July 18, 1950 C. N. HOYLER ET AL 2,515,874

TRANSFORMER

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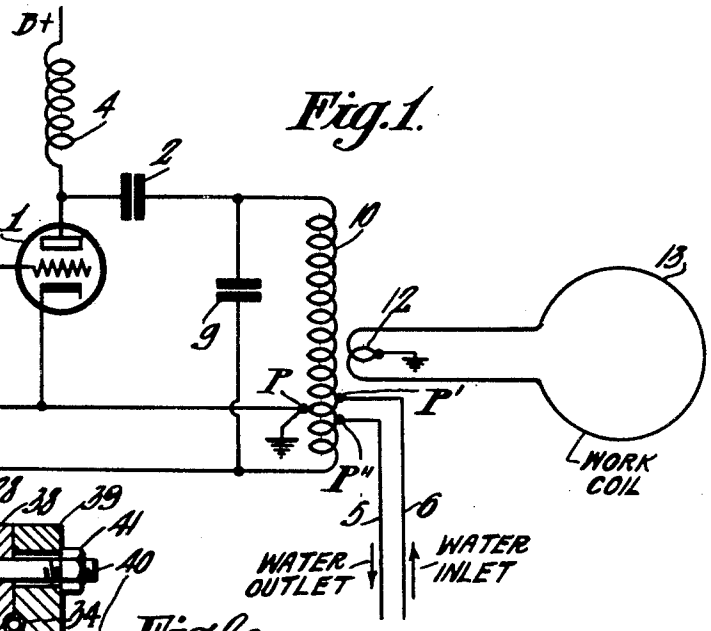


Fig. 1.

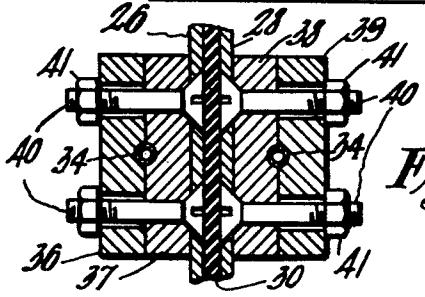


Fig. 1a.

Fig. 2.

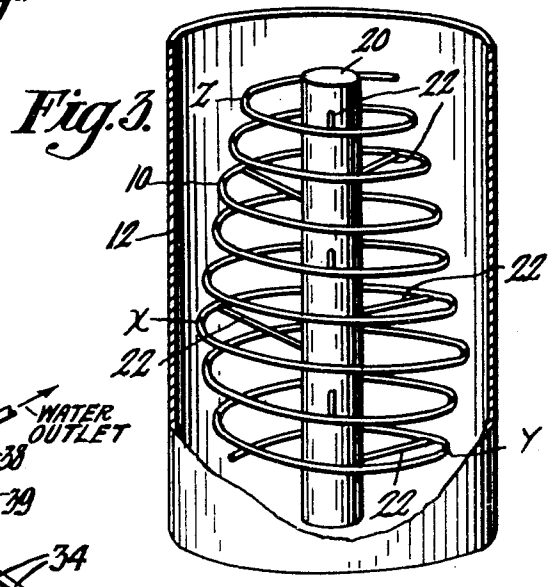
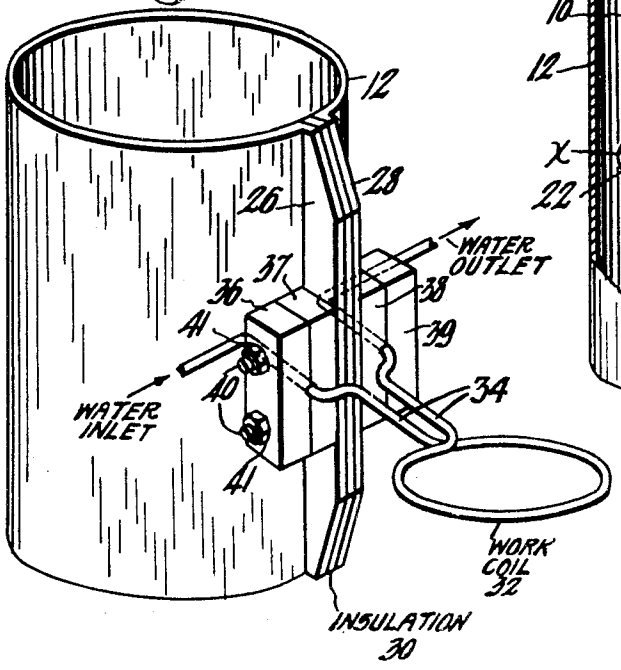


Fig. 3.



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TRANSFORMER

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4 Claims. (Cl. 175—359)

1

This invention relates to current transformers, and particularly to such transformers which are adapted for use in power generators for induction heating purposes.

An object of the present invention is to provide a current transformer having a primary winding composed of a number of turns which are differently spaced from a surrounding secondary.

Another object is to provide a transformer having a primary winding which is more closely spaced at a point intermediate its ends than at both ends with respect to a surrounding secondary.

A further object is to provide a current transformer having a water-cooled primary coil tapered inward toward each end, a surrounding single-turn secondary sheet, and a terminal assembly for attaching a load-coupling coil to the secondary sheet.

A detailed description of the invention follows, in conjunction with a drawing, wherein:

Figure 1 illustrates an oscillator circuit for an induction heating system in which the current transformer of the invention may be used;

Fig. 2 illustrates the cylindrical single-turn secondary of the current transformer of the invention, with the terminal assembly and attached load-coupling coil;

Fig. 2*a* is a vertical cross-section of the terminal assembly of Fig. 2; and

Fig. 3 is a view, partly in perspective and partly in section, of the current transformer of the invention.

Referring to Fig. 1, there is shown the high frequency generator portion of a high frequency induction heating system in which the current transformer of the invention may be employed. This circuit is given by way of illustration only, as other types of oscillator circuits may be used. The system of Fig. 1 includes a vacuum tube 1 having its anode, grid and cathode electrodes connected as a Hartley oscillator. The tank or frequency determining circuit compries the primary winding 10 of the current transformer shunted by a condenser 9. The anode is connected to one terminal of the tank circuit 9, 10 through a blocking and bypass condenser 2. The grid is connected via condenser 3 to the other terminal of the tank circuit. The grid is also connected through a resistor 7 to the cathode which, in turn, is connected to a point P on the primary winding 10 intermediate its ends. It should be noted that point P is grounded. Anode polarizing potential from the positive terminal B of a source of unidirectional voltage is supplied via a choke coil 4 to the anode. The secondary of the transformer comprises a single turn 12 inductively coupled to the primary coil 10, and this secondary is coupled to a work coil

2

13 which surrounds the load or batch of metallic material to be heated.

In practice, the primary winding 10 comprises a plurality of turns of copper tubing through which cooling fluid, such as water, may be passed. The cooling water outlet and the cooling water inlet are indicated respectively by the numerals 5 and 6 which are connected to points P' and P'' on the primary 10, at or near ground potential.

By way of illustration only, the anode polarizing potential B may be 20,000 volts D. C. relative to ground; the primary winding 10 may have 20 to 30 turns; the frequency of oscillation may be anywhere in the range from 100 kc. to 250 kc.; the power output from the generator may be 100 kw.; the peak radio frequency voltage in the primary winding may be 18,000 volts and the peak radio frequency voltage in the secondary may be 700 to 900 volts; the primary circulating current may be 50 to 100 amperes, while the circulating current in the secondary may be 1500 amperes and upward.

Fig. 3 shows the general configuration of the current transformer of the invention comprising the primary winding 10 and the surrounding single turn secondary sheet 12.

The secondary 12 is a copper cylinder which surrounds the primary winding 10 along substantially its entire length and is suitably spaced from the primary coil. The copper cylinder constituting the secondary is split lengthwise on one side so as to form a slot (note Fig. 2). The secondary is provided with wide sheet-like copper flanges 26 and 28. These flanges are separated from one another by suitable insulation 30. The flanges serve a dual purpose: First, the spacing between the two flanges is held to a minimum thus reducing the leakage reactance to as low a value as possible, and second, the wide output connections cause the secondary current to flow more nearly uniformly throughout the cross-section of the secondary.

The primary coil surrounds a suitable insulating form 20 such as Bakelite, and this Bakelite form is provided with a plurality of porcelain stand-offs or studs 22 along its length for supporting the individual turns of the primary winding. It should be noted that successive insulating studs 22 are spaced from one another circumferentially a distance of ¾ of a turn; hence, each turn is supported by an insulating stud from the Bakelite tube or form 20. In practice, the primary winding 10 is a hollow spirally wound tube through which cooling water flows.

An important feature of the present invention is the tapered spacing between the turns of the primary winding 10 and the surrounding cylindrical single-turn secondary sheet 12. It should be noted that point X on the primary winding is more closely spaced from the secondary 12 than

points Y and Z of the primary winding, and that point Y is closer to the secondary 12 than the point Z. Point X is, in practice, grounded and corresponds to point P of Fig. 1 and the spacing of the turns gradually increases in distance away from the secondary sheet 12 as the peak radio frequency voltage increases on the primary winding. Thus, as the peak radio frequency voltage across both ends of the primary winding 10 is 18,000 volts, the peak radio frequency voltage between points Z and X may be 16,000 volts while the peak radio frequency voltage between points X and Y may be 2,000 volts. The increased spacing between the secondary sheet 12 and the turns of the primary winding prevents breakdown between the primary winding and the secondary sheet.

The terminal assembly for attaching the load coupling, or work coil 32 is shown in Figs. 2 and 2*a*. This work coil may be copper tubing. This assembly includes a pair of metallic blocks 36 and 37 on flange 26 and another pair of metallic blocks 38 and 39 on flange 28. The blocks 36 and 37 are provided at their centers with semicylindrical apertures for enabling one metallic tubular conductor 34 to enter therein and be securely connected to the blocks 36, 37. Similarly, blocks 38, 39 are also provided with semicylindrical apertures or holes in the center thereof for enabling the other conductor 34 to enter therein and be securely connected to the blocks 38, 39. The leads 34 are thus securely fastened mechanically, and are electrically connected to the blocks 36, 37 and the blocks 38, 39. For rigidly linking metallic blocks 36, 37 together and to flange 26, and for rigidly connecting blocks 38, 39 to flange 28, there are provided pairs of studs or screws 40, 40 and lock nuts 41, 41, the details of which are shown clearly in Fig. 2*a*. The insulation spacer 30 electrically spaces the flanges 26 and 28 and hence, the blocks 37, 38 from each other.

It should be noted from an inspection of Fig. 1 that the cooling water is fed into the primary coil and taken out therefrom in the direction shown by the arrows at points which are substantially at ground potential. Thus, the water inlet and outlet pipes may be of insulation or other suitable material as they do not cary any appreciable voltage.

What is claimed is:

1. A current transformer comprising a single primary coil of a plurality of spirally wound spaced turns and a single-turn secondary sheet surrounding said primary coil over its entire length and spaced therefrom, the spacing between the turns of said primary coil and said secondary increasing from an intermediate point toward both ends, an insulating form extending longitudinally of and within said primary coil, and stand-off studs positioned along the length of said insulating form and secured to the individual turns of said primary coil for supporting the same, adjacent insulating studs being circumferentially spaced from one another by a distance which is an appreciable fraction of the circumferential distance of a single turn of said primary coil.

2. A current transformer having a primary coil of a plurality of turns and a cylindrical single-turn secondary surounding said primary coil over its entire length and spaced therefrom, said secondary being cut longitudinally along its length, spaced flanges on both sides of said longitudinal cut, and a terminal assembly for said secondary comprising a pair of metallic blocks for each flange, the blocks of each pair having transverse holes at their adjacent edges, said holes together forming a larger opening into which an electrical connection can be inserted and secured between the blocks, and nut and bolt means for rigidly linking the blocks of each pair to each other and to the associated flange.

3. A current transformer comprising a primary coil of a plurality of spirally wound spaced turns and a cylindrical secondary sheet surrounding said primary coil over its entire length and spaced therefrom, the spacing between the turns of said primary coil and said secondary increasing from an intermediate point toward both ends, an insulating form extending longitudinally of and within said primary coil, and stand-off studs positioned along the length of said insulating form and secured to the turns of said primary coil for supporting the same, adjacent insulating studs being circumferentially spaced from one another by a distance which is an appreciable fraction of the circumferential distance of a single turn of said primary coil.

4. A current transformer having a primary coil of a plurality of turns and a cylindrical secondary surrounding said primary coil over its entire length and spaced therefrom, said secondary being cut longitudinally along its length, spaced flanges on both sides of said longitudinal cut, and a terminal assembly for said secondary comprising a pair of metallic blocks for each flange, the blocks of each pair having transverse holes at their adjacent edges, said holes together forming a larger opening into which an electrical connection can be inserted and secured between the blocks, and means for rigidly linking the blocks of each pair to each other and to the associated flange.

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