L. H. BURNHAM.

TRANSFORMER.

APPLICATION FILED JAN. 29, 1917.

1,304,451.

Patented May 20, 1919.

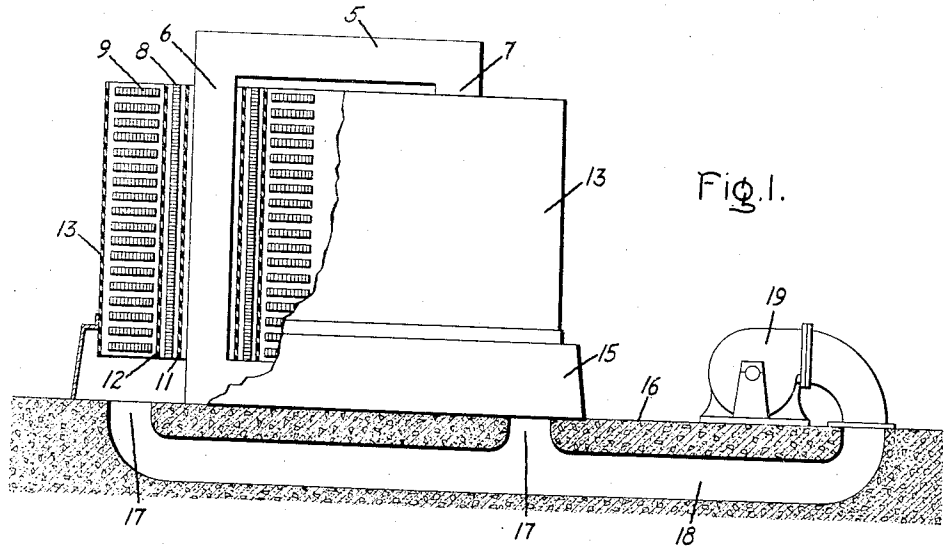


Fig. 1.

Fig. 2.

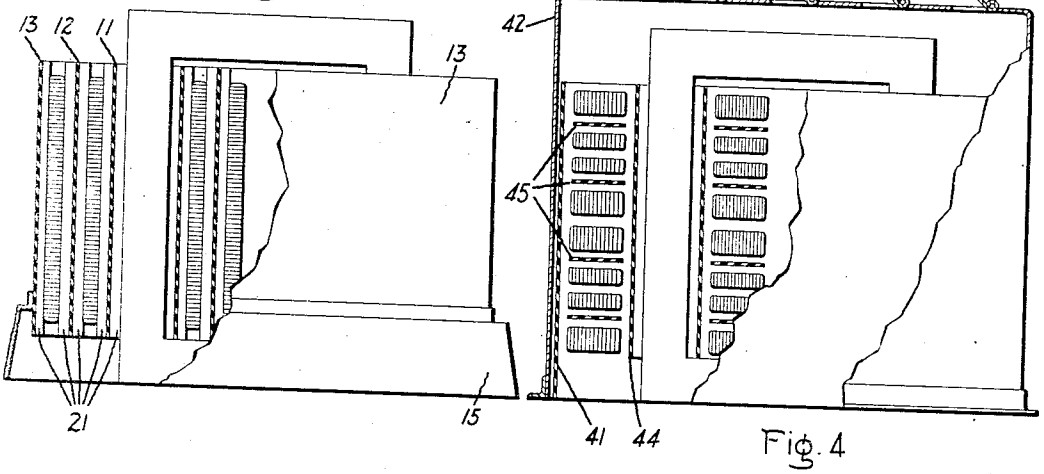
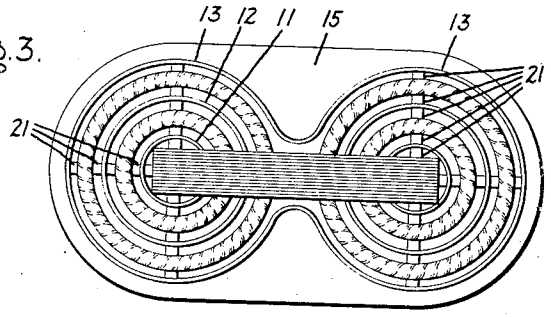


Fig. 4

Fig. 3.



Inventor:
Locke H. Burnham.
by Albert G. Davis
His Attorney.

UNITED STATES PATENT OFFICE.

LOCKE H. BURNHAM, OF PITTSFIELD, MASSACHUSETTS, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

TRANSFORMER.

1,304,451. Specification of Letters Patent. Patented May 20, 1919.

Application filed January 29, 1917. Serial No. 145,131.

To all whom it may concern:

Be it known that I, LOCKE H. BURNHAM, a citizen of the United States, residing at Pittsfield, county of Berkshire, State of Massachusetts, have invented certain new and useful Improvements in Transformers, of which the following is a specification.

My invention relates to the cooling of transformers, including under that latter term somewhat analogous apparatus such as auto-transformers or compensators, some reactances, etc. It particularly relates to such devices of the so-called core type and similar forms in which considerable portions of the external surfaces of the windings are exposed to the influence of a cooling fluid, and preferably are arranged to be cooled by the forced flow of the cooling fluid. Some of the objects of my invention are to improve the cooling or ventilating of such apparatus, and increase the capacity thereof. The increase in capacity is secured by better cooling or ventilation.

I accomplish the objects of my invention by requiring the cooling fluid to flow in thorough contact with the transformers, or at least the windings thereof, preferably in directions generally parallel to the extent of the core legs, and preferably by means of casings or barriers fairly closely and uniformly surrounding the parts to be cooled for directing the flow of the cooling fluid thereover; preferably the casings or barriers are used in combination with means for forcing the flow of the cooling fluid.

The casings or barriers of my invention may be employed with many types of windings, but it is notable that using such casings or barriers with windings of separated disk coils, with which type of winding such direction of fluid flow as is obtained by my invention would seem to have little promise, I have secured quite surprisingly satisfactory results using air as the cooling fluid and forcing the flow thereof.

In the accompanying drawings and following description I have illustrated and described in some detail certain preferred embodiments of my invention in transformers of the core type, from which my invention may be more completely understood. Figure 1 is an elevation partly in section of an air blast concentric disk-cylindrical coil transformer embodying my invention. Fig. 2 is an elevation partially in section of a concentric cylindrical coil transformer also embodying my invention. Fig. 3 is a plan view of the transformer of Fig. 2. Fig. 4 is an elevation also partially in section of an interleaved disk, coil transformer embodying my invention; this figure also illustrates a casing about a transformer and provided with ventilations for governing the amount of cooling fluid flowing through the transformer. In all the figures the transformers are shown in very simple form, all connections, taps, etc., being omitted for the sake of clearness.

In the transformer of Fig. 1 the core 5 is generally rectangular in shape, the legs 6 and 7 thereof carrying the windings and being generally vertically disposed. The windings on each leg comprise the low voltage cylindrical coil 8 and a number of disk coils 9 separated from each other along their winding axis and core leg and concentric with and outside the cylindrical coil 8. Within the cylindrical coil 8 and spaced therefrom and from the core leg 6 is a cylinder or barrier 11 of insulating material for both assisting in the insulation of the coil 8 from the core leg 6 and for directing and proportioning the air flowing over the core leg 6 and over the inner surface of the coil 8. Likewise between the coil 8 and the disk coils 9, and separated from all these coils, is a similar cylinder or barrier 12 likewise assisting in the insulation of the coil 8 and proportioning the air to the inner edges of the disk coils 9 and to the outer surface of the coil 8. An inclosing casing or barrier 13 disposed close to the outer edges of the disk coil 9 substantially surrounds and is substantially uniformly spaced from the entire circumferences of the windings on both the core legs 6 and 7. The shape of this casing 13 in plan more clearly appears in Fig. 3. It will be understood that the windings and internal cylinders or barriers on the core leg 7 are similar to those on the core leg 6. The coils and insulating casings and barriers (that is 11, 12 and 13) are spaced from each other by any suitable spacers providing for the exposure of so much of the coil surfaces, faces and edges, to the flow of the cooling air as possible, the ventilating spacer or passages adjacent the barrier being preferably parallel to the winding axis. Surrounding the lower yoke of the core 5 is a receiving compartment or casing 15

resting directly on the floor 16 carrying the transformer. The top of this receiving casing 15 is provided with an opening of the same shape as the plan of the casing 13 and the casing 13 sets into this opening, the sides of the casing being joined to the edges of this opening as appears from Fig. 1. The lower end of the receiving casing 15 is open to the floor openings 17 through which air is forced into the transformer through the passage 18 from the compressor or blower 19.

As may be observed from Fig. 1 and the above description, air from the blower 19 is forced to flow through the passage 18 and the openings 17 into the receiving casing 15, and from thence vertically upward within the casing or barrier 13 until it escapes to the atmosphere above the upper end of the casing 13. In its passage upward air from the receiving casing is directed into thorough contact with the outer edges of all the disk coils 9 by means of a casing or barrier 13, this casing or barrier being preferably sufficiently closely placed to the edges of these coils to secure this result. Furthermore this air is brought into substantially thorough contact about substantially the entire circumferences of the windings by reason of the peculiar shape of the casing 13 (as appears from Fig. 3) whereby the casing 13 is substantially uniformly spaced from the exteriors of the windings which in this case are the parts of the transformer particularly to be cooled. Other portions of the air coming into the receiving casing 15 pass upward between the inner edges of the coils 9 and the outer surfaces of the cylinders 12, between the inner surfaces of the cylinders 12 and the inner surfaces of the coils 8, between the inner surfaces of the coils 8 and the outer surfaces of the cylinders 11 and between the inner surfaces of the cylinders 11 and the outer surfaces of the core legs. Undoubtedly there is more or less circulation of the cooling fluid between the coils 9 for some distances from their edges. The cylinders 11 and 12 are placed as close to the adjacent coils as is necessary to secure the most efficient cooling of the windings so far as the other conditions of the transformer allow or justify; the spacing of the casing 13 from the winding surfaces can depend more upon the efficiency of cooling to be secured thereby. If the casings which direct the flow of the cooling fluid are disposed too closely to the parts to be cooled thereby, the amount of cooling or the economy of a given heat loss is less than it need be, and likewise if the casings are too far moved the same effects are experienced. If the casings or barriers are properly disposed, however, efficient cooling is developed. I have found that disposing the casings about $\frac{1}{2}$ to $\frac{3}{4}$ of an inch radially from the circumference of the windings gives very satisfactory results when the cooling fluid is air and is forced through the apparatus. It will be understood of course that this spacing will vary with the different constructions. The casings or barriers are preferably substantially uniformly spaced from the parts to be cooled, in the case illustrated from the winding circumference, in order that those parts may be uniformly cooled.

In Fig. 2 the transformer is likewise of the core type, but the windings are of the concentric cylindrical type. In this transformer there are likewise three barriers bearing the same reference characters as the three barriers of Fig. 1. Likewise there is a receiving casing 15 open at the bottom as before. The spacers 21 for spacing the coils and barriers are illustrated in this figure, and also in Fig. 3 which is a plan view of the same transformer.

The transformer of Fig. 4 is of the interleaved disk coil type. Like the transformers of the preceding figures this transformer is provided with an inclosing casing or barrier 41 (which in plan is like the casing 13 of Fig. 3), and in addition is provided with a casing 42, totally inclosing the transformer and the casing or barrier 41 and providing the exterior surface of the device. The casing 42 is provided in its cover with a number of openings which may be more or less closed by adjustable leaves 43. There is no physically separate receiving casing like the receiving casing 15 of the preceding figures, but instead the receiving casing is formed by an extension of the inclosing casing or barrier 41 to the floor. There is also a cylinder 44 of insulating material surrounding each leg of the transformer between the windings and the core leg and separated from both to provide ventilating spaces as before indicated. Annular insulating plates or collars 45 insulate the winding coils from each other as necessary, and preferably are separated from the coil faces to allow access of the cooling fluid to those faces. Suitable spacers may be used to maintain the proper spacing between the barriers, insulating plates and coils, such spacers being separated from each other to provide ventilating passages and spaces as before indicated. While the inclosing casing 41 generally conforms in plan to the casing 13 of the preceding figures, the casing 42 may be of substantially any desired shape in plan. This latter is allowable since the casing 41 closely and uniformly surrounds the windings and directs the flow of the cooling fluid in through contact with the windings and core legs. It will be understood of course, that the cooling fluid for the transformer of Fig. 4 enters the transformer adjacent one yoke and leaves

adjacent the other, the entire flow being within the casing 41 and preferably upward. The cooling fluid leaves the casing 42 below the leaves 43.

I am aware that it has been heretofore proposed to use barriers or casings about whole transformers, and even about individual parts of transformers, which to some extent direct the flow of the cooling fluid something like parallel to the winding axis. However, so far as I am aware, these barriers and casings have been disposed quite differently than the barriers or casings of my invention; so far as I am aware there has been no realization of the advantages of disposing the barriers or casings in the manner I propose, that is so that substantially the whole of the cooling fluid is forced to flow in thorough contact with the parts of the transformers to be cooled. The prior known barriers or casings seem to have been intended only for purposes quite different from those of my invention, as preventing eddy currents in the cooling fluid, separating the cooling fluid into two bodies so that the fluid itself is more efficiently cooled, separating the cooling fluid into two or more portions as one for cooling the coils and another portion for cooling the core, for effectually directing the cooling fluid into contact with the cooling means therefor as water coils, etc. To carry out these purposes, the barriers and casings have been disposed without the consideration of their effect which is particularly the subject of my invention, that is, directing the flow of the fluid into direct contact with all the transformer parts to be cooled by the fluid flow. My invention is therefore distinguished from such prior constructions.

While I have described the principle of my invention and the best mode I have contemplated for applying this principle, other modifications will occur to those skilled in this art and I aim in the appended claims to cover all modifications which do not involve a departure from the spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States, is:

1. The combination with a core, of a plurality of coiled windings coaxially mounted to surround a leg of said core, means for supplying a stream of a cooling and insulating medium to said windings, and means relatively close to the edges of said windings for causing said stream to be divided into currents moving substantially parallel to the winding axis and passing over both the inner and outer edges of said windings.

2. The combination with a casing having a core therein, of a plurality of coiled windings coaxially mounted to surround a leg of said core, means for supplying a stream of a cooling and insulating medium to said windings, and means relatively close to the edges of said windings for causing said stream to be divided into currents moving substantially parallel to the winding axis and passing over both the inner and outer edges of said windings; said currents emerging from said casing as a reunited stream.

3. The combination with a casing having a core therein, of a plurality of coiled windings coaxially mounted to surround a leg of said core, means for supplying a stream of a cooling and insulating medium to said windings, and barriers spaced a predetermined distance from the edges of said windings and adapted to divide said stream into currents moving substantially parallel to the winding axis and passing over both the inner and outer edges of the windings; said casing having an outlet for the united currents.

4. The combination with a casing having a core therein, of a plurality of coiled windings coaxially mounted to surround a leg of said core, means for supplying a stream of a cooling and insulating medium to said windings, and inner and outer cylindrical barriers spaced a predetermined distance from the respective inner and outer edges of said windings arranged to divide said stream into currents moving substantially parallel to the winding axis and passing over the edges of said windings; said casing being provided with a common outlet for the united currents.

5. The combination with a casing having a core therein, of a plurality of coiled windings coaxially mounted to surround a leg of said core, a receiving compartment adjacent one end of said casing, means for supplying a cooling and insulating medium to said compartment, means close to but spaced a predetermined distance from both the inner and outer edges of said windings for dividing the medium in said compartment into currents moving parallel to the winding axis and over the edges of said windings; said currents emerging from the casing as a reunited stream.

6. The combination with a casing having a core therein, of a plurality of coiled windings coaxially mounted to surround a leg of said core, a receiving compartment adjacent one end of said casing, cylindrical barriers placed adjacent to but a predetermined distance from the edges of said windings and arranged to divide the medium supplied to said compartment into a plurality of currents moving substantially parallel to the winding axis and over both the inner and outer edges of said windings; said casing having a common outlet for the emerging currents.

7. The combination with a casing having a core therein, of a plurality of coiled windings coaxially mounted to surround a leg of

said core, a receiving compartment adjacent one end of said casing, open ended barriers projecting into said compartment and spaced a predetermined distance from the edges of said windings, said barriers arranged to have one end divide the medium supplied to said compartment into a plurality of currents moving substantially parallel to the winding axis and over both the inner and outer edges of said windings; said casing having a common discharge for the currents emerging from the other end of said barriers.

8. The combination with a casing having a core therein, of a plurality of disk coils arranged coaxially on a leg of said core, insulating collars interleaved with said coils, a receiving compartment formed in said casing, means for forcing a cooling and insulating fluid into said compartment, insulating cylinders placed adjacent to and at a predetermined distance from both the inner and outer edges of said coils said cylinders having one end projecting into said compartment, the casing being provided with an outlet for said fluid adjacent to the other end of said cylinders.

In witness whereof, I have hereunto set my hand this twenty-third day of Jan., 1917.

LOCKE H. BURNHAM.