Dec. 17, 1935. R. L. BROWN 2,024,716

TRANSFORMER AIR BLAST EQUIPMENT

Filed Sept. 29, 1934 3 Sheets-Sheet 1

Fig. 1.

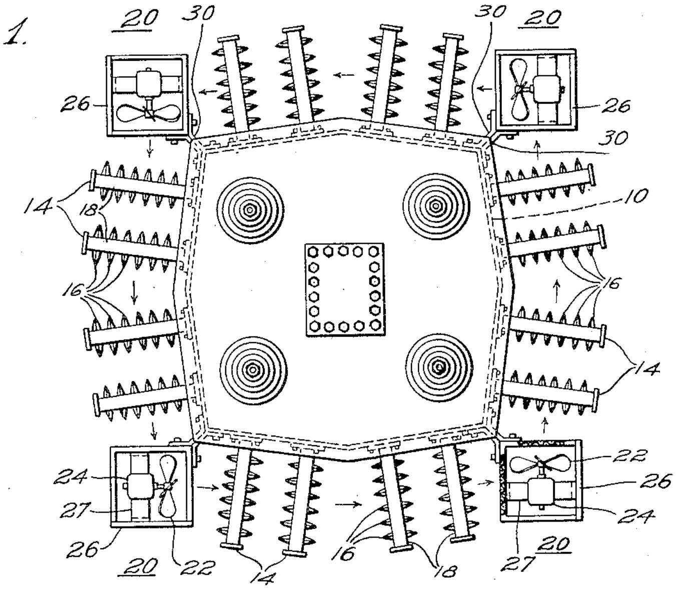
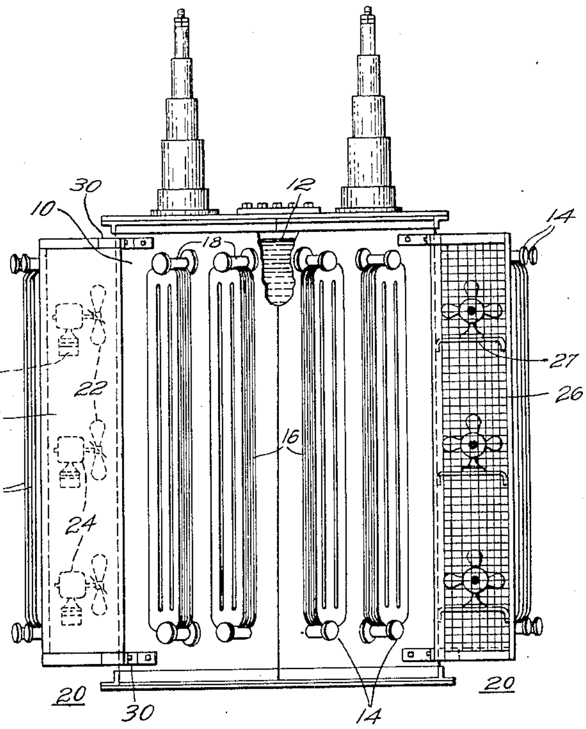


Fig. 2.



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Filed Sept. 29, 1934 3 Sheets-Sheet 2

Fig. 3.

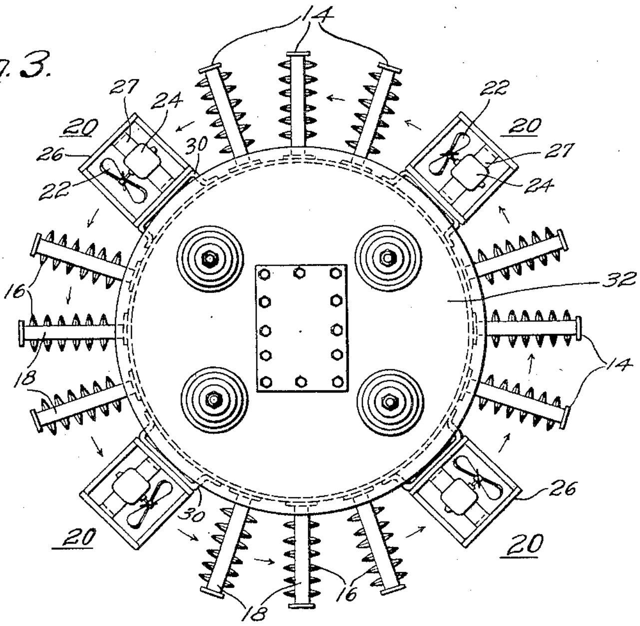

Fig. 4.

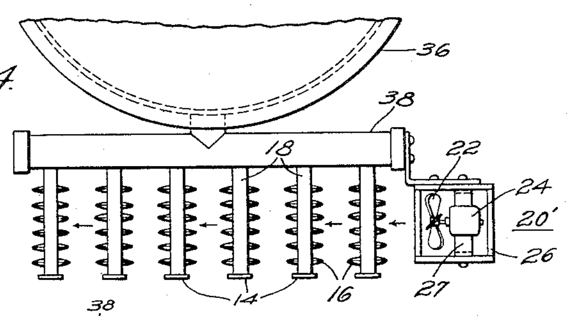

Fig. 5.

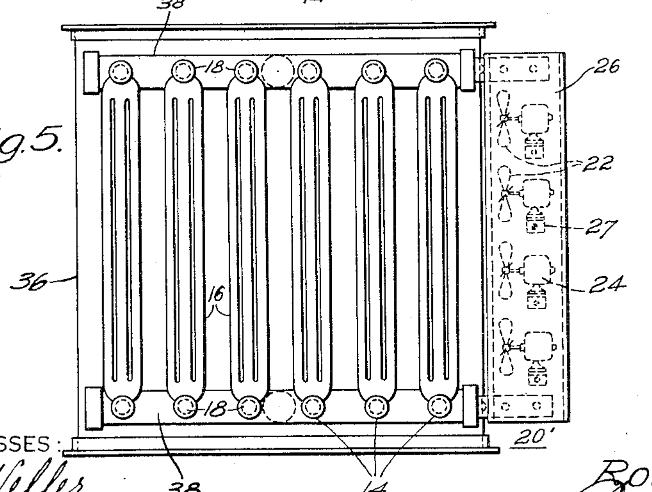

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Fig. 6.

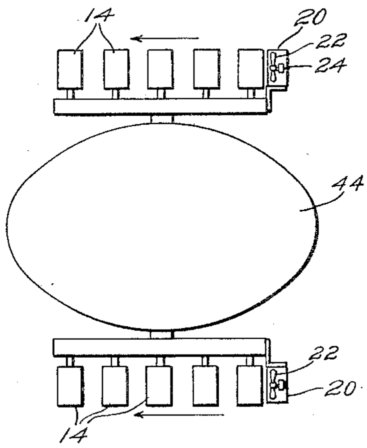


Fig. 7.

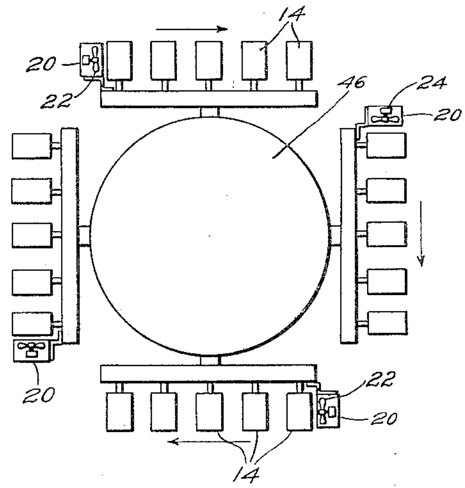


Fig. 8.

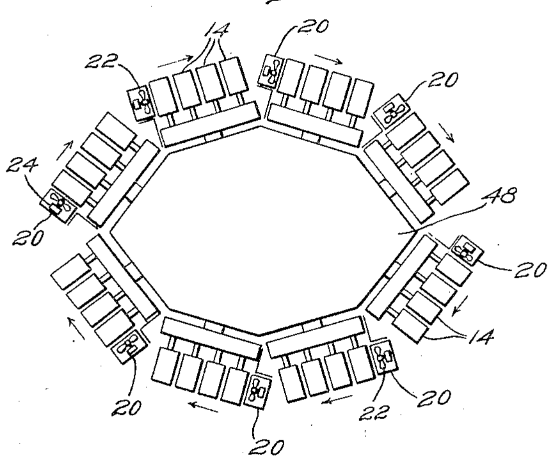
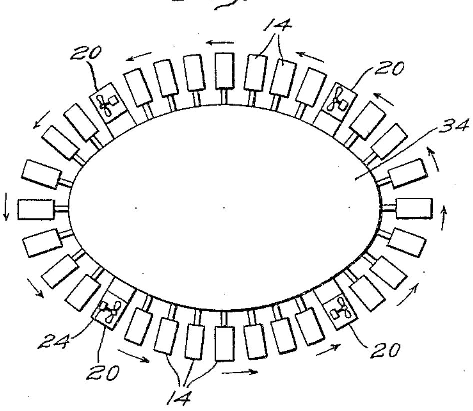


Fig. 9.



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UNITED STATES PATENT OFFICE

2,024,716

TRANSFORMER AIR-BLAST EQUIPMENT

Roy L. Brown, Sharon, Pa., assignor to Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., a corporation of Pennsylvania

Application September 29, 1934, Serial No. 746,236

7 Claims. (Cl. 257—191)

My invention relates to equipment for cooling transformers and other comparable electrical apparatus of the fluid-immersed type and it has particular relation to air-blast equipment adapted to increase the effectiveness of the heat-dissipating radiators which are attached to the apparatus tank.

In transformers, induction regulators and other electrical apparatus of the fluid-immersed self-cooled variety, it is frequently desirable, especially in the higher ratings, to provide means for projecting blasts of air upon the cooling surfaces of the radiators through which the oil or other insulating fluid circulates to transfer the heat generated in the apparatus to the outside atmosphere. The use of such air blast materially raises the effectiveness of the radiators and thus permits the apparatus to be operated at above its normal or self-cooled rating. Furthermore, by such use the number or capacity of the externally attached radiators required for a given application may be materially reduced. In situations where space is at a premium this is a highly important consideration.

All previously proposed arrangements and positionings of draft-producing equipments intended to benefit transformer or other apparatus radiators with which I am familiar have been subject to a number of objections chief among which are high first cost, large space requirements, incapability of standardization, low effectiveness, high power consumption, and decrease in radiator efficiency during self-cooling operation. For example, in one well known prior art system a large number of ducts are required to direct separate air blasts, produced by a common blower, against each of the numerous radiating surfaces of the apparatus. The cost of such ducts, which conventionally are constructed of metal, is exceedingly high, a large percentage of the pressure produced by the blower is lost in forcing the air to follow the various changes of direction present in the ducts, the conduit system is bulky and wasteful of space, and the effectiveness of the self-cooling operation of the radiators is materially lowered by its presence. Such equipment cannot be standardized and, due to the tendency of the duct walls to vibrate, is frequently noisy in operation.

In another system known to the prior art, an individual blower is provided for each radiator. While such an arrangement possesses relatively greater simplicity, cheapness and capability of standardization, it likewise is found to be inefficient. In one preferred embodiment the air must be turned at least twice through a sharp angle before it is impinged upon the radiator surfaces, and since tests reveal that every time air is so turned through a 90° angle it loses approximately one-half of its energy, it will be appreciated that the effectiveness and power consumption requirements of this individual-blower arrangement must of necessity be very low.

There exists, therefore, a need for an equipment which will preserve the property of being standardized but will have very much higher efficiency than any which has heretofore been developed. My invention is directed to an improved method of applying air blast to heat-dissipating radiators which by possessing these and other desirable characteristics overcomes the disadvantages above named and possesses additional advantages to be particularized hereinafter.

Generally stated, the object of my invention is to reduce the cost and improve the effectiveness of air-blast equipment, for radiators of fluid-immersed transformers and other like electrical apparatus.

Another object of my invention is to provide equipment of the above-specified character which permits of ready standardization.

An additional object of my invention is to provide a method of applying air blast to transformer and other radiators which results in a substantially direct application of the air to the radiator surfaces, and in which the direction of air-flow over such surfaces produces a maximum scouring effect while being subjected to a minimum retardation resistance.

Another object of my invention is to provide an air-blast system which, when not in actual operation, has no detrimental effect upon the normal or self-cooling functioning of the radiators to which it is applied.

A further object of my invention is to provide a system of the type previously characterized which may be readily applied to transformers already installed and in operation for the purpose of increasing their rating.

An additional object of my invention is to reduce the noise, simplify the assembly and allow the use of larger fan driving motors in such equipments.

A still further object of my invention is to reduce the floor space required by radiator air blast systems.

An additional object of my invention is to provide a system of the type previously characterized which is especially applicable to radiators built up of a plurality of vertically-extending substantially flat and parallel spaced fluid conducting sections.

My invention itself, together with additional objects and advantages thereof, will best be understood through the following description of specific embodiments when taken in conjunction with the accompanying drawings, in which:

Figure 1 is a plan view of a self-cooled transformer embodying supplementary cooling means arranged in accordance with one preferred form of my invention;

Fig. 2 is a view in side elevation, partially in section, of the transformer and cooling equipment depicted in Fig. 1;

Fig. 3 is a plan view of the air blast equipment of my invention applied to a transformer having a substantially circular tank;

Fig. 4 is a plan view showing the air-blast equipment of my invention applied to a group of radiators mounted in a straight line upon a separate header;

Fig. 5 is a view in side elevation of the equipment of Fig. 4;

Fig. 6 is a simplified plan view of an elliptical transformer tank to each side of which is attached the unit-type cooling equipment depicted in Figs. 4 and 5;

Fig. 7 is a simplified plan view of a circular transformer tank similarly equipped with four header-mounted radiator and air-blast assemblages;

Fig. 8 is a plan view of an octagonal transformer tank to each of the sides of which the unit equipment of Figs. 4 and 5 is shown as being attached; and

Fig. 9 is a similar plan view of an elliptical transformer tank to which the radiators and cooling apparatus of my invention are directly attached.

Referring to the drawings, and particularly Figs. 1 and 2 thereof, I have there illustrated one preferred form of the air-blast equipment of my invention as applied to a self-cooled transformer which for purposes of explanation of my new system will be considered as representative of all types of fluid-immersed electrical apparatus, including, of course, induction regulators.

The transformer shown comprises a tank **10** containing oil or other insulating and heat dissipating fluid **12** in which the transformer core and winding structures (not shown) are immersed in well known manner. To the outside of the tank, which is represented as being octagonal in shape, are attached a plurality of radiators **14** through which the liquid **12** is caused to flow upon dissipation thereto of the heat produced, during transformer operation, by the immersed coil and core structure.

As illustrated, each of the radiators **14** is made up of a plurality of relatively flat fluid-conducting sections **16** which are spaced apart in parallel relation, and there held by being secured at the tops and bottoms thereof to suitable pipe or conduit members **18** connected with the transformer tank in a manner to allow the tank liquid to circulate through these radiator sections. Each radiator thus presents a relatively large surface area from which heat may be dissipated to the surrounding air from the liquid circulating therethrough.

In order to increase the effectiveness or raise the rate of this dissipation, I contemplate the provision of means whereby this air may be rapidly circulated through the radiators between the sections **16** thereof, and for this purpose, I prefer to utilize a plurality of draft producing equipments, generally represented at **20**. As shown, each of these equipments comprises a casing in which is supported, at vertically spaced points, a plurality of motor driven fans **22**. Preferably, the fan driving motors **24** are secured to the casing or frame structure **26** by means of suitable brackets **27**. Energizing connections (not shown) are made with these several motors in well known manner.

In operation of the air blast equipment depicted by Figs. 1 and 2, each of the equipments **20** directs a stream of air into the group of radiators directly in front of it, the path which the air takes progressively through the radiators being generally indicated in Fig. 1 by the arrows. It will be noted that the blowers are so arranged that the air flow through all of the radiators mounted around the transformer tank **10** is in the same circumferential direction and thus any residual velocity remaining when the air from one bank of fans reaches the next bank will not be lost but will instead be taken advantage of by that bank. As a result, there will be set up a spiral motion of the air around the tank, which air gradually rises as it picks up more and more heat. In practice, the magnitude of this rise is found to be slight since a relatively large volume of air may be conveniently handled by the blowers when arranged in accordance with my invention. The idea of causing each blower to aid the following one in producing a tangential flow of air around the tank is found to be of material advantage in reducing the power required by the fan-driving motors, and hence, it is one of great utility.

Since the elements of the radiators of the particular type disclosed and described are parallel to the surface of the tank when mounted in the manner shown, they act as natural baffles which mutually assist in carrying the air from one radiator to the next. In practice, it is found that each bank of fans is able to effectively cool from six to ten radiators of such conventional design. Furthermore, since the fans deliver to the radiators practically their full free discharge volume of air, the arrangement is indeed an effective one, such effectiveness being enhanced by the fact that no flow restricting shrouds are required around the fans, and further, that the elements of the illustrated type of radiators offer very little resistance to the flow of air over their surface. When this flow is of high velocity, I have found that it will effectively break up the surface film and thus carry away the heat with exceedingly great rapidity. Such rapidity is favored by the fact that the air from the blowers flows over both surfaces of each fluid-conducting section.

It will be noted that in the case of the octagonal tank represented in Figs. 1 and 2, I have illustrated a blower unit as being positioned at each of the four main corners of the structure, attachment to the tank being effected by means of suitable bracket members **30**. In the case of a square or a rectangular tank a similar corner positioning is usually found preferable. However, in the case of a circular tank such as illustrated at **32** in Fig. 3, the blowers **20** may be mounted in any desired positions around the tank circumference, which positions are preferably uniformly spaced.

It will be noted that in Fig. 3 the blowers occupy positions exactly comparable to those occupied by the radially mounted radiators **14**, so that in the case of previously installed apparatus, application of the forced draft equipment of my invention may readily be made merely by removing one or more of the radiators at the proper points around the tank circumference and substituting therefor the blower units **20**. As in the case of the before-described Figs. 1 and 2, the air is caused to flow in the same direction around the tank structure, the natural baffling action of the radiators effectively directing the path of flow through the radiator structures. A similar application to an oval or elliptical tank **34** is depicted in Fig. 9.

In view of the simplicity of the draft producing equipment of my invention the motor driven fans may be made more rugged and hence, more trouble-free than in previously utilized systems. Furthermore, the assembly of the blower units in the radiator banks themselves makes them more readily accessible, than in previously known arrangements, for such maintenance and repair as may periodically be necessary.

Since all parts can be made rugged and are capable of being so designed that no objectional vibration results, my improved units are relatively free from noise. If necessary, each blower assemblage may be insulated from the tank by means of rubber or other resilient blocks (not shown) which serve to isolate any vibration or noise which may originate in the unit.

A further marked advantage possessed by the system of my invention is that the air blast equipment thereof in no way interferes with the natural cooling action of the radiators when the equipment is not in operation. Previously employed arrangements, particularly those utilizing complicated duct or hood systems in close contact with the radiators, are found to substantially decrease the natural cooling capacity thereof. Furthermore, the thin metal edges of such ducts frequently vibrate against the edges of the radiator fins despite preventive provisions, thereby producing considerable noise, which in many localities, is highly objectionable. As already indicated, the system of my invention eliminates both of these disadvantages.

In certain situations it may be preferable to build up the desired radiator capacity in the form of one or more groups of radiators mounted in a straight line upon auxiliary header devices, which, in turn, are connected with the transformer tank. Such a scheme is represented in simplified form in Figs. 4 and 5, in which representations the tank is indicated at **36**, and the headers connected thereto at **38**, from which headers a plurality of radiators **14** are supported in substantially a straight line. Each of these radiators is represented as being of the type previously explained in connection with Figs. 1 to 3 inclusive.

At one end of radiator bank a group of draft producing fans **20'** may be mounted in the manner shown. In operation, air is forced through the radiators in the direction indicated by the arrows, the main air stream in effect passing through all of these radiator sections **14**, each of which serves to direct the stream on to the section following.

Actual tests of the arrangement depicted by Figs. 4 and 5 show that it is exceedingly effective. On a bank of six radiators mounted in a straight line side-by-side with four fans arranged to blow air directly into the end of the bank in the manner shown, the heat, expressed in watts, dissipated per square inch of radiator surface for each centigrade degree of temperature difference existing between the air blown through the radiators and the fluid circulating therein, was 0.00505. The measured volume of air delivered through the test bank of radiators by these four fans was 7,550 cu. ft. per minute. With free discharge these same four fans delivered only 9,800 cu. ft. of air per minute.

A hood type of blower previously considered highly efficient, which this equipment replaces, is capable of giving a value of watts per square inch per degree centigrade of not over 0.00455 when applied to the same group of six radiators. Such equipment requires six fans, one for each radiator, and the total air delivered thereby is approximately 3,300 cu. ft. per minute, instead of 7,550, delivered by my new system. In addition, the floor space required by the hood type blowers and the six radiators with which they are associated is 55'' by 106'', whereas the space required by the new system depicted and described in connection with Figs. 4 and 5 is only 35'' by 92''.

As has already been indicated, the air blast system of my invention is entirely independent of the contour of the tank since the blowers direct the air through the ducts formed by the radiator elements. My improved system is, therefore, capable of great flexibility in application since it is relatively self-contained and entirely independent of the character of the transformer tank upon which it is mounted. A unit of the type depicted in Figs. 4 and 5 may furthermore be made relatively standard, in which case installation on transformer tanks of practically all sizes and shapes may readily be effected.

For example, in the case of an oval tank such as is depicted at **44** in Fig. 6, such a header-type assemblage may be attached in the manner shown to each side of the tank. Likewise, in the case of a circular tank of the type illustrated at **46** in Fig. 7, a plurality of comparable units may be positioned at uniformly spaced points around the tank circumference. Similarly, as is illustrated in Fig. 8, a unit assemblage may be attached to each of the individual sides of a polygonal tank of which the octagonal structure shown at **48** is representative. In the last two instances, it is preferable, for the reasons before explained, to so arrange the units that the air will flow continuously in the same direction around the tank structure. It will be understood, however, that if desired other arrangements may also be utilized.

Although I have shown and described certain specific embodiments of my invention, I am fully aware that many modifications thereof are possible. My invention, therefore, is not to be restricted except insofar as is necessitated by the prior art and by the scope of the appended claims.

I claim as my invention:

1. In combination with an electrical apparatus housed within a tank containing cooling fluid, a plurality of radiators mounted around the periphery of said tank, and a plurality of draft-producing equipments also positioned at spaced points around the tank periphery and adapted to circulate air through the radiators in the same direction continuously around the tank, each of said equipments picking up and accelerating a portion of the air set in motion by the preceding equipment.

2. In combination with an electrical apparatus housed within a tank containing cooling fluid, a plurality of radiators mounted around the periph-

ery of said tank, each of said radiators comprising a plurality of vertically extending relatively flat fluid-conducting sections so spacedly positioned as to guide air blown therethrough progressively from one radiator to another in a path substantially tangential to the tank contour, and a plurality of draft-producing equipments also positioned at spaced points around the tank periphery and adapted to circulate air through the radiators in the same direction continuously around the tank, each of said equipments picking up and accelerating a portion of the air set in motion by the preceding equipment.

3. In combination with an electrical apparatus housed within a tank containing cooling fluid, a plurality of radiator banks so connected with the tank that said fluid may circulate therethrough, each of said banks comprising a plurality of radiators supported in substantially a straight line, and draft-producing equipment positioned at one end of each of said banks and adapted to direct air thereinto, the radiators of each bank being so constructed as to guide said air from one radiator to the next in its progressive flow through the bank, and the positioning of said draft-producing equipment being such that the air circulated through the radiator banks proceeds in the same direction continuously around the tank.

4. In combination with an electrical apparatus housed within a tank containing cooling fluid, a plurality of radiators supported in substantially a straight line and so connected with the tank that said fluid may circulate therethrough, each of said radiators comprising a plurality of vertically extending relatively flat fluid-conducting sections so spacedly positioned as to guide air blown therethrough progressively from one radiator to another, and draft-producing equipment positioned at one end of said line of radiators and adapted to direct air thereinto.

5. In combination with an electrical apparatus housed within a tank containing cooling fluid, a plurality of radiator banks so connected with the tank that said fluid may circulate therethrough, each of said banks comprising a plurality of radiators supported in substantially a straight line, and draft-producing equipment positioned at one end of each of said banks and adapted to direct air thereinto, the radiators of each bank being so constructed as to guide said air from one radiator to the next in its progressive flow through the bank.

6. In combination with an electrical apparatus housed within a tank containing cooling fluid, a plurality of radiators, each of which comprises a plurality of spaced vertically extending and relatively flat fluid-conducting sections, mounted around the periphery of said tank, and draft-producing equipment adapted to blow air progressively through said radiators in a direction which at all points is substantially tangential to the tank.

7. In combination with an electrical apparatus housed within a tank containing cooling fluid, a plurality of radiators, each of which comprises a plurality of spaced vertically extending and relatively flat fluid-conducting sections, mounted around the periphery of said tank, and draft-producing equipment adapted to blow air progressively through said radiators in a direction which at all points is substantially tangential to the tank, the said sections of the radiators being so positioned as to effectively guide the air in the said path of flow.

ROY L. BROWN.