L. R. ALBERGER.

SURFACE CONDENSER.

APPLICATION FILED AUG. 12, 1907.

957,175. Patented May 10, 1910.

3 SHEETS—SHEET 1.

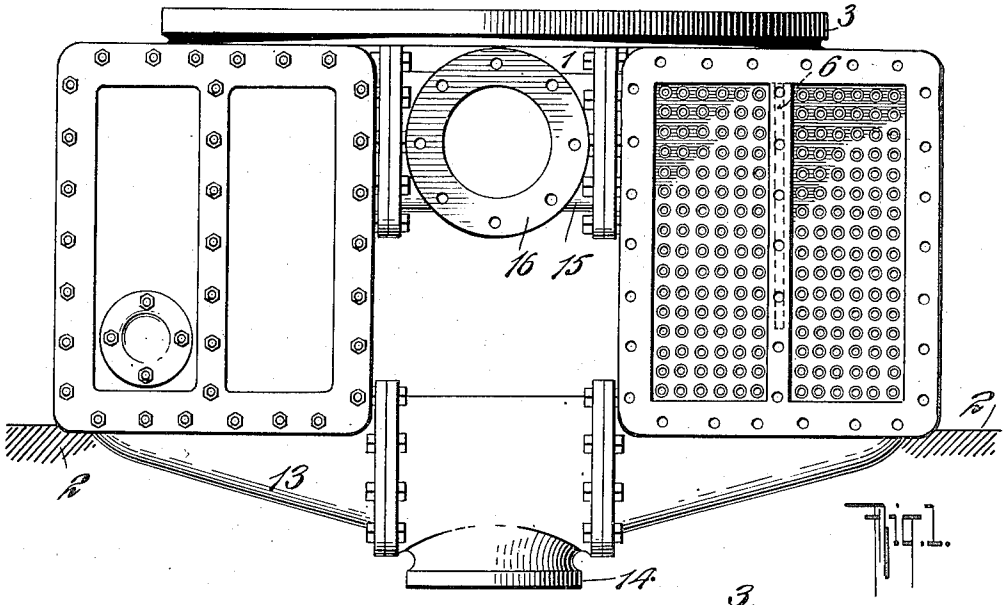

Fig. 1.

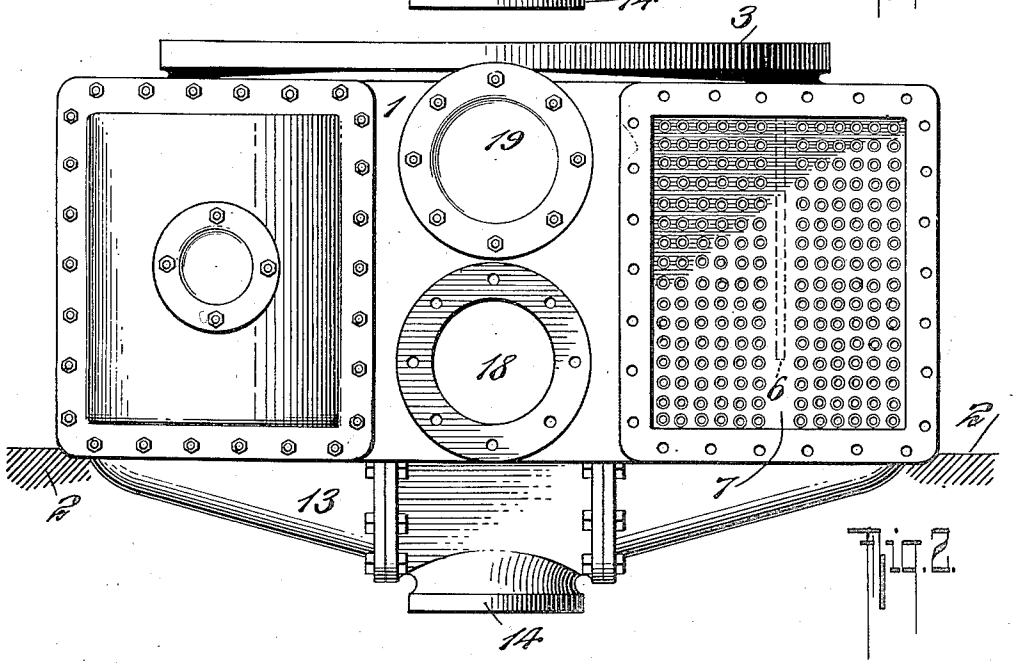

Fig. 2.

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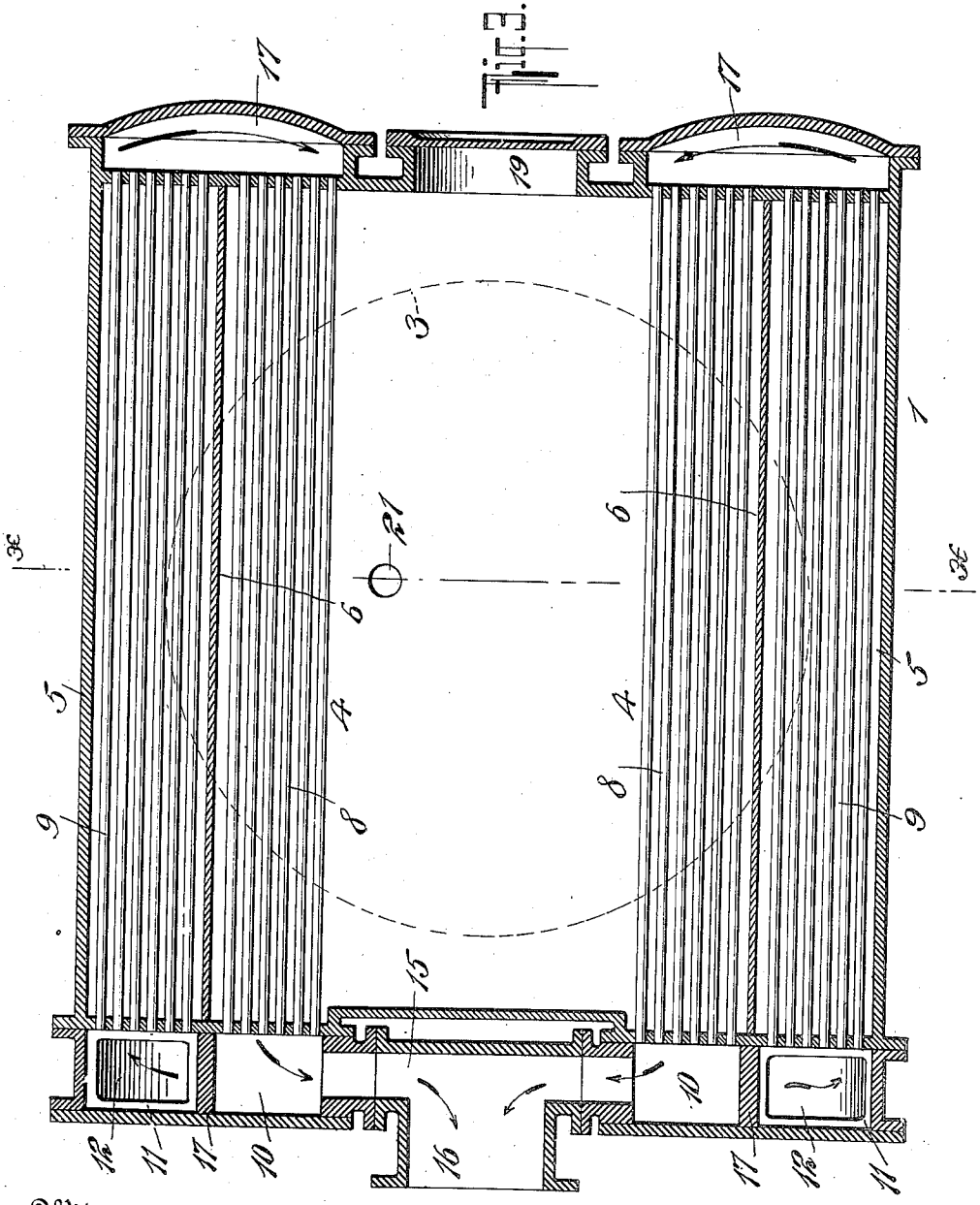
3 SHEETS—SHEET 2.

Fig. 3.



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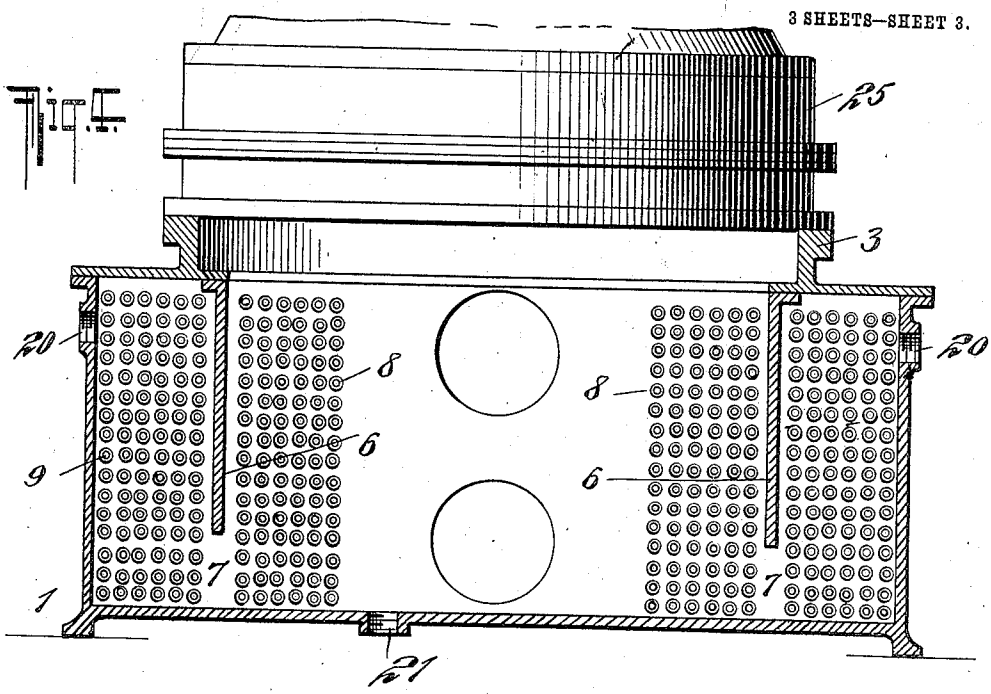
3 SHEETS—SHEET 3.

Fig. 5.



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SURFACE CONDENSER.

957,175. Specification of Letters Patent. Patented May 10, 1910.

Application filed August 12, 1907. Serial No. 388,135.

To all whom it may concern:

Be it known that I, LOUIS R. ALBERGER, a citizen of the United States of America, and a resident of Greenwich, county of Fairfield, State of Connecticut, have invented certain new and useful Improvements in Surface Condensers, of which the following is a specification.

This invention relates to the condensation of exhaust steam from engines, steam turbines, and various kinds of steam motors, and to the production of a vacuum by the use of the dry vacuum system.

The invention is especially useful with that class of apparatus known as surface condensers, in which the condensation is effected by the contact of the steam with water-cooled surfaces.

The object of the invention is to promote the usefulness of condensers by providing a surface condenser having a very high efficiency; and further to furnish a condenser of maximum efficiency suitable for location under a steam turbine or other motor, of which it may be considered as constituting a supporting base or frame.

In my former Letters Patent on surface condensers, No. 868,390, dated October 15, 1907, I have illustrated and described various forms of base condensers, consisting essentially of a section in which the steam and commingled air entering above come into contact with tubes containing the cooling water, by which the steam is partially condensed, the steam, air and water of condensation traveling in the same direction; and another section in which the steam and commingled air are received below from the first section, and pass upward coming into contact with tubes containing cooling water until the steam is entirely condensed, the air being removed above at or near the top of the condenser by a dry vacuum pump. The cooling water may enter above in that kind of a condenser, and the air separated from the exhaust steam be removed above, so that the air may be brought into contact with the coldest tubes before removal, while the water of condensation is brought into contact with the exhaust steam. Said invention contained in my other application is grounded upon the principle that in a surface condenser the highest efficiency can best be obtained by bringing the exhaust steam and commingled air into the condenser at or near the bottom, and bringing the circulating water in at or near the top, and causing the water of condensation to gravitate against the incoming steam and air; but inasmuch as there are situations, as in the case of a steam turbine, where it is not always convenient to introduce the exhaust steam into the bottom of the condenser, a part of the condenser is so arranged as that steam may be introduced at the top, from which part the said steam so introduced enters the bottom of another part, and so the advantage of using a bottom-steam-inlet is secured along with the necessitated arrangement of a primary introduction of the steam at the top.

My present invention consists of a specific form of base condenser analogous in some respects to certain of the forms described in my aforesaid co-pending application, but differing in certain other respects. It comprises a condenser having a part into which the steam and commingled air enter above and come into contact with tubes containing cooling water by which the steam is partially condensed, and another part into which the steam and commingled air enter below from the first part, and then pass upward and come into contact with tubes containing cooling water until the steam is entirely condensed. A suitable division is placed at each side between the primary or secondary parts or chambers, but arranged to allow of a passage at the bottom from the first part to the second. The cooling water preferably enters the condenser at the bottom and leaves it at the top, both the water connections being at the same end of the condenser so that the other end may be left free and without obstructive projections. In order to provide for the proper circulation of the water, the tubes are arranged in nests or groups in a horizontal series, said nests or groups communicating at one end of the condenser with a common chamber, and at the other end with individual chambers, the latter being arranged in a horizontal series, one receiving the incoming water just after it enters the condenser, and the other receiving the outgoing water just before it is ready to be withdrawn from the

condenser. This arrangement which I have just outlined is duplicated, so that in reality I provide a condenser wherein a double two-pass distribution of the water is effected; that is to say, the water supplied by the circulating pump is divided into two portions, one passing to one side of the base, and the other to the other side, and the construction of the condenser permitting two passes through each side, one in each direction, so that there is a double two-pass distribution. And the invention also consists in various details and peculiarities in the combination and arrangement of parts, substantially as will be hereinafter more fully described and claimed.

In the accompanying drawing illustrating my invention, Figure 1 is an end elevation of my improved surface condenser, the end shown being that where the circulating water enters and leaves the condenser shell, the cover for the water chambers at one side being removed. Fig. 2 is an opposite end elevation of my improved surface condenser with one cover plate belonging to one of the water chambers on that side of the condenser removed, in order to indicate a chamber located directly opposite to a pair of chambers like those exposed in Fig. 1. Fig. 3 is a horizontal section of my improved surface condenser. Fig. 4 is a transverse vertical section on the line x x of Fig. 3.

Similar characters of reference designate corresponding parts throughout all the different figures of the drawing.

The condenser frame 1 may have any suitable shape and size, and I am not restricted, therefore, to the specified form and dimensions illustrated. It is supported in any desired manner, as, for instance, upon a suitable groundwork at 2. As the condenser in this particular type of my invention generally serves as the base of a steam motor, the latter will be superposed thereon in any preferred way, and it has not seemed necessary to illustrate in the drawings any specimen or example of motor other than the partial outline 25 in Fig. 4. Ordinarily it may be a steam turbine or other form of steam engine. I have represented in the drawings a cylindrical inlet 3 through which the steam from the turbine or other motor, as 25, passes downward into the top of the condenser 1. It, of course, will be clearly understood that I am not restricted to any particular type of steam generator, but my condenser is adapted to be used with all kinds of steam motors; neither am I confined to placing my condenser in the base of the turbine or other motor, although this is the preferable and at present the intended location therefor.

Inside the shell 1, at the opposite longitudinal sides, are sections or chambers wherein the cooling surfaces are located.

4, 4 denote the innermost sections, and 5, 5 the outermost, said sections 4 being divided from the sections 5 by means of vertical partitions 6 which are secured to the condenser shell 1 at the top, but stop short of the bottom of the shell so as to leave a space or opening at 7, through which the steam may pass from the sections 4 to the sections 5. The sections 4, 4 usually and preferably constitute together a single large chamber in which condensing surfaces will be located at the sides with some considerable intervening free and open steam space between them. The condenser shell 1 thus in reality, as I have portrayed it, consists of two duplicate condenser shells, each composed of a chamber 4 and its contained cooling surface, and a chamber 5 and its contained cooling surface, with the intervening partition 6, there being between these duplicate constructions the steam space open at the top to receive the exhaust steam from the motor. In each chamber 4 is a nest of longitudinal tubes 8, and in each chamber 5 there is a corresponding nest of longitudinal tubes 9, these tubes 8 and 9 being for the purpose of carrying the cooling water which is introduced thereinto at the ends.

At one end of the condenser shell 1 on each side,—that is to say, for each of the tube nests 8 and 9,—are water chambers 10 and 11, water chamber 10 being entered by the tubes belonging to the nest 8, and the water chamber 11 being entered by the tubes belonging to the nest 9. Thus it will be seen that at one end of the frame 1 there will be two water chambers 10 and two water chambers 11, as illustrated in Fig. 3. The two chambers 11 have openings 12 in the bottom which are connected by a water pipe 13 having an inlet opening 14, to which any suitable piping may be connected, running to some source of water supply for furnishing the circulating water to cool the aforesaid tubes, into contact with which the steam is brought for condensation purposes. The other two water chambers 10 at this end of the condenser are connected by a pipe 15 having an outlet 16 to which may be coupled some suitable pipe to lead away the circulating water from the condenser. At the opposite end of the condenser frame 1, there are single chambers 17, 17, one on each side, each of which chambers receives the tubes of one of the nests 8 and likewise the tubes of one of the nests 9, so that in this manner the chamber 17 acts as a connection between the ends of the tubes of the two nests and enables the water emerging from tubes 9 to pass around through this chamber and enter the tubes 8.

The tube nests 8 and 9 are separated from each other, as already stated, by the partitions 6, below which are the openings 7, said partitions 6 being placed vertically or

otherwise as desired. Hence the nests 8 and 9 lie in the same horizontal plane or are situated in a horizontal series. The chambers 10 and 11 are separated from each other by vertical partitions 17, and hence these chambers may be viewed as located in the same horizontal plane or in a horizontal series. The water supply pipe 13 first delivers water through the bottom inlet openings 12 into the chambers 11 which are the outside chambers, and thence it passes into the nests of tubes 9 which are the outside nests, making these outside nests consequently the colder nests, and flows through them to the other end of the condenser, where it fills the chambers 17 and passes thence into the other tube nests 8, returning therethrough to the end of the condenser from which it started, and entering the inside chambers 10 it finds exit from the apparatus through the connection 15 and outlet 16. Thus it will be seen that by this construction and arrangement the water makes one pass from the water inlet end of the condenser to the opposite end, and one pass back to the inlet end again, or in all two passes; and as this is done on both sides of the condenser, or in other words as the construction is duplicated, I find it convenient to express the operation as a double two-pass distribution of the circulating water accomplished through the medium of a horizontal series of distinct nests of tubes. In this way, the water from the circulating pump is divided into two parts after it is introduced through the inlet 14, one part going to one side of the condenser shell, and the other part going to the other side, each part making two passes through the shell and coming back to the end of the condenser whence it started, so that I am enabled in this manner to cause the circulating water to enter and leave at the same end of the condenser, which is an important object, since it keeps both the openings, the inlet and the outlet, at one end of the condenser, and enables the other end of the condenser to be utilized for other things, and also eliminates the necessity of any channels or connections of any kind at the other end of the condenser. In the present example of the invention, I place at the other end of the condenser an exhaust opening 18 available for use when the engine is to be run non-condensing, and likewise a manhole 19 for permitting access to the interior of the condenser shell.

The accomplishment of the object of having the water enter and leave at the same end of the condenser is only possible where there is an even number of passes. In a condenser which may be called a single two-pass condenser, or one where the water entering at one end of the condenser flows through one tube nest on one side of an inner steam space to the other end and returns to the first end through a second nest on the other side of said steam space, it is usually necessary to provide piping at the other end to connect the two nests, so that the water can flow from the end of one pass to the end of the other pass, and this piping, thus necessitated, obstructs the openings that are desirably placed on that end of the shell of the condenser, as 18 and 19 already referred to. Such a single two-pass condenser would be one having merely two nests, as 8, 8, whose ends opposite to the water inlet would have to be connected by piping as stated. Another form where there is an even number of passes is what may be termed a single four-pass condenser where the water passes through one nest from the inlet end to the other end of the condenser, and then returns through a second nest; it then passes through a third nest from the inlet end to the other end of the condenser and finally back again through a fourth nest; but here there is a large amount of frictional resistance to the flow of the required amount of the water through four passes. This resistance is eight times as great as it is in my double two-pass condenser; or, in other words, in my improvement, the friction is only one-eighth of what it is in a single four-pass condenser. With my form which I designate a double two-pass condenser, there is a great reduction in the resistance to the flow; while at the same time the other end of the condenser is kept free for the convenient location of the non-condensing and manhole openings.

The operation is as follows: The steam from the turbine or other motor, as 25, passes down through the cylindrical inlet 3 and enters the central steam space 4, there coming into contact with the tube nests 8 and being partially condensed. The steam then flows through the openings 7 into the sections 5 and comes into contact therein with the tube nests 9 where the rest of the steam is condensed. As the cooling water flows first in the arrangement I have described into the outer tubes 9, it is evident that they are cooler than the tubes 8, and are in fact the coldest surfaces in the condenser. In the central exhaust steam space or the sections or chambers 4, therefore, it must be observed that the exhaust steam, the air commingled therewith, and the water of condensation all travel in a downward direction; whereas in the sections or chambers 5, the exhaust steam, and the air commingled therewith both travel in a direction the reverse of that of the travel of the water of condensation. At suitable points in the walls of the condenser frame 1, proximate to the coldest condensing surfaces,—that is to say, for an example, at certain points in the walls of the sections or chambers 5 adjoining the coldest

tubes 9,—I place openings 20 for the exit of the air at these points. Pipes leading to an air or vacuum pump may be coupled in the ordinary way. These openings are at or near the top of the condenser, and are obviously separate from the steam inlet; and, moreover, the partition 6, or other equivalent means, has the function of directing the entering steam away from the air exit. Thus it will be seen that the air is brought into contact with the coolest tubes 9 immediately before its removal through the air outlets 20, and furthermore it is equally evident that the water of condensation which falls down into the lower part of the chambers 5 is brought into contact with the exhaust steam before removal through the opening or openings 21 which are placed at suitable points in the bottom of the condenser; and in the case of the water of condensation which falls to the bottom of the chambers 4, it will be brought into contact either with the hottest tubes or exhaust steam before removal. At any suitable point in the sections or chambers 4 and 5, as at 21, I provide an outlet or outlets for the water of condensation. When there are several of these, they may be connected by suitable piping running to a withdrawal pump.

Many changes may be made in the precise combination and arrangement of the various parts without going outside of the scope of the present invention. The construction may be multiplied several times so long as the results attained justify such increase in the construction and arrangement, and so long as the whole structure operates as a single unit. Obviously, moreover, the steam may not enter exactly at the top of the condenser, nor pass exactly in a vertical direction in either of the forms, but may pass obliquely or laterally; and one of the principal objects of the invention is reached when the steam entering at or near the top of the condenser is completely condensed into water which comes into contact with the steam before being removed, and when the air is cooled by tubes containing cooling water immediately before being removed by the dry vacuum pump. There may be a wide variation also in many of the details and peculiarities of construction, and I therefore reserve the liberty of modifying the invention in these respects, in order to secure the best results.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent, is:

1. In a surface condenser, the combination of a shell containing a central steam space provided at one end with an opening to the atmosphere, two groups or nests of water-cooled tubes at each side of the steam space, the members of said groups or nests being arranged in a horizontal series, one group at each side carrying the cooling water in one direction and the other in the opposite direction, so that one group of tubes is colder than its companion group, and means for introducing cooling water into the condenser at one end thereof and withdrawing it from the same end, whereby at each side of the condenser a return circulation of the water from one end of the condenser to the other end and back to the first end again is effected, and means at each side of the condenser for dividing the colder group from the warmer group of tubes and thus allowing the steam to pass from contact with one group into contact with the companion group.

2. In a surface condenser, the combination of a shell or frame, having a top inlet for the steam and a central inner steam space, the latter being provided with a free exhaust opening to the atmosphere and also with a manhole, two groups of tubes for the cooling water arranged at opposite sides of the steam space, and two other parallel companion groups for the cooling water alongside of the first-mentioned groups, the members of all of said groups of tubes being arranged in horizontal series, means for dividing the inner groups of tubes from the outer and providing an opening whereby the steam may pass from contact with the inner groups into contact with the outer groups, and means for introducing circulating water into said groups at one end of the condenser and withdrawing it from the same end of the condenser.

3. In a surface condenser, the combination with a steam motor, of a base therefor comprising condensing apparatus consisting essentially of a shell or frame into the top of which the steam passes from the motor, said shell having an inner steam space provided at one end with a free exhaust opening into the atmosphere and also with a manhole, groups or nests of tubes at opposite sides of the steam space, groups or nests of tubes parallel to the first-mentioned groups, and means for introducing circulating water at one end of the condenser first into the outer groups or nests of tubes and withdrawing it at the same end of the condenser from the inner groups or nests of tubes, whereby a return circulation is effected, the water flowing from one end of the condenser to the other end and back to the first end at each side of the steam space.

4. In a surface condenser, the combination with a steam motor, of a base therefor comprising condensing apparatus consisting essentially of a shell having an inner steam space which first receives the steam at the top from the motor, said steam space being furnished at one end with an exhaust opening to the atmosphere and also with a man-

hole, two parallel groups or nests of tubes at each side of the steam space, the members of said groups or nests being arranged in a horizontal series and separated from each other by dividing means which allows the steam to pass from the inner group to the outer group, means for introducing circulating water first at one end of the condenser into the outer groups of tubes and allowing it to traverse the length of the condenser and return through the inner groups of tubes so that it may be removed from the same end of the condenser where it enters, said end being opposite to the location of the exhaust opening and the manhole, whereby a return circulation of the water is effected, said water being colder in its first pass on each side of the condenser than it is in its second return pass.

5. In a surface condenser, the combination with a steam motor, of a base therefor comprising condensing apparatus consisting essentially of a shell having an inner steam space receiving the exhaust steam at the top from the motor, groups of water-cooled tubes at each side of said steam space, other groups of water-cooled tubes alongside the first-mentioned groups and parallel thereto, the groups at each side of the steam space being in a horizontal series, individual chambers at one end of the condenser belonging to each group of tubes, other chambers at the opposite end of the condenser arranged so that each chamber is common to two groups, means for introducing circulating water at one end of the chamber and removing it at the same end, so that the water may make one pass through a group of tubes at each side of the steam space and return to the first end of the condenser through the companion group, substantially as described.

6. In a surface condenser, the combination of a shell or frame, means for dividing it into sections or chambers, there being a pair of such chambers at each side of the shell, the chambers communicating with each other, groups or nests of horizontal tubes containing cooling water and arranged in a horizontal series in the said chambers, together with a horizontal series of water chambers at one end of said groups of tubes, other chambers at the opposite ends connecting the tubes of two groups, means for introducing cooling water into the said groups of tubes so that it will make a pass through one group at each side and return through the companion group at the same side, cooling water thus being introduced into and withdrawn from the condenser at the same end, while the other end is left free and is provided with a non-condensing exhaust opening and an access opening for the interior, and a steam space within the shell intermediate between the inner nests or groups of tubes, the circulation of the cooling water being a return circulation on each side of the steam space and passing from one end of the condenser to the opposite end thereof and then back again to the first end on the same side of the steam space.

7. In a surface condenser for the condensation of exhaust steam and the production of a vacuum, the combination of a chamber having an inlet at or near the top for the admission of exhaust steam, a chamber having an inlet at or near the bottom for the admission of exhaust steam coming from the first chamber, condensing surfaces in the chambers, those in one chamber being colder than those in the other, means for introducing cooling water from below first to the cooling surfaces of one chamber, said cooling surfaces of the two chambers being arranged in a horizontal series, the latter combination operating so that the air may be brought into contact with the coldest surfaces before removal and the water of condensation may be brought into contact with the exhaust steam before removal, the circulation of the cooling water being from one end of the condenser to the opposite end thereof and back again to the first end of the condenser on the same side of the steam space.

8. In a surface condenser for the condensation of exhaust steam and the production of a vacuum, said condenser having horizontal tubes containing cooling water, said tubes arranged in groups or nests, some of which are colder than the others, said groups or nests being arranged in a horizontal series, the combination of a chamber having an inlet above for the exhaust steam, in which chamber the exhaust steam, the air commingled therewith and the water of condensation all travel together in the same direction, with a chamber having an inlet for the exhaust steam below, in which chamber the exhaust steam and the air commingled therewith both travel in a reverse direction to that of the water of condensation, the coldest tubes being in the second chamber contiguous to the point where the air is removed, so as to bring the air into contact with said coldest tubes before removal and the water of condensation into contact with the exhaust steam before removal, the circulation of the cooling water being a double return circulation on each side of the steam space, the water passing from one end of the condenser to the other end and then back again to the first end on the same side of the steam space.

9. In a surface condenser, the combination with a steam motor, of a base therefor comprising condensing apparatus consisting essentially of divisions or chambers having nests of horizontal tubes containing cooling water, said nests being arranged in a hori-

zontal series, one of said chambers being a top-steam-inlet chamber and another being a bottom-steam-inlet chamber, means for dividing these chambers from each other so that the exhaust steam may pass readily from one to the other, the said means directing the steam away from the outlet for the air, means for bringing the cooling water in at the bottom and withdrawing it at the top at the same end of the condenser and causing a water circulation through the tubes, and means for withdrawing the air from the condenser in such a manner that the air may be brought into contact with the coldest surfaces before removal and the water of condensation may be brought into contact with the exhaust steam before removal.

10. In a surface condenser, the combination with a steam motor, of a base therefor comprising condensing apparatus consisting essentially of a chamber having an inlet above for the exhaust steam, in which chamber the exhaust steam, the air commingled therewith and the water of condensation all travel together in the same direction, and a second chamber which receives the exhaust steam below from the first chamber, in which second chamber the exhaust steam and the air commingled therewith both travel in a direction the reverse of that in the first chamber, nests of tubes in the two chambers which vary as to coldness, said nests being located in a horizontal series and provided at one end with a horizontal series of individual water chambers, and at the other end with water chambers connecting two groups together, means for dividing the condensing chambers from each other, said means directing the steam away from the outlet for the air, means for introducing the circulating water from below at one end of the condenser and removing it from above at the same end, all the parts being arranged so that the air may be brought into contact with the coldest surfaces before removal and the water of condensation into contact with the exhaust steam before removal.

11. In a surface condenser having nests of horizontal tubes containing cooling water, which nests are situated in a horizontal series, a section in which the exhaust steam enters above, in combination with another section in which the exhaust steam enters below after leaving the first section, means for introducing the circulating water below at one end of the condenser and removing it above at the same end, water chambers arranged in horizontal series at the water inlet end of the condenser, there being one chamber for each nest of tubes, and a water chamber at the opposite end of the condenser common to two nests so that the water therein may pass from one nest to the other, all arranged so that the air separated from the exhaust steam may be brought into contact with the coldest tubes in the second condensing chamber by the removal while the water of condensation is brought into contact with the exhaust steam before removal.

12. In a surface condenser, a shell having a steam inlet at or near the top and an air exit at or near the top separate from the steam inlet, in combination with a partition directing the steam away from the air exit and dividing the shell into two communicating chambers, together with nests of tubes situated in said chambers in a horizontal series, in one of which chambers the steam, the commingled air and the water of condensation travel together in the same direction, and in the other of which the steam and the commingled air travel in a direction opposite to that of the travel of the water of condensation, water chambers arranged in a horizontal series at one end of the condenser, there being one chamber for each nest of tubes, and a water chamber at the opposite end of the condenser connecting two nests of tubes.

13. In a surface condenser, a shell having a steam inlet at or near the top and an air exit at or near the top separate from the steam inlet, in combination with a partition directing the steam away from the air exit and dividing the shell into two communicating chambers, a nest of tubes in each chamber, said nests being arranged in a horizontal series, means for introducing circulating water into the condenser at one end below and withdrawing it from above at the same end, water chambers at one end of the condenser arranged in a horizontal series, one serving as an inlet chamber in conjunction with one nest of tubes, and the other serving as an outlet chamber in conjunction with the other nest of tubes, and a water chamber at the opposite end of the condenser serving to connect the two nests of tubes, all arranged so that the air may be brought into contact with the coldest tubes in the second chamber before removal and the water of condensation may be brought into contact with the exhaust steam before removal.

14. In a surface condenser, the combination with a steam motor, of a base comprising condensing apparatus consisting essentially of divisions or chambers containing nests or groups of tubes containing cooling water, said nests or groups being arranged in a horizontal series, and said divisions or chambers primarily receiving the exhaust steam and air commingled therewith at or near the top of the condenser and which provide exit for the air separate from the steam at or near the top of the condenser, means for introducing the cooling water

otherwise as desired. Hence the nests 8 and 9 lie in the same horizontal plane or are situated in a horizontal series. The chambers 10 and 11 are separated from each other by vertical partitions 17, and hence these chambers may be viewed as located in the same horizontal plane or in a horizontal series. The water supply pipe 13 first delivers water through the bottom inlet openings 12 into the chambers 11 which are the outside chambers, and thence it passes into the nests of tubes 9 which are the outside nests, making these outside nests consequently the colder nests, and flows through them to the other end of the condenser, where it fills the chambers 17 and passes thence into the other tube nests 8, returning therethrough to the end of the condenser from which it started, and entering the inside chambers 10 it finds exit from the apparatus through the connection 15 and outlet 16. Thus it will be seen that by this construction and arrangement the water makes one pass from the water inlet end of the condenser to the opposite end, and one pass back to the inlet end again, or in all two passes; and as this is done on both sides of the condenser, or in other words as the construction is duplicated, I find it convenient to express the operation as a double two-pass distribution of the circulating water accomplished through the medium of a horizontal series of distinct nests of tubes. In this way, the water from the circulating pump is divided into two parts after it is introduced through the inlet 14, one part going to one side of the condenser shell, and the other part going to the other side, each part making two passes through the shell and coming back to the end of the condenser whence it started, so that I am enabled in this manner to cause the circulating water to enter and leave at the same end of the condenser, which is an important object, since it keeps both the openings, the inlet and the outlet, at one end of the condenser, and enables the other end of the condenser to be utilized for other things, and also eliminates the necessity of any channels or connections of any kind at the other end of the condenser. In the present example of the invention, I place at the other end of the condenser an exhaust opening 18 available for use when the engine is to be run non-condensing, and likewise a manhole 19 for permitting access to the interior of the condenser shell.

The accomplishment of the object of having the water enter and leave at the same end of the condenser is only possible where there is an even number of passes. In a condenser which may be called a single two-pass condenser, or one where the water entering at one end of the condenser flows through one tube nest on one side of an inner steam space to the other end and returns to the first end through a second nest on the other side of said steam space, it is usually necessary to provide piping at the other end to connect the two nests, so that the water can flow from the end of one pass to the end of the other pass, and this piping, thus necessitated, obstructs the openings that are desirably placed on that end of the shell of the condenser, as 18 and 19 already referred to. Such a single two-pass condenser would be one having merely two nests, as 8, 8, whose ends opposite to the water inlet would have to be connected by piping as stated. Another form where there is an even number of passes is what may be termed a single four-pass condenser where the water passes through one nest from the inlet end to the other end of the condenser, and then returns through a second nest; it then passes through a third nest from the inlet end to the other end of the condenser and finally back again through a fourth nest; but here there is a large amount of frictional resistance to the flow of the required amount of the water through four passes. This resistance is eight times as great as it is in my double two-pass condenser; or, in other words, in my improvement, the friction is only one-eighth of what it is in a single four-pass condenser. With my form which I designate a double two-pass condenser, there is a great reduction in the resistance to the flow; while at the same time the other end of the condenser is kept free for the convenient location of the non-condensing and manhole openings.

The operation is as follows: The steam from the turbine or other motor, as 25, passes down through the cylindrical inlet 3 and enters the central steam space 4, there coming into contact with the tube nests 8 and being partially condensed. The steam then flows through the openings 7 into the sections 5 and comes into contact therein with the tube nests 9 where the rest of the steam is condensed. As the cooling water flows first in the arrangement I have described into the outer tubes 9, it is evident that they are cooler than the tubes 8, and are in fact the coldest surfaces in the condenser. In the central exhaust steam space or the sections or chambers 4, therefore, it must be observed that the exhaust steam, the air commingled therewith, and the water of condensation all travel in a downward direction; whereas in the sections or chambers 5, the exhaust steam, and the air commingled therewith both travel in a direction the reverse of that of the travel of the water of condensation. At suitable points in the walls of the condenser frame 1, proximate to the coldest condensing surfaces,—that is to say, for an example, at certain points in the walls of the sections or chambers 5 adjoining the coldest