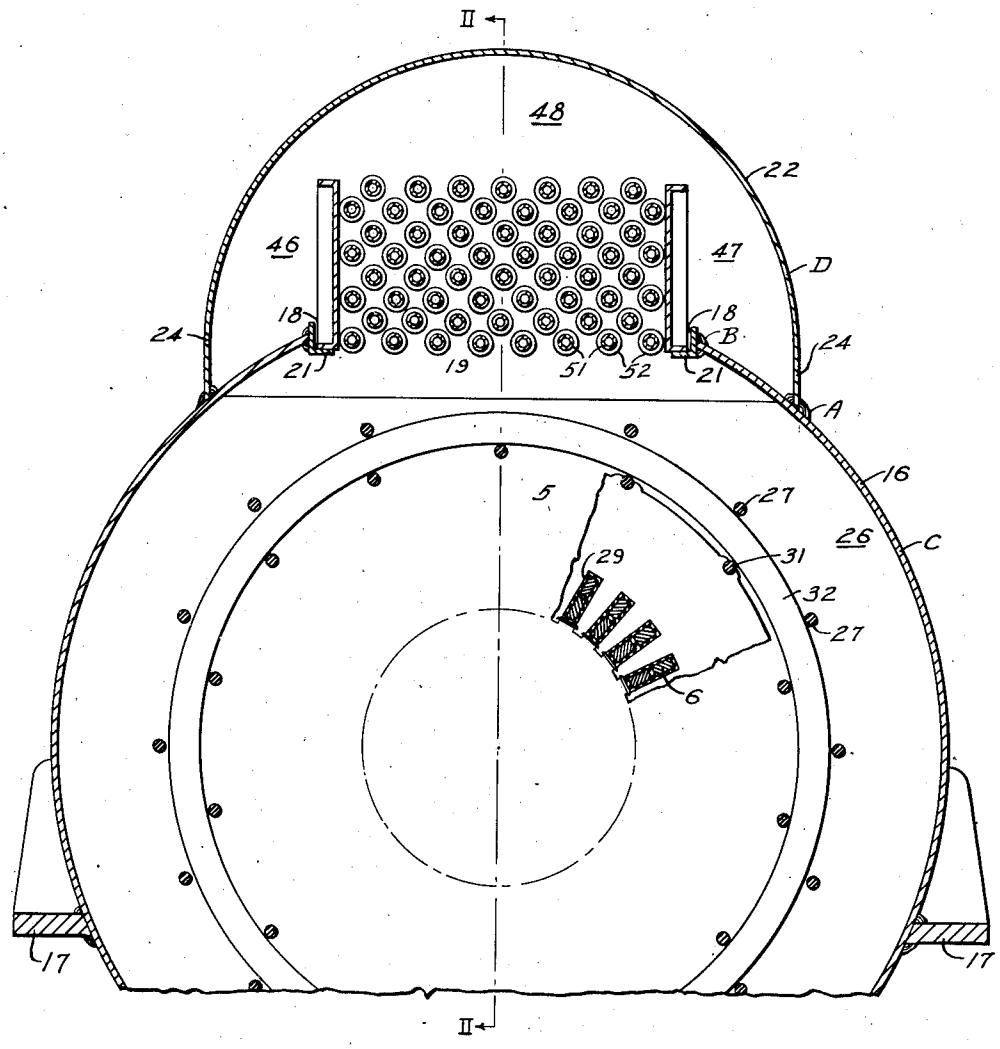
Sept. 23, 1947. R. A. BAUDRY 2,427,702

TURBOGENERATOR COOLING

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Fig. 1.



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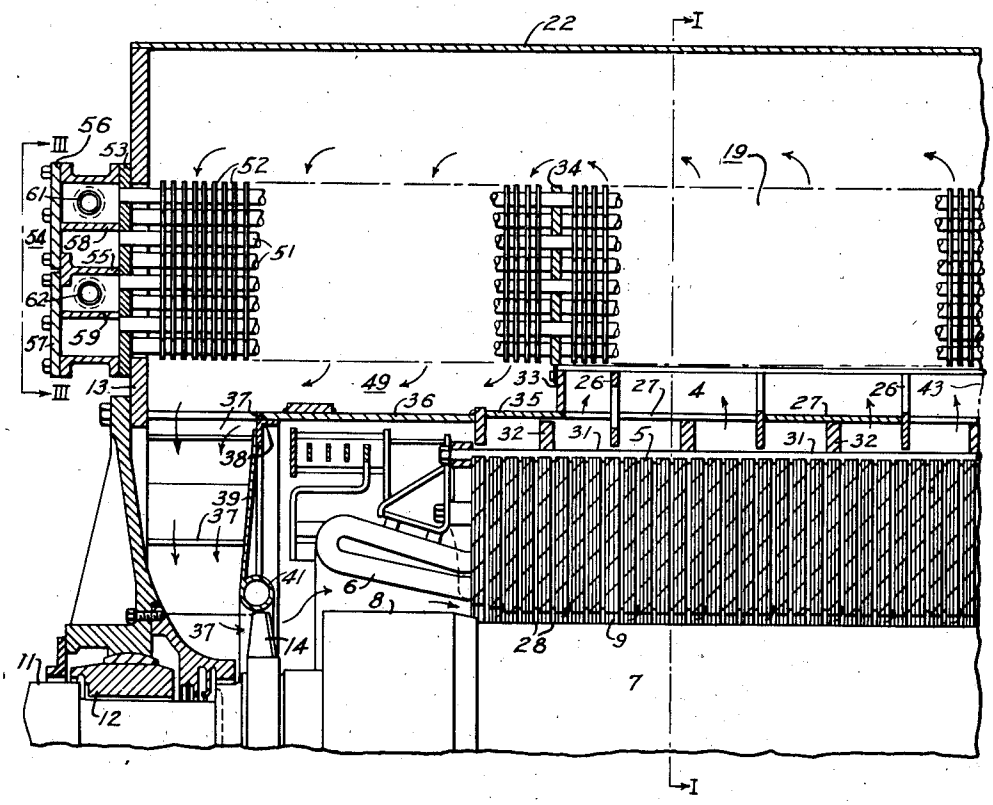
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Filed May 27, 1944 2 Sheets-Sheet 2

Fig. 2.



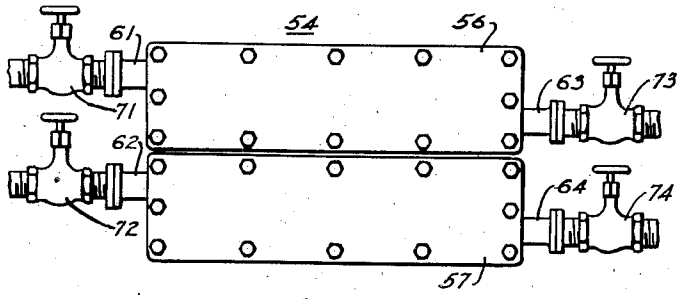


Fig. 3.

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TURBOGENERATOR COOLING

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8 Claims. (Cl. 171—252)

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My invention primarily relates to the cooling of totally enclosed dynamo-electric machines, and it has particular reference to the cooling of large horizontal-shaft hydrogen-cooled turbo-generators, which must have an explosion-resistant housing of considerable strength, and which must have a minimum possible width, with no bulges in the lateral direction, in order to facilitate the shipment of the machine, and to conserve floor-space when the machine is in service.

An object of the invention is to produce a ventilating-system which has only a single axially extending cooler located in a single bulge above the stator of a turbo-generator. In order to make this feasible, in any practical machine, it is necessary to build the cooler with divided water-boxes, so as to constitute two (or more) cooler-sections through which the ventilating gas of the machine passes serially, as distinguished from turbo-generator ventilation in which the ventilating gas passes, in a plurality of separate, parallel paths, through a plurality of separate coolers, usually located in as many separate bulges. The reason for this is that impure water is commonly utilized for circulation in the coolers, and the pipes of the coolers rapidly become contaminated, so that they must be cleaned, while the machine is in operation.

If, for example, there were four parallel-connected coolers, the water-connections of one of these coolers could be shut off, so that the cooler could be opened up and cleaned out, while the machine was in operation, resulting in a 25% loss of cooling during the time required to clean out the faulty cooler. In the case of coolers connected in two serially-connected sections, if one of these sections should be cut out of service for cleaning purposes, the cooling effect of the remaining section would not be one-half, but something of the order of three-quarters, of the cooling effect of the two sections in series, because the most effective part of a cooler is the first part thereof, where the greatest temperature-differential exists between the cooler-temperature and the temperature of the gaseous ventilating medium of the machine.

Thus, by serially connecting the cooler-sections, it is possible to utilize a smaller number of separately controlled water-boxes or cooler-sections, than in cases where the ventilating gaseous medium is passed, in parallel paths, through the several cooler-sections or units. As a result of the application of this idea to a generator-frame designed with one cooler disposed in a single longitudinally extending bulge at either the top

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or the bottom of the frame, preferably the top, the cost of the cooler is reduced, the cost of the frame is reduced, the frame-baffling is simplified, and the overall width of the frame is held down to the barest minimum, because no laterally extending cooler-bulges are required.

A further object of the invention is to provide a novel construction in which an explosion-resistant machine-housing comprises a main cylindrical housing having a longitudinally extending opening in its top, and an auxiliary housing providing an enclosed bulge over said longitudinally extending opening, the side-walls of said auxiliary housing terminating on the outside wall of the main housing at a distance from said longitudinally extending opening, as well as at an angle to the outside wall of the main housing. Thus, when these walls are joined together, they come together at an angle, like a T-beam, so that each reinforces the other against displacement as a result of internal gaseous pressures within the machine. A further advantage of this construction is to minimize the height of the bulge, by causing the cross-sectional area of the bulge to extend out laterally, on each side of the cooler which is disposed therein, as well as having a vertical clearance above the cooler, thus increasing the cross-sectional area of the bulge without involving an increase in the height thereof.

With the foregoing and other objects in view, my invention consists in the structures, apparatus, parts systems, and methods hereinafter described and claimed, and illustrated in the accompanying drawing, wherein Figure 1 is a transverse sectional view of the stator-member of a hydrogen-cooled turbo-generator embodying my invention, with parts broken away for clarity of illustration, the section-plane being indicated at I—I in Fig. 2, Fig. 2 is a central longitudinal sectional view of the top left-hand quarter of such a machine, and Fig. 3 is an end view of the cooler.

The illustrated turbo-generator comprises a stator-member 4 having a laminated stator-core 5, carrying primary windings 6, and a rotor-member 7 which carries the exciting windings 8 and which is separated from the stator-core 5 by an air-gap 9. The rotor-member 7 is carried by a horizontal shaft 11 which is journaled in bearings 12 carried by the end-brackets 13 of the stator-housing. The rotor-member 7 also carries a ventilating-fan 14 at each end of said rotor-member, for maintaining an internal circulation of the ventilating gaseous medium.

The stator-member 4 of the machine is enclosed in an explosion-resistant gas-tight housing which may be filled with hydrogen, or other gaseous ventilating medium. The housing comprises a main housing 16, which is preferably cylindrical in shape, for maximum strength and minimum weight. The main housing 16 carries feet 17 or other supporting-brackets which are secured along its sides, for supporting the machine over the customary pit (not shown).

The main housing 16 is provided with a single longitudinally extending opening 18, preferably at the top thereof, for receiving a cooler 19, which may be supported, for example, on angle-iron brackets 21, which are secured to the edges of the housing-opening 18. The housing-opening 18 is closed by an auxiliary semi-cylindrical housing 22 which provides an enclosing bulge over said opening 18, and also over and around the cooler 19, there being clearance between the bulge 22 and the cooler, both above the cooler and on each side thereof. The side-walls 24 of the auxiliary housing or bulge 22 terminate on the outside of the wall of the main housing 16 and at an angle thereto, as shown in Fig. 1, and at a distance from the longitudinally extending opening 18, said walls being joined together, as by welding at A, so that, because of their angular relationship, each reinforces the other against displacement as a result of internal gaseous pressures within the machine, providing, in effect, a T-beam, the base of which may be regarded as the portion BAC of the main housing, and the flange of which may be regarded as the portion DA of the auxiliary housing or bulge.

Suitable bracing and reinforcing members are employed, including a plurality of longtudinally spaced rings 26 around which the main housing 16 is secured. The rings 26 may also be joined by longitudinally extending bolts or other connecting-members 27.

The stator-core 5 is built up of bundles of laminations which are separated by radial ventilating-spaces 28. The bore of the laminations 5 is provided with axially extending slots 29 for receiving the primary winding 6. The outer periphery of the laminations 5 is carried by longitudinally extending bolts or rods 31, to which are connected a number of spaced rings 32 which are suitably supported by the stator frame or housing.

The stator frame also includes suitable baffling means, for co-operating with the ventilating fan 14 of the rotor, to provide a recirculation of the hydrogen or other gaseous ventilating medium which is enclosed within the housing. Near each end of the stator-core 5, but spaced from the end, the stator frame-member is provided with an annular baffle-plate 33 which co-operates with a corresponding transverse baffle-member 34 in the cooler 19, and which also co-operates with cylindrical baffles 35—36 which are connected to the inner periphery of each annular baffle 33, extending out from said baffle 33 to the end-bracket 13 at that end of the machine. The end of the cylindrical baffle 36 is provided with a plurality of slots 37, at spaced points all around the circumference, and the inner ends of these slots 37 are joined at 38 to an annular baffle 39 which terminates in an annular pipe 41 which is spaced with close clearance from the outer periphery of the fan 14 at that end of the machine.

In accordance with my invention, it is important that the ventilating gaseous medium, which is enclosed within the gas-tight housing of the machine, shall be recirculated in such manner

that it passes radially outwardly through one or more portions of the longitudinally extending opening 18 in the main housing, then flowing across all of the pipes at a portion of the cooler 19 and into the portion of the cross-section of the bulge 22 which is not filled by the cooler 19, thence passing longitudinally along the bulge, then flowing back across all of the pipes at another portion or portions of the cooler, and radially inwardly through another portion or portions of the longitudinally extending opening 18 in the main housing, and thus circulating back through the machine.

The precise details of the circulating path or paths inside of the machine, before the ventilating gaseous medium passes through the longitudinally extending opening to be cooled by the cooler 19, is subject to considerable variation. A very simple internal ventilating circuit for the recirculating gaseous medium is indicated in Fig. 2, in which the ventilating fan 14 causes the gas to flow axially inwardly through the air-gap 9 toward the center of the machine, which is indicated by the center-line 43. From the air-gap 9, the air passes radially outwardly through each of the radial ventilating-spaces 28 of the stator core, and thence passes into the central portion of the cooler 19, that is, the portion bounded by the baffles 33—34 at one end or half of the machine, and by the corresponding baffles (not shown) on the other side of the center-line 43, which may be a duplicate of the illustrated portion in Fig. 2, so far as the gaseous circulation is concerned. The ventilating gas then passes through the cooler 19 and gets out into the rest of the space within the bulge 22, filling the spaces 46 and 47 (Fig. 1) on each side of the cooler 19, as well as the space 48 above said cooler, within said bulge 22.

In the simple ventilating-circuit illustrated in Fig. 2, the ventilating gaseous medium then flows longitudinally through the bulge 22, toward each end thereof, returning back through the cooler, and through the corresponding portion of the longitudinally extending slot 18 (Fig. 1) into an annular space 49 which is bounded by the annular baffle 33, the cylindrical baffles 35 and 36, and the end-bracket 13. From the annular space 49, the ventilating gas escapes inwardly through the several slots 37, and thence passes to the intake side of the fan 14 at that end of the machine, being constrained to flow in this path by means of the annular baffle 39.

The cooler 19 consists of a large number of cooler-pipes 51 extending longitudinally throughout the length of the machine, these pipes being provided with external fins 52 to facilitate the heat-transfer between the ventilating gas and the cooler-pipes. The cooler-pipes 51 terminate in end-heads 53, and each end-head 53 is covered by a water-box 54.

In practicing my invention it is important that each water-box 54 should be built in two sections, one above the other, separated by a horizontal partition 55, and the two sections of the water-box are provided with separate detachable end-plates or covers 56 and 57, respectively. Each section of the water-box at the left-hand end of the cooler is further subdivided by intermediate partitions 58 and 59, so that the water (or other coolant) may be admitted into the space, say, above the partition 58, and above the partition 59, by inlet pipes 61 and 62, respectively, from which the water passes longitudinally through the pipes which terminate above the partitions 58 and 59, respectively, pass-

ing entirely through the cooler to the other, or right-hand, end thereof, where the water returns through the pipes which are connected below the partitions **58** and **59**, respectively, at the first end, and the water is finally discharged by outlet-pipes **63** and **64**, respectively, at the first, or left-hand, end of the cooler.

By placing separate water-valves **71**, **72**, **73** and **74** in the respective pipes **61**, **62**, **63** and **64**, it becomes possible to close off the water from either half of the cooler, such as the top half which is controlled by the valves **71** and **73**, after which it is possible to remove the corresponding end-plate or cover **56**, at each end of the cooler, thus exposing the ends of the pipes of that half of the cooler, so that they can be cleaned.

From the foregoing description, it will be perceived that I have achieved the objects outlined at the outset of this description, resulting in a construction which is remarkably simple, efficient, economical, light in weight, and of the minimum possible size.

I claim as my invention:

1. A dynamo-electric machine having a main housing enclosing the same, said housing having a longitudinally extending opening, an auxiliary housing providing an enclosed bulge bridging said longitudinally extending opening, a cooler comprising longitudinally extending cooler-pipes disposed within said bulge and occupying less than all of the cross-sectional area of said bulge, and baffling and ventilating means arranged in such manner as to cause a gaseous ventilating medium to flow radially outwardly from the main housing of the machine through one or more portions of said longitudinally extending opening, and thence across all of the pipes of one or more portions of said cooler, then longitudinally along the bulge, and back across all of the pipes at another portion or portions of said cooler and radially inwardly through another portion or portions of said longitudinally extending opening and thus back into the main housing of the machine.

2. An explosion-resistant, totally enclosed, dynamo-electric machine having a main housing enclosing the same, said housing having longitudinally disposed opening-means in a wall thereof, an auxiliary housing providing an enclosed bulge bridging said longitudinally disposed opening-means, a wall of said auxiliary housing terminating on the outside of the wall of the main housing at an angle thereto and at a distance from said longitudinally disposed opening-means, said walls being joined together whereby, because of their angular relationship, each reinforces the other against displacement as a result of internal gaseous pressures within the machine, a cooler comprising longitudinally extending cooler-pipes disposed within said bulge and occupying less than all of the cross-sectional area of said bulge, said cooler fitting said opening-means in the housing, and baffling and ventilating means arranged in such manner as to cause a gaseous ventilating medium to circulate through the machine and said cooler.

3. An explosion-resistant, totally enclosed, dynamo-electric machine having a main housing enclosing the same, said housing having a longitudinally extending opening in a wall thereof, an auxiliary housing providing an enclosed bulge bridging said longitudinally extending opening, a wall of said auxiliary housing terminating on the outside of the wall of the main housing at an angle thereto and at a distance from said longitudinally extending opening, said walls being joined together whereby, because of their angular relationship, each reinforces the other against displacement as a result of internal gaseous pressures within the machine, a cooler comprising longitudinally extending cooler-pipes disposed within said bulge and occupying less than all of the cross-sectional area of said bulge, said cooler fitting said opening-means in the housing, and baffling and ventilating means arranged in such manner as to cause a gaseous ventilating medium to flow radially outwardly from the main housing of the machine through one or more portions of said longitudinally extending opening, and thence across all of the pipes at one or more portions of said cooler, then longitudinally along the bulge, and back across all of the pipes at another portion or portions of said cooler and radially inwardly through another portion or portions of said longitudinally extending opening and thus back into the main housing of the machine.

4. A dynamo-electric machine having a housing enclosing the same, a multiple-unit cooler comprising cooler-pipes, means for circulating a coolant through said cooler-pipes and for separately controlling such coolant-circulation through each unit of the cooler in such manner that one unit may be cleaned while the machine continues its operation, and baffling and ventilating means arranged in such manner as to cause a gaseous ventilating medium to circulate through the machine and said cooler in such manner that said gaseous ventilating medium passes successively, one after another, through all of the units of said cooler.

5. A horizontal-shaft dynamo-electric machine of limited width, having a main housing enclosing the same, said housing having longitudinally disposed opening-means in a wall thereof, an auxiliary housing providing an enclosed bulge bridging said longitudinally disposed opening-means, a multiple-unit cooler comprising longitudinally extending cooler-pipes disposed within said bulge and occupying less than all of the cross-sectional area of said bulge, means, including sectionalized coolant-header-boxes at the respective ends of the longitudinally extending cooler-pipes, for circulating a coolant through said cooler-pipes and for separately controlling such coolant-circulation through each unit of the cooler, each section of each of said coolant-header-boxes having a separate removable end-cover-plate whereby one unit may be cleaned while the machine continues in operation, and baffling and ventilating means arranged in such manner as to cause a gaseous ventilating medium to circulate through the machine and said cooler, said gaseous ventilating medium passing successively, one after another, through the plurality of units of said cooler.

6. A horizontal-shaft dynamo-electric machine of limited width, having a main housing enclosing the same, said housing having a longitudinally extending opening in a wall thereof, an auxiliary housing providing an enclosed bulge bridging said longitudinally extending opening, a multiple-unit cooler comprising longitudinally extending cooler-pipes disposed within said bulge and occupying less than all of the cross-sectional area of said bulge, means, including sectionalized coolant-header-boxes at the respective ends of the longitudinally extending cooler-pipes, for circulating a coolant through said cooler-pipes and for separately controlling such coolant-circulation through each unit of the cooler, each section

of each said coolant-header-boxes having a separate removable end-cover-plate whereby one unit may be cleaned while the machine continues in operation, and baffling and ventilating means arranged in such manner as to cause a gaseous ventilating medium to flow radially outwardly from the main housing of the machine through one or more portions of said longitudinally extending opening, and thence across all of the pipes at one or more portions of said cooler, then longitudinally along the bulge, and back across all of the pipes at another portion or portions of said cooler and radially inwardly through another portion or portions of said longitudinally extending opening and thus back into the main housing of the machine, said gaseous ventilating medium passing successively, one after another, through the plurality of units of said cooler, each time it flows across said cooler-pipes.

7. A horizontal-shaft, explosion-resistant, totally enclosed, dynamo-electric machine of limited width, having a main housing enclosing the same, said housing having longitudinally disposed opening-means in a wall thereof, an auxiliary housing providing an enclosed bulge over said longitudinally disposed opening-means, a wall of said auxiliary housing terminating on the outside of the wall of the main housing at an angle thereto and at a distance from said longitudinally disposed opening-means, said walls being joined together whereby, because of their angular relationship, each reinforces the other against displacement as a result of internal gaseous pressures within the machine, a multiple-unit cooler comprising longitudinally extending cooler-pipes disposed within said bulge and occupying less than all of the cross-sectional area of said bulge, said cooler fitting said opening-means in the housing, means, including sectionalized coolant-header-boxes at the respective ends of the longitudinally extending cooler-pipes, for circulating a coolant through said cooler-pipes and for separately controlling such coolant-circulation through each unit of the cooler, each section of each of said coolant-header-boxes having a separate removable end-cover-plate whereby one unit may be cleaned while the machine continues in operation, and baffling and ventilating means arranged in such manner as to cause a gaseous ventilating medium to circulate through the machine and said cooler, said gaseous ventilating medium passing successively, one after another, through the plurality of units of said cooler.

8. A horizontal-shaft, explosion-resistant, totally enclosed, dynamo-electric machine of limited width, having a main housing enclosing the same, said housing having a longitudinally extending opening in a wall thereof, an auxiliary

housing providing an enclosed bulge over said longitudinally extending opening, a wall of said auxiliary housing terminating on the outside of the wall of the main housing at an angle thereto and at a distance from said longitudinally extending opening, said walls being joined together whereby, because of their angular relationship, each reinforces the other against displacement as a result of internal gaseous pressures within the machine, a multiple-unit cooler comprising longitudinally extending cooler-pipes disposed within said bulge and occupying less than all of the cross-sectional area of said bulge, said cooler fitting said opening in the housing, means, including sectionalized coolant-header-boxes at the respective ends of the longitudinally extending cooler-pipes, for circulating a coolant through said cooler-pipes and for separately controlling such coolant-circulation through each unit of the cooler, each section of each of said coolant-header-boxes having a separate removable end-cover-plate whereby one unit may be cleaned while the machine continues in operation, and baffling and ventilating means arranged in such manner as to cause a gaseous ventilating medium to flow radially outwardly from the main housing of the machine through one or more portions of said longitudinally extending opening, and thence across all of the pipes at one or more portions of said cooler, then longitudinally along the bulge, and back across all of the pipes at another portion or portions of said cooler and radially inwardly through another portion or portions of said longitudinally extending opening and thus back iinto the main housing of the machine, said gaseous ventilating medium passing successively, one after another, through the plurality of units of said cooler, each time it flows across said cooler-pipes.

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