E. D. TREANOR.

WATER COOLED TRANSFORMER.

APPLICATION FILED SEPT. 13, 1918.

1,310,097. Patented July 15, 1919.

Fig. 1.

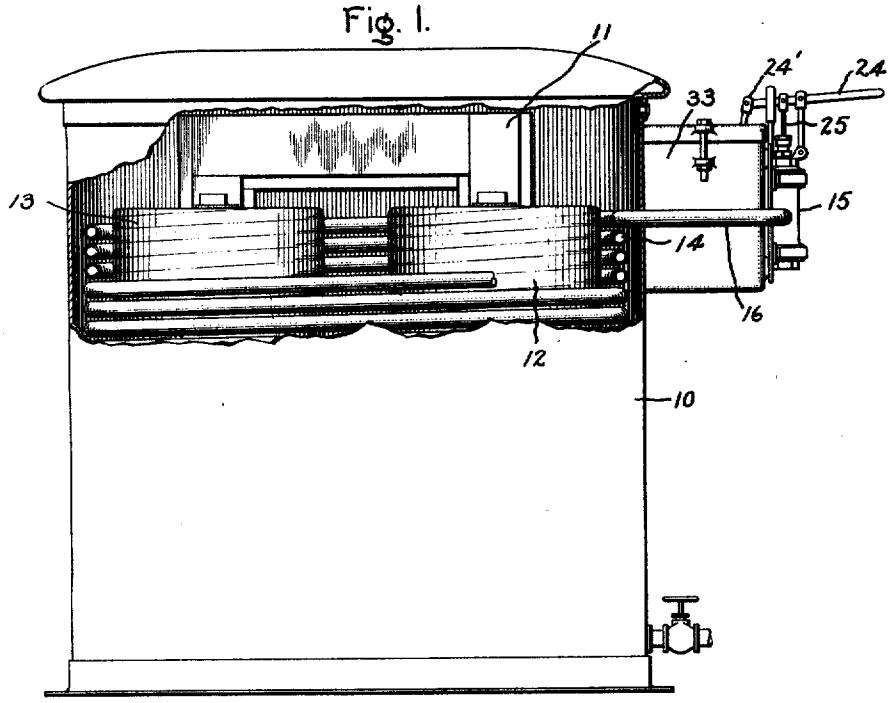


Fig. 2.

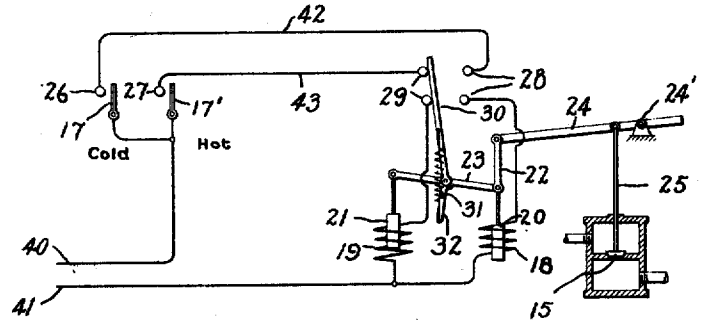
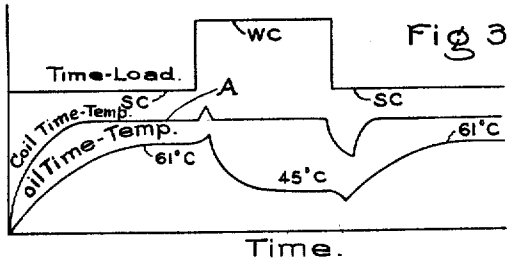


Fig 3.



Inventor:
Edward D. Treanor
by Albert G. Davis
His Attorney.

THE COLUMBIA PLANOGRAPH CO., WASHINGTON, D. C.

UNITED STATES PATENT OFFICE.

EDWARD D. TREANOR, OF PITTSFIELD, MASSACHUSETTS, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

WATER-COOLED TRANSFORMER.

1,310,097. Specification of Letters Patent. Patented July 15, 1919.

Application filed September 13, 1918. Serial No. 253,997.

To all whom it may concern:

Be it known that I, EDWARD D. TREANOR, a citizen of the United States, residing at Pittsfield, county of Berkshire, State of Massachusetts, have invented certain new and useful Improvements in Water-Cooled Transformers, of which the following is a specification.

My invention relates to electrical apparatus which is submerged in a cooling and ventilating medium such as oil and which has an auxiliary cooling system for cooling the oil or other insulating fluid by convection as well as by radiation, my invention being particularly applicable to so-called "water-cooled" transformers.

The object of my invention is to provide automatic means for controlling the cooling of such a transformer or other electrical apparatus submerged in oil, in such a manner that it may be operated economically at a plurality of different ratings.

In transformers which have an auxiliary cooling system, such as water circulating coils submerged in the oil bath for the windings, the oil ordinarily serving as a cooling and insulating medium for the windings, it has been found that the most economical operation for such apparatus when under small loads or loads very much under the full rated capacity is to have such apparatus operate as self-cooled units without the forced circulation of water or other cooling fluid in the auxiliary cooling system and only to resort to such cooling when the load exceeds a certain definite value. It has been proposed to have thermally actuated devices for automatically turning on and cutting off the water circulating devices when the oil bath in the containing tank for the apparatus reached a certain temperature, such thermally actuated devices operating to maintain the oil bath at substantially constant temperature.

Devices of this character, however, do not take into consideration the fact that the windings when operating under full load must radiate heat at a greater rate than when operating on a small load, in order to prevent injury to the windings, and in accordance with my invention I overcome this difficulty by the provision of an automatic control which will permit a transformer or other apparatus to operate as a self-cooled unit in the ordinary manner until the cooling medium exceeds a predetermined temperature which has been found in practice to be the maximum temperature permissible under such load conditions and which will operate when the temperature of the cooling medium exceeds this predetermined value to bring into operation the auxiliary cooling system and to maintain the same in operation, cooling the medium to a predetermined lower value which is sufficiently low to permit of the necessary radiation of heat from transformer windings when operating at a higher rating but operating to cut the auxiliary system out of operation when a certain predetermined minimum temperature is reached.

In the practice of my invention, this automatic control of the auxiliary cooling system for maintaining the cooling medium at these different temperatures during operation of the apparatus at the different ratings, is accomplished by thermally actuated devices, such as thermostats, placed either in the windings or in the cooling medium itself. When such thermally actuated devices are placed among the windings they would be set to follow closely the so-called "hot-spot" temperature, but with sufficient lag in responding to temperature variations of the windings to insure that the load has changed in value to a different rating. In the alternative practice, which I now deem the preferable one, where these devices are placed in the cooling medium or in equivalent proximity thereto, they are set to respond separately to the higher and lower temperature of the cooling medium with sufficient lag to insure a change in load to a different rating.

For a more complete understanding of the nature and objects of my invention reference may be had to the following detailed description when taken in connection with the accompanying drawing in which Figure 1 is a side elevation of a transformer tank, parts being broken away, showing my invention applied; Fig. 2 shows in diagrammatic form an arrangement of thermally actuated devices which embodies this invention; while Fig. 3 is an explanatory diagram.

Referring now to Fig. 3, I have drawn a curve denoted "Time-load" whose ordinates

denote a load on an oil immersed transformer or other apparatus to be operated in accordance with my invention, which ordinates are plotted against time as abscissae. The portion of this curve denoted SC denotes the maximum value for which the transformer is to operate as a self cooled unit. The curve also has a portion WC denoting some value assumed by the load when the apparatus is operating as a water cooled unit. The departure of the load from the maximum self cooled value to a water cooled value is here shown as abrupt, but it will be understood that in practice this departure may be gradual or with some minor variations.

Below the Time-load curve are drawn two curves, one denoted Coil time-temp. indicating average winding or coil temperatures plotted against time corresponding to the load values represented by the Time-load curve, the other denotes Oil-time-temp., indicating oil temperatures plotted against time.

Assuming now that the transformer has an inital load thrown on it, represented by the zero-load ordinate, as time elapses the coils will be heated up quickly coming to a steady temperature denoted by the horizontal portion A of the Coil time-temperature curve which state continues until the maximum-self-cooled value of the load is exceeded. The oil temperature follows the rise of the coil temperature and comes to a steady state marked 61° C. on the Oil time-temperature curve, which is reached after that of the windings is reached and continues until the maximum self-cooled value of the load is exceeded.

When the load rises to a water cooled value, the temperature of both the coils and the oil will rise until a certain permissible maximum is reached which maximum I utilize to actuate the thermally actuated devices which set the auxiliary cooling system into operation. These maximums are indicated by the upturned cusps on the Oil time-temperature and the Coil time-temperature curves.

The operation of the auxiliary cooling system will substantially immediately bring the coil temperature back to the steady state for the oil temperature is reduced by such operation to a predetermined lower value here indicated by the portion of the Coil temperature-curve denoted 45° C.

When the load drops as indicated on the Time-load curve to the self-cooled value again, the operation of the auxiliary cooling system causes a rapid drop in the oil and coil temperatures indicated by the down turned cusps on the two temperature curves, which drops are utilized to cut the auxiliary cooling system out of operation.

In Fig. 1, 10 denotes a tank or casing for a transformer having therein a core 11, around the legs of which are mounted the windings 12 and 13.

The windings 12 and 13 are normally submerged in oil or other suitable fluid insulating medium designed to circulate among the windings to cool them, the oil (which term as hereinafter used is to be understood as including any suitable fluid insulating medium) normally dissipating its own heat by radiation.

The auxiliary cooling system is here shown as comprising coils of pipe 14 for the circulation of water, secured in the tank 10 which coils preferably surround the windings 12 and 13 and are located below the normal surface of the oil.

The circulation of water in the coils of pipe 14 is maintained by any convenient means (not shown) and is controlled by a valve 15 in the connection 16 which may be in either the inlet or the outlet connection of the coils.

The valve 15 is designed to be closed in order to prevent circulation of the water when the transformer is operating on loads less than a certain predetermined value, hereinafter referred to as the "self-cooled rating" and to be open, in order to permit the circulation of water in the coils 14 for all loads above the "self-cooled rating" up to the full load capacity of the unit or the value hereinafter referred to as the "water-cooled rating". In accordance with my above expressed preference, I take the temperature of the oil as an index of the load on the transformer and mount the thermally actuated devices in the oil or in such juxtaposition thereto as to be responsive to the temperature of the oil and arrange them to automatically control the movements of the valve 15.

These devices here comprise thermostats or compound bars 17 and 17′ as shown in Fig. 2, arranged to make and break electric circuits which energize power devices, here shown as electromagnets 18 and 19, whose respective armatures or cores 20 and 21 are jointly connected to actuate the valve 15 through the instrumentality of link 22 which transmits the movements of rocking beam 23 (to the ends of which the cores 20 and 21 are pivoted) to the lever 24 fulcrumed at some convenient point as 24′, the lever 24 being connected to reciprocate the valve stem 25 of the valve 15.

The compound bar 17 is arranged to bend with a falling temperature so as to make contact on the member 26 which is in conducting relation with one of a pair of contacts 28 which are bridged by a conducting member 30 pivotally mounted on the beam 23 so as to be moved by it when the beam has rocked to one of its ultimate positions in a manner hereinafter more fully ex-

plained; the member 30 being preferably insulated from the beam 23. The other contact 28 is connected to the winding of the electromagnet 18.

In like manner compound bar 17′ is arranged to bend with a rising temperature so as to make contact with member 27 which is in conducting relation with one of a pair of contacts 29 which are bridged by member 30 when rocking beam 23 has been swung to the position shown in the drawing; the other contact 29 being connected to the winding of electromagnet 19.

In order that the rocking beam 23 may be in a state of stable equilibrium when not being acted upon by a current of full strength in the electromagnets, which may be caused by the thermostat's failure at first to bear up hard against its contact, I provide a spring 31 or other device under tension between a point on member 30 and the end of tongue 32 which is integral with beam 23. This will bias the member 30 against the contacts bridged thereby, in the position to which it was last moved by one of the electromagnets until the beam 23 has moved sufficiently to throw the lower end of spring 31 to the other side of the pivot of beam 23, when the spring will quickly move member 30 to bridge the other pair of contacts.

The member 30, which I have just described as adapted to bridge either the contacts 28 or the contacts 29, constitutes in effect a switch for throwing one thermostat out of commission after it has actuated its electromagnet and throwing the other thermostat into commission. This switch, together with the electromagnets 18 and 19 for actuating valve 15 are conveniently mounted in a housing shown at 33 in Fig. 1, which housing is suitably secured to the transformer tank.

The operation of my invention is as follows:

We shall assume that the transformer is to operate in a room whose temperature is about 25° C. so that thermostat 17′ would conveniently be set to make contact with member 27 on rising temperature when 61° C. has been reached, which represents the maximum permissible temperature during operation at or below the "self-cooled rating" as seen in the "Oil time-temp." curve in Fig. 3; and that thermostat 17 is set to make contact with member 26 on falling temperature when 45° C. has been reached, which represents the maximum permissible temperature at "water-cooled rating" or above "self-cooled rating"; and indicated by the depressed portion of the "Oil time-temp." curve in Fig. 3.

When the load on the transformer is less than the "self-cooled rating", the oil in the tank 10 will be sufficiently cool to permit the heat from the windings to be dissipated as fast as generated. The valve 15 will be closed and the transformer will operate as an ordinary self-cooled unit.

Suppose that the load on the transformer increases so as to exceed the "self-cooled rating". The increased amount of heat radiating from the windings 12 and 13 will cause a momentary increase in the oil's temperature above 61° C. so that thermostat 17′ will make contact with member 27, closing an electric circuit so that current will flow from bus 40, or other convenient source of E. M. F. through thermostat 17′, contact 27, conductor 43 and contacts 29 to electromagnet 19 and from thence to the other bus 41. The electromagnet 19 when energized, will attract the core 21 so as to move the rocking beam 23, thereby opening valve 15 to permit water to circulate in the coils 14 and cool the oil. The movement of beam 23 will have moved member 30 away from contacts 29 and across contacts 28, thereby throwing thermostat 17′ out of commission and putting thermostat 17 in commission. The transformer may be operated in this manner at the reduced oil temperature of 45° C. up to its full load capacity or the so-called "water-cooled rating".

Suppose now that the load begins to fall off; the oil which is being rapidly cooled by the circulating water, will have been cooled momentarily to a temperature below 45° C. which is indicated by the downturned cusp in the "Oil time-temp." curve at the point where the load falls to the "self-cooled rating". Consequently the thermostat 17 will make contact with member 26, closing an electric circuit, so that current will flow from bus 40 through thermostat 17, member 26, conductor 42, and contacts 28 to electromagnet 18 (the member 30 having been thrown by the previous movement of beam 23 to bridge contacts 28) and thence to bus 41. The electromagnet 18, when energized, will attract core 20 to move the rocking beam 23 and again close valve 15; thereby cutting off the circulation of the water so that the transformer operates as a self cooled unit until such an increase in the load occurs as would actuate the thermostat 17′ whereupon the cycle of operations described would be repeated.

It is, of course, obvious to those skilled in the art that one thermostat could be so designed that it would make contact with two members 26 and 27 at the desired temperatures, instead of using the two compound bars 17 and 17′ above described.

While I have here shown an embodiment of my invention which is, at present the best means known to me for carrying the same into effect, I would have it understood that this is merely illustrative and that I do not mean to be limited thereby to the precise de-

tails here disclosed since obvious alterations thereof will appear to those skilled in this art, nor in the choice of recognized equivalents except as defined in my claims hereunto annexed.

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

1. The combination with an electrical apparatus provided with a casing containing a cooling and insulating medium for the windings of said apparatus, of an auxiliary cooling system for said cooling and insulating medium, and means responsive to the heat generated in said windings for controlling said auxiliary system to maintain said medium at a plurality of temperatures corresponding to a plurality of different ratings of said apparatus.

2. The combination with an electrical apparatus provided with a casing containing a cooling and insulating medium for the windings of said apparatus, of an auxiliary cooling system for said cooling and insulating medium, and thermally actuated devices arranged to follow the temperature variations in said windings and control said auxiliary cooling system to maintain said medium at a predetermined temperature when said apparatus operates as a self cooled rating and at a predetermined lower temperature when said apparatus operates at a higher rating.

3. The combination with an electrical apparatus provided with a casing containing a cooling and insulating medium for the windings of said apparatus, of an auxiliary cooling system for said cooling and insulating medium, and means responsive to the temperature of said medium for setting said auxiliary system into operation when the temperature of said medium rises above a predetermined value, and maintaining the same in operation until the temperature of said medium falls below another predetermined lower value.

4. The combination with an electrical apparatus provided with a casing containing a cooling and insulating medium for the windings of said apparatus, of an auxiliary cooling system for said cooling and insulating medium, power devices for operating said auxiliary cooling systems, and thermally actuated devices responsive to the temperature of said medium arranged to actuate said power devices at a plurality of different temperatures each corresponding to a certain rating of said apparatus.

5. The combination with a transformer having a casing containing a cooling and insulating medium for the transformer windings, of coils of pipe secured in said casing adapted to be submerged in said medium and to be traversed by a cooling fluid under forced circulation, a valve for controlling said circulation, power devices for opening and closing said valve, and thermally actuated devices responsive to the temperature of said medium arranged to operate said power devices to open said valve at a temperature materially above the temperature at which said power devices are operated to close said valve.

6. The combination with a transformer having a casing containing a cooling and insulating medium for the transformer windings, of coils of pipe secured in said casing adapted to be submerged in said medium and to be traversed by a cooling fluid under forced circulation, a valve for controlling said circulation, electromagnets for opening and closing said valve, and thermostats responsive to the temperature of said medium arranged to energize one of said electromagnets to open said valve at a temperature materially above that at which another of said electromagnets is energized to close said valve.

7. The combination with a transformer having a casing containing a cooling and insulating medium for the transformer windings, of coils of pipe secured in said casing adapted to be submerged in said medium and to be traversed by a cooling fluid under forced circulation, a valve for controlling said circulation, a rocking beam connected to transmit an opening and closing movement to said valve, a pair of electromagnets for moving said rocking beam when energized, and a pair of compound bars responsive to the temperature of said medium arranged to close electric circuit through said electromagnets; one of said bars being adjusted to close the electric circuit upon rising temperature when a predetermined degree is reached which is materially above the predetermined degree at which the other bar closes the electric circuit upon falling temperature.

8. The combination with a transformer having a casing containing a cooling and insulating medium for the transformer windings, of coils of pipe secured in said casing adapted to be submerged in said medium and to be traversed by a cooling fluid under forced circulation, a valve for controlling said circulation, and devices for automatically opening and closing said valve in response to the temperature of said medium and adjusted so that said valve is opened when a predetermined temperature is reached which is materially above the predetermined temperature at which said valve is closed.

9. The combination with a transformer having a casing containing a cooling and insulating medium for the transformer windings, of coils of pipe secured in said casing adapted to be submerged in said medium and to be traversed by a cooling fluid under

forced circulation, a valve for controlling said circulation, a housing on said tank adjacent said valve, and devices therein for automatically opening and closing said valve responsive to the temperature of said medium and adjusted so that said valve is opened when a predetermined temperature is reached which is materially above the predetermined temperature at which said valve is closed.

In witness whereof, I have hereunto set my hand this tenth day of September, 1918.

EDWARD D. TREANOR.

Copies of this patent may be obtained for five cents each, by addressing the "Commissioner of Patents. Washington, D. C."