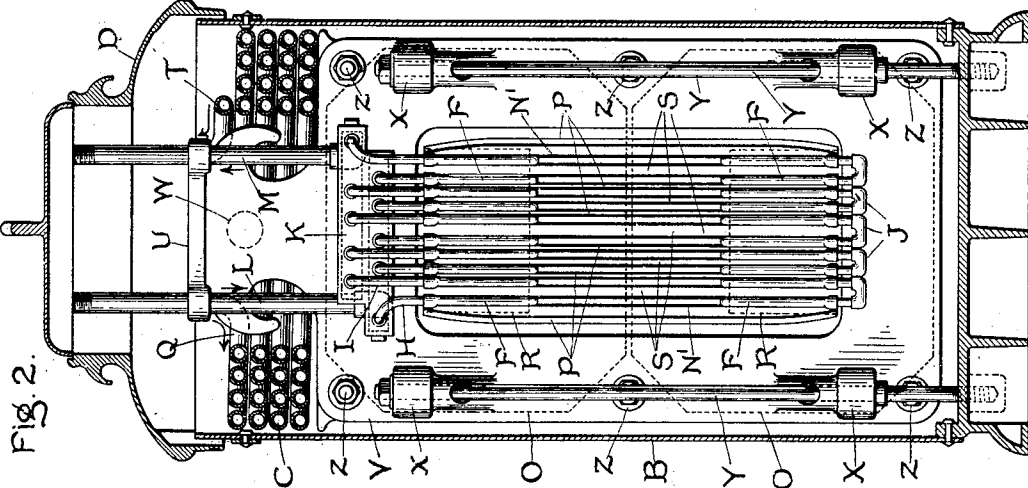
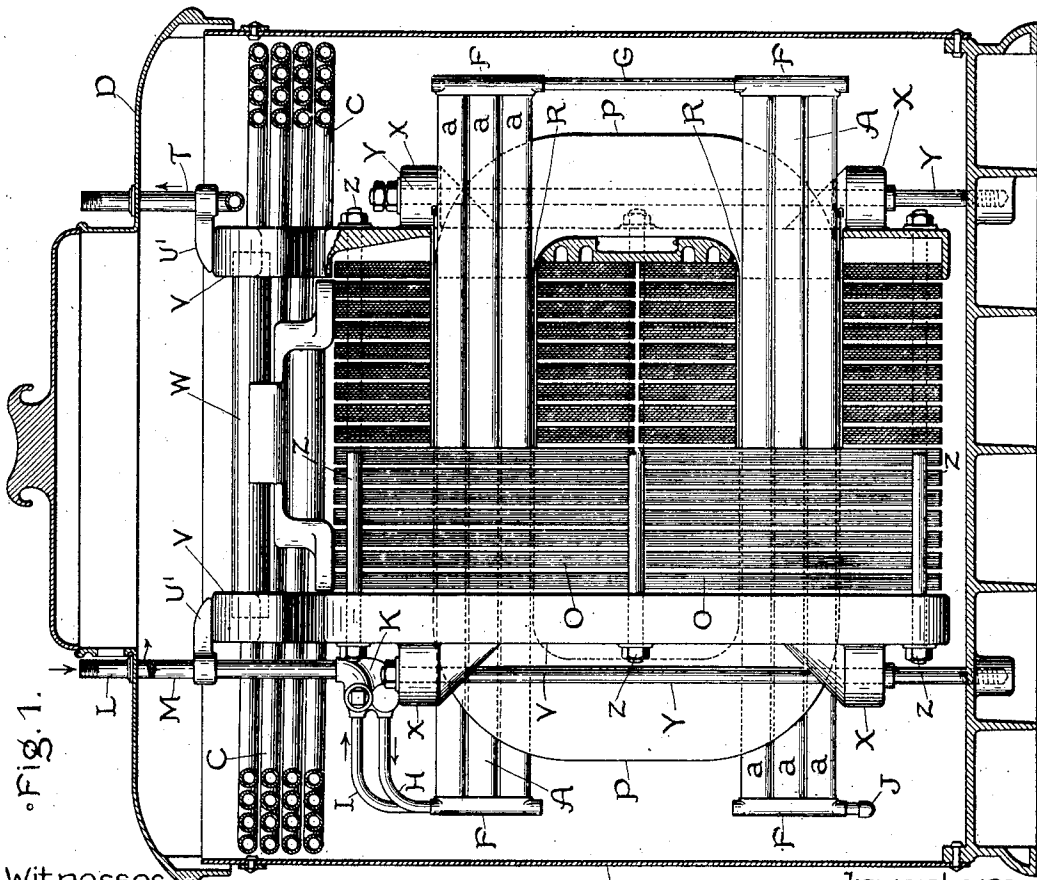


W. S. MOODY & W. L. R. EMMET.
TRANSFORMER.

(Application filed Oct. 26, 1900.)

(No Model.)

2 Sheets—Sheet 1.



Witnesses

Lewis Le Abell

Benjamin B. Hall

Inventors:

Walter S. Moody
William LeR. Emmet

by *Wm. B. Davis*

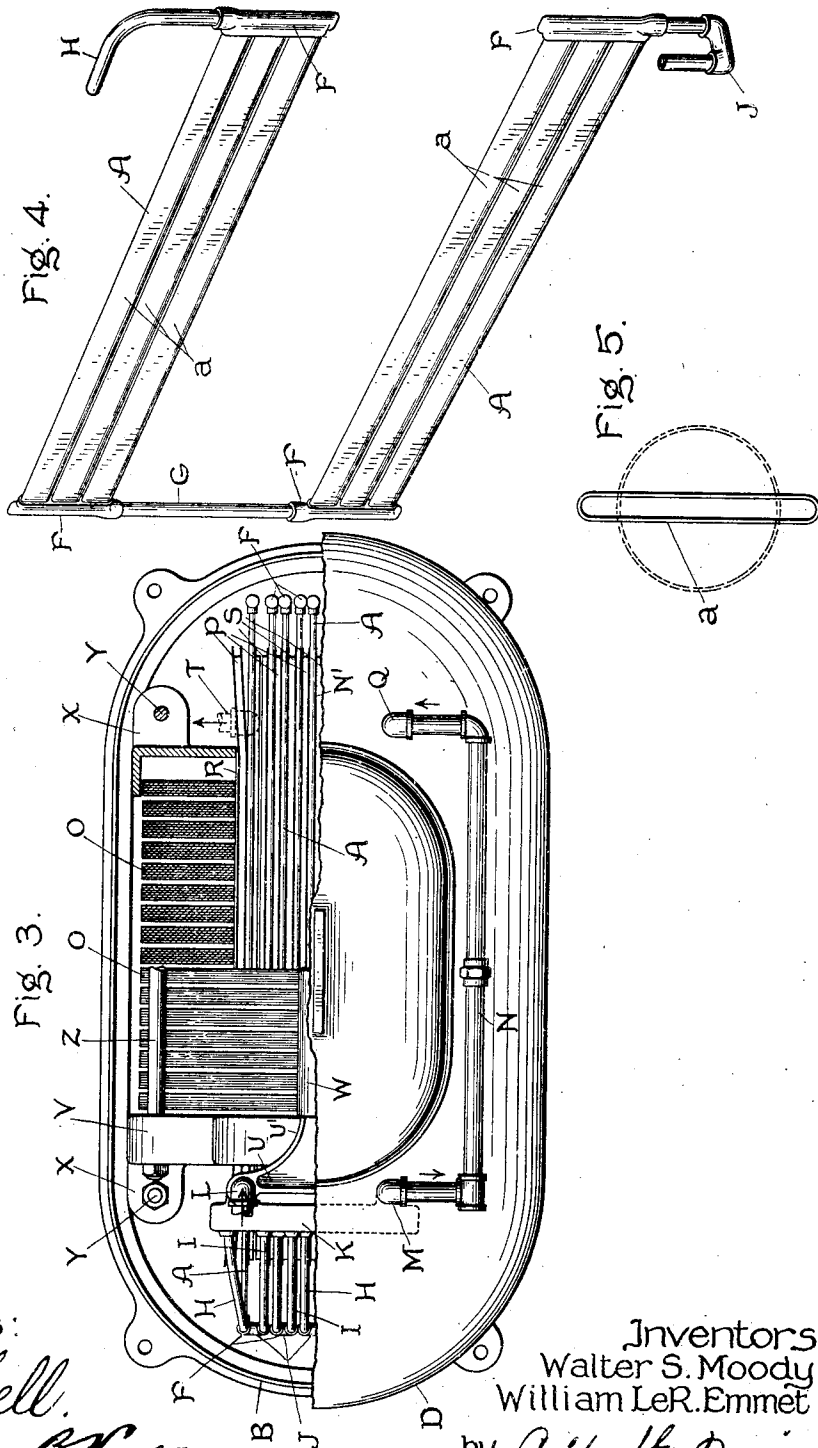
Atty.

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Witnesses:

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Atty

UNITED STATES PATENT OFFICE.

WALTER S. MOODY AND WILLIAM L. R. EMMET, OF SCHENECTADY, NEW YORK,
ASSIGNORS TO THE GENERAL ELECTRIC COMPANY, OF NEW YORK.

TRANSFORMER.

SPECIFICATION forming part of Letters Patent No. 665,573, dated January 8, 1901.

Application filed October 26, 1900. Serial No. 34,425. (No model.)

To all whom it may concern:

Be it known that we, WALTER S. MOODY and WILLIAM LE ROY EMMET, citizens of the United States, residing at Schenectady, in the county of Schenectady, State of New York, have invented certain new and useful Improvements in Transformers, (Case No. 1,232,) of which the following is a specification.

This invention relates to means for cooling transformers; and it consists of improvements on the apparatus shown in the patent to Moody, No. 646,500, dated April 3, 1900.

The means described in the above-mentioned patent is perfectly satisfactory for transformers designed for certain capacity, but is not adapted to be embodied in transformers designed for different classes of work.

The improvements herein described are intended to be utilized especially in transformers designed for high-tension transmission and are being now embodied in apparatus in process of construction for the Niagara transmission, in which instance the cooling of transformers is one of the most important problems with which the engineers have to deal.

In some cases it is not practicable to make the secondary conductor hollow, as in the patent noted, because the secondary is not sufficiently large, and in other cases where the transformers have high-voltage secondaries the hollow secondary is not desirable, because even if an insulating-coupling were interposed between the hollow secondary and the supply-pipe there would be danger that impure water or other cooling fluid passing through the secondary would establish a ground connection. Transformers have in some cases been cooled by coils of pipe located in the oil away from the windings instead of by means of the hollow secondary, which latter is an improved method. The pipe-coils in such cases were located beyond the space affected by the field of force set up by the windings or coils of the transformer, so that there was no generation of a current through the pipes, which would ground the apparatus. If, however, such pipe-coils were led adjacent to the windings, such currents would be generated.

In a transformer constructed in accordance

with this invention metallic ducts for a cooling fluid are so disposed with respect to the insulated coils that the ducts absorb by conduction the heat generated in the latter. The novel feature about this arrangement and its chief distinction from the hollow secondary of the patent above mentioned are that these metallic ducts are necessarily so located with respect to the magnetic field that electromotive forces are generated in them which would result in a flow of current, which would prevent the use of the invention if means were not provided to overcome this difficulty. To this end the ducts are so disposed that all the electromotive forces which are generated in the ducts oppose and neutralize each other, so that energy, losses, and the danger of a ground in the metallic ducts are avoided.

Hitherto in transformers designed for large capacities and necessarily containing a large mass of copper it has been customary to employ oil-spaces between the coils for the purpose of cooling. In large transformers larger coils were used, and consequently the length of the spaces between the coils was increased. The flow of oil through the spaces was caused by its differences in temperature and hence if it was desired to keep the temperature of the transformer down to a certain point it was necessary to increase the width of the spaces in proportion to their increased length, in order that a sufficient amount of oil could flow through the spaces to absorb heat enough to maintain the desired low temperature. The coil was spaced apart for this purpose by suitable insulation. It is clear that such a construction is not sufficiently compact and rigid to well withstand the service which is required of it. The insulation around and between the coils is subjected to a slow oxidation by the heated oil, and it therefore shrinks, so that when current due to the large number of ampere-turns flows through the coils it throws them apart, causing them to vibrate, with accompanying noise and abrasion of the insulation and general deterioration of the apparatus.

In transformers constructed in accordance with this invention the openings between the coils which formerly served as open oil-spaces contain, tightly fitted therein, flat hollow

tubes of drawn brass of only the thickness of metal necessary, and through these tubes a circulation of water or other suitable cooling fluid is maintained. The fluid is forced through these tubes under moderate pressure, which causes the flat tubes of thin metal to tend to assume a circular shape, so that in proportion as the insulation of the windings shrinks the tubes will expand and compensate for the shrinkage, thus continually pressing against the windings and preventing the same from vibrating. These flat tubes serve mainly to conduct heat from the coils; but they extend out beyond the coils and core into the surrounding oil, where they absorb a portion of the heat conveyed by the oil from the core and from those portions of the coil which extend out beyond the core. The tubes extend outside the core in order that supply-pipes can be fitted to them at points outside the core and windings, for if these joints were made inside the winding the water from a leaking joint would cause serious injury to the insulation, whereas when the joints are made outside a leak might exist for some time without damage to the windings and can readily be detected by occasionally drawing off a test quantity of oil from the bottom of the transformer. Furthermore, by this construction the tubes are more readily accessible for repairs, cleaning, and similar purposes. This extension of the flat tubes or pipes increases the width of the operative portions of the transformer, and hence makes a larger casing necessary. Therefore it is desirable to make the casing of the oblong shape shown in the drawings in order to reduce the quantity of oil required to fill the casing. However, the structure may be modified, if desired, so that the usual cylindrical or square casing can be used.

Connected in series or other suitable manner with the flat pipes is a pipe-coil located near the top of the casing, surrounded by the oil of highest temperature and occupying a portion of the extra space made necessary by the elongation of the casing. The cooling fluid can pass through this coil on its way to or from the tubes and serves to cool the pipe, so that it absorbs heat from the oil, which the latter has conveyed from the core and from the portions of the windings which extend beyond the core. The portions of the tubes or aqueducts which extend beyond the core may conform with the contour of portions of the coils which extend beyond the core, so as to absorb heat by conduction therefrom; but for reasons hereinafter described this is not done in the present case. Of the drawings, Figure 1 is a longitudinal section of the transformer-casing, showing the interior of the apparatus in elevation with portions of the upper pipe-coils and the core in section; Fig. 2, a transverse section of the casing, showing the interior of the apparatus in end elevation with the upper pipe-coils in section; Fig. 3, a plan view of the

transformer, a portion of the cover thereof being removed to show a plan of the interior; Fig. 4, a perspective view of one-half an aqueduct unit, and Fig. 5 shows the shape of one of the tubes of which the aqueduct is composed.

In Fig. 1, A represents the aqueduct, which, with the primary and secondary coils, one of which is shown at P, completely fills up the core space or openings R through the core O. The core O is built up in two sections around the primary and secondary windings and is composed of laminations of sheet-metal punchings, which are secured together by bolts Z, supported in a frame V, which in turn is carried by bolts Y, which pass through shoulders X and engage in the bottom of the cast-iron transformer-casing B. The bar W at the top of the frame serves for lifting the windings from the casing and to make the upper portions of the frame rigid. Thus the primary and secondary coils or windings extend through one opening in the core, out into the other side of the casing, down to and through the other opening R, and out into the open part of the casing again, where they join the portions of the coils in the first opening.

As shown in Figs. 2 and 3, the primary and secondary coils are arranged alternately. The aqueducts A are tightly fitted between the primary and secondary coils throughout the width of the winding-space. The object of the alternate arrangement of the primary and secondary coils is to reduce the leakage flux, which is directly proportional to the distance between the coils. Consequent upon this reduction of leakage flux is the diminution of eddy-currents in the metallic aqueducts, which will not be neutralized like the electromotive forces in the manner described above. The energy losses and heating caused by the eddy-currents are thus avoided. The water or other cooling fluid which flows through the aqueducts is supplied through a pipe L, which is fitted to a connection-chamber which is divided into two compartments. A second pipe M serves as an outlet from the other compartment of the chamber K. The aqueduct may be connected with the double chamber K in any suitable manner; but as shown in Fig. 2 it is divided into five separate aqueducts which are connected in parallel with the chamber, one set of ends of these aqueducts being fitted into one compartment and the other set of ends being fitted into the other compartment of the chamber. The parts lettered F in Figs. 1 and 2 are hollow brass castings into which the ends of each aqueduct are soldered. The parts lettered G are the pipes which are also fitted in these castings to connect the sections of the aqueduct which are in the upper and lower openings of the coil.

A conception of the separate aqueduct units which are connected in parallel in the chamber K is best obtained from Fig. 4, which represents one-half of one of such units, which is provided at its upper end with a pipe H,

which is adapted to be fitted in the chamber K, and at its lower end with a brass casting J, in which are fitted pipes which connect the two halves of the aqueduct units together.

5 In their operative positions these two halves of an aqueduct are placed side by side, so that the pipe H, which is connected in the upper end of one, lies parallel with the pipe I, which is fitted into the upper end of the other, these pipes being fitted in the respective compartments of the chamber K. All the five units shown in Fig. 2 are connected up in like manner.

As shown more clearly in Fig. 1, the pipes 15 G, which connect the upper and lower tubes of each half unit, are all on one side of the apparatus, and immediately behind the half unit shown in elevation in Fig. 1 is its complementary unit, connected therewith by the joint J in the lower left-hand corner of the casing. Thus water entering through the supply-pipe 20 L flows through the lower compartment of the chamber K, the pipe H, the upper tube A, the pipe G, the lower tube A, and the joint J to the tube in the lower core or winding space R, parallel to the tube A, but in reversed direction, up through a similar pipe 25 behind the pipe G, through a tube in the upper core or winding space R, parallel to the upper tube A, but in an opposite direction, and out through the pipe I, through the upper compartment of the chamber K. Since this continuous metallic aqueduct is located within the winding-space of the transformer, 30 it will be clear that alternating electromotive forces will be generated in it; but owing to the manner in which the aqueduct is turned back upon itself through the coil they will oppose and neutralize each other and no current will flow.

As more clearly shown in Fig. 3, the flat tubes A alternate with the coils in the core-space, the entire structure being firmly wedged and fitted into the core or winding 45 space. The coils and the tubes are separated from each other by sheets of insulation N', so that the tubes absorb the heat generated in the coils direct therefrom by conduction through the sheets of insulation.

50 Each of the tubes A is composed of a plurality of tubes *a*, placed with their narrow sides adjacent. This is for the purpose of making the large tube stronger, since the drawn brass of which each tube *a* is composed is as thin as it is safe to make it for the purpose for which it is to be used. Each tube *a* is flattened, as shown in Fig 5, so that when the fluid is forced through it under moderate pressure it will tend to assume its circular shape. Since these tubes are made sufficiently thin for the purpose above described, the tubes are tightly fitted, when under no internal pressure, between the coils in the core or winding space, so that with a moderate internal pressure in the tubes they will tend to expand and press against the coils, and when the insulation shrinks they will fill the space

occupied thereby and prevent vibration of the coils, which would otherwise be caused by current passing through them.

As shown in Figs. 2 and 3, the outlet-pipe 70 M is fitted in the upper compartment of the double chamber K and extends outside the connection D of the transformer, where it is fitted to a pipe N, which in turn is connected 75 to a pipe Q, which leads to the pipe-coil C in the upper portion of the casing. From this pipe-coil is led an outlet T. As the chief function of the aqueducts A is to cool the primary and secondary coils P and S, so the 80 main office of the coil C is to absorb the heat from the oil with which the casing is filled to a point above the coil which has conveyed it from the core O; but as portions of the primary and secondary coils extend out from 85 the core into the body of oil in the casing the oil also conveys heat away from these portions of the coils, which heat is also absorbed by the coil C in coöperation with the conducting-casing B. Furthermore, as the aqueducts A extend out beyond the core or winding 90 space into the body of oil they will absorb heat from the oil, which has conveyed it from the core and from the portions of the primary and secondary coils which extend 95 beyond the core, thus coöperating with the coil C and with the conducting-casing B. The chamber K and its connecting-pipes being heavy and subject to severe strains are supported by a yoke U, which is provided with 100 two lugs U', which rest upon the frame V. The pipe-coil C rests bodily upon the frame V.

The construction of the aqueducts in single straight pieces of seamless pipe obviates the danger of a leak within the coils, which 105 might do serious injury. This construction also permits the making of the joints of the aqueduct after the core and coils have been assembled. Furthermore, the end connections of the tubes can be removed, so that 110 their interior is readily accessible for repairs or cleaning when it is necessary.

In the specification and claims we have used the word "aqueduct;" but we do not wish to be understood as limiting our invention or claims 115 by this word to the use of water, as any other cooling liquid or gas may be substituted, as oil, air, &c. In practice we prefer water.

Having thus described our invention, what we claim as new, and desire to secure by Letters Patent of the United States, is—

1. Means for generating a magnetic field, and a metallic structure so located with respect to such field that electromotive forces will be generated in it, the metallic structure 125 being turned back upon itself so that the electromotive forces generated in it mutually oppose and neutralize each other.

2. The combination with the windings of an electrical apparatus, of a metallic aqueduct in heat-transferring relation therewith, and turned back on itself so that mutually-opposing electromotive forces are generated in it.

3. In a transformer, the combination with primary and secondary windings, of a metallic aqueduct in heat-transferring relation therewith, and turned back on itself so that mutually-opposing electromotive forces are generated therein.

4. In a transformer, the combination with the core, of the primary and secondary windings extending therethrough, and a metallic aqueduct extending forward and back throughout the winding-space and in heat-transferring relation with respect to the windings.

5. In a transformer, the combination with a core having two openings, of the primary and secondary windings extending through both openings, and a metallic aqueduct extending in heat-transferring relation with respect to the windings, first through one opening and then in the opposite direction through the other opening, then back through the latter opening, and then in the opposite direction through the first opening.

6. The combination with the windings of an electrical apparatus, of a fluid-duct which is adapted to be expanded by the fluid against the said windings, to prevent the vibration thereof.

7. The combination with an electrical apparatus of a flat expansible tube adjacent to the windings.

8. In a transformer, the combination with the primary and secondary windings, of an aqueduct adapted to be expanded by internal pressure against said windings.

9. In a transformer, the combination with a heat-conducting casing, of a body of oil therein which is heated by the transformer losses, windings located in the casing, the insulation of which is liable to shrink, and an aqueduct through which a flow of fluid is maintained under moderate pressure to cool the heated oil, which fluid also expands the walls of the aqueduct against the windings to prevent vibration.

10. In a transformer, the combination with the core, of windings extending therethrough, and an expansible aqueduct between the windings, which with the latter, completely fills the core or winding space.

11. In an electrical apparatus, the combination with the windings, of an aqueduct adjacent thereto which is composed of a plurality of flat metallic expansible tubes.

12. A flat cooling-tube for an electrical apparatus, the material of which is sufficiently thin to permit the tube to expand under moderate internal pressure.

13. A flat expansible cooling-tube for an electrical apparatus, which is composed of thin drawn brass.

14. In a transformer, the combination with the core and windings, of a heat-conducting casing therefor, a fluid therein for conveying heat chiefly from the core, an aqueduct for absorbing heat direct by conduction from the windings, and an aqueduct surrounded

by the cooling fluid for absorbing therefrom the extra heat which is not absorbed by the casing.

15. In a transformer, the combination with the core, of the windings, a heat-conducting casing therefor, a fluid therein for conveying heat, an aqueduct for absorbing heat direct by conduction from the windings and extending out into the coil for absorbing the heat that the latter conveys from the core and the parts of the windings extending outside the core, and an aqueduct surrounded by the cooling fluid and cooperating with the heat-conducting casing to absorb the heat conveyed by the fluid from the core and from the parts of the windings which extend into the oil.

16. In a transformer, the combination with the core, of the windings extending through and outside the core, an aqueduct also extending outside the core adjacent to the windings, a heat-conducting casing, a fluid therein for conveying heat from the core and from the parts of the winding which extend outside the core, and an aqueduct surrounded by the fluid for cooperating with the portion of the first aqueduct which extends beyond the core, to absorb heat from the fluid.

17. In a transformer, the combination with the core and windings, of a heat-conducting casing therefor, a cooling fluid in the casing, an aqueduct for cooperating with the casing to absorb heat from the fluid, and an aqueduct in communication therewith which absorbs heat directly from the windings by conduction.

18. In a transformer, the combination with the core, of the windings extending therethrough, a tube also extending through the core, a hollow casting with which said tube is connected, and a supply-pipe fitted in the casting.

19. In a transformer, the combination with the core, of windings extending therethrough, a plurality of flat tubes arranged together to form a flat aqueduct, and extending through the core in contact with the windings, a hollow casting outside the core with which the tubes are connected, and a supply-pipe fitted in said casting.

20. In a transformer, the combination with a core having two openings, of the coils extending through the openings, flat straight seamless tubes extending through the openings, hollow castings in which said tubes are fitted, and a pipe connecting said castings.

21. In a transformer, the combination with the coils, of a plurality of aqueducts in contact therewith, a double connection-chamber into one compartment of which one of the sets of ends of the aqueducts are fitted, and into the other compartment of which the other of the sets of ends of the aqueducts are fitted, and supply and outlet pipes fitted in the respective compartments.

22. In a transformer, the combination with the coils, of straight seamless tubes in con-

fact therewith, hollow castings into which the ends of said tubes are connected, pipes fitted into said castings, a double connection-chamber into which the other ends of the pipes are fitted, and main supply and outlet pipes fitted in the respective compartments of the chamber.

23. In a transformer, the combination with the core and coils, of aqueducts in contact with the coils, a frame to which the core is secured, and supply-pipes for such aqueducts supported on such frame.

24. In a transformer, the combination with a heat-conducting casing, a cooling fluid in the casing, a core, a frame for the core mounted in the casing, coils extending through the core, aqueducts extending through the core in contact with the coils, and supply-pipes for said aqueducts and supported on the core-frame.

25. In a transformer, the combination with a core, of primary and secondary windings extending therethrough, and independent aqueducts also extending through the core to absorb heat from said coils by conduction.

26. In a transformer, the combination with a core, of primary and secondary windings extending therethrough, suitable insulation

for the windings, and a metallic aqueduct turned back on itself through the core and in contact with said insulation.

27. In a transformer, the combination with a core, of primary and secondary windings extending therethrough, sheets of insulating material adjacent to said windings, and a metallic aqueduct turned back on itself through the core, and in contact with said sheets.

28. In a transformer, the combination with the windings, of hollow metallic ducts not carrying current and located in heat-conducting relation with respect to the windings, and connections for supplying a cooling fluid to the tube.

29. In a transformer, the combination with the primary and secondary coils disposed alternately, of metallic tubes for a cooling fluid, located between the proximate primary and secondary coils.

In witness whereof we have hereunto set our hands this 24th day of October, 1900.

WALTER S. MOODY.
WILLIAM L. R. EMMET.

Witnesses:

BENJAMIN B. HULL,
MARGARET E. WOOLLEY.