit the transformer is required to handle at an ultra audio-frequency a large amount of power.

In one particular example the transformer 30 was required to operate at frequencies between 40,000 and 75,000 cycles with 6,000 volts on the primary side and also with a superimposed direct current of two amperes at a direct current potential of 12,500 volts above ground through the same winding. The total secondary or low voltage winding was designed to give a voltage of 1,200 volts.

In order to obtain satisfactory operation under the above described conditions the toroidal core was made with an approximate inside diameter of $4\frac{1}{4}$ " and outside diameter of approximately $7\frac{1}{2}$ " and an axial height of 3" built up of .003" sheet silicon steel laminations insulated from one another by a thin coating of shellac. Because of the superimposed direct current on the high voltage winding it was found preferable to have a small gap in the core which was filled with non-magnetic material.

When the transformer is operating on full voltage at 75,000 cycles, considerable heat must be dissipated from the core and as the high voltage winding is preferably

applied next to the core, it was found desirable to have between the core and the high voltage winding, a framework of insulating material which would allow this heat to be dispersed and conducted away from the core while still insulating the core from the winding for the high potentials. For these reasons a solid dielectric around the core was found undesirable and four phenol fibre rings having an angular cross-section were provided to fit over the four edges on the toroid. When the transformer is immersed in oil, the oil forms a dielectric between the winding and the core except where the winding is supported by the phenol fibre rings.

One of the advantages resulting from the use of the transformer of this invention is the relatively low magnetic leakage obtained because of the use of a toroidal core in spite of the relatively large separations between primary and secondary windings required because of the high voltages employed. It has been found that in the rectangular core type transformer with windings designed to operate at the required frequencies and with windings separated far enough from each other and from the core to stand up under the high voltages to which the transformer is subjected, that the magnetic leakage was generally so great as to render its use objectionable. With the use of a toroidal core, however, the transformer of this invention has been found to operate satisfactorily with a load as high as 10 K. V. A.

The manner in which the leads for the transformer windings 13 and 20 may be taken out of the casing 7 has not been disclosed since it may be done in any conventional manner as will be known in the art of high power low frequency transformers. It is also to be understood that it frequently will be preferable to design suitable means for suspending the transformer from the top of the casing 7 although such a feature has not been shown in the drawing since it is a well known expedient in low frequency power transformers.

It is to be understood that the form of this invention disclosed in Fig. 1 is capable of various modifications without departing

in any wise from the spirit of this invention as defined in the appended claims.

The invention claimed is:

1. A high power radio frequency transformer immersed in an insulating fluid and comprising a toroidal core, a high voltage winding uniformly distributed around said core, a low voltage winding superposed on said first winding, and means for separating said windings from one another and from the core to permit the free circulation of the insulating fluid.

2. An ultra audio-frequency power transformer, comprising a toroidal core, a skeleton framework of insulating material around said core, a winding uniformly distributed around said framework, a second skeleton framework disposed around said core and spaced from said first winding, a second winding wound around said second framework, and a non-conducting fluid substantially filling the space around said windings and insulating the windings from each other and from the core.

3. An ultra audio-frequency power transformer immersed in an insulating fluid and comprising a toroidal core, a skeleton framework surrounding said core, a high voltage winding wound uniformly on said framework whereby said winding is spaced from said core to allow the insulating fluid to separate the winding from the core, annular plates on opposite sides of said core, means for supporting and spacing said plates away from said first winding, and a second winding wound around said plates.

4. An ultra audio-frequency power transformer immersed in an insulating fluid and comprising a toroidal core having rectangular edges, annular rings having an angular core section fitting over the four edges of the toroid, a high voltage winding wound around said annular rings, annular plates on opposite sides of said toroid, means supported by said annular rings for supporting said annular plates and for spacing said plates away from said first winding, and a second winding wound around said plates.

In witness whereof, I hereto subscribe my name this 24th day of April A. D., 1923.

WILLIAM J. SHACKELTON.