July 22, 1924. 1,502,256

W. LONSDALE

CONDENSER

Filed Oct. 3, 1922 4 Sheets-Sheet 1

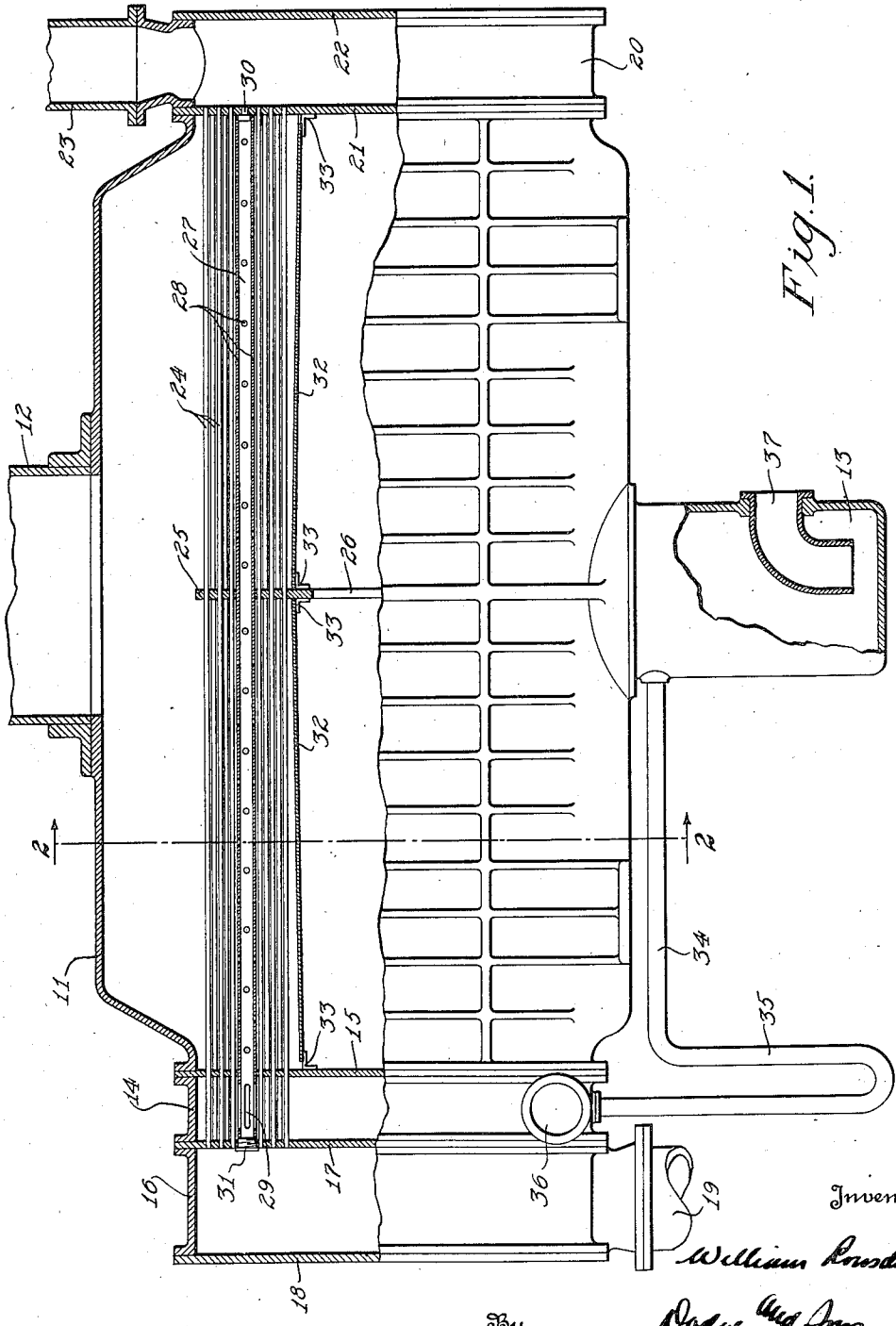

Fig. 1.

Inventor

William Lonsdale

By Dodge Mud Sons

Attorneys

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W. LONSDALE

CONDENSER

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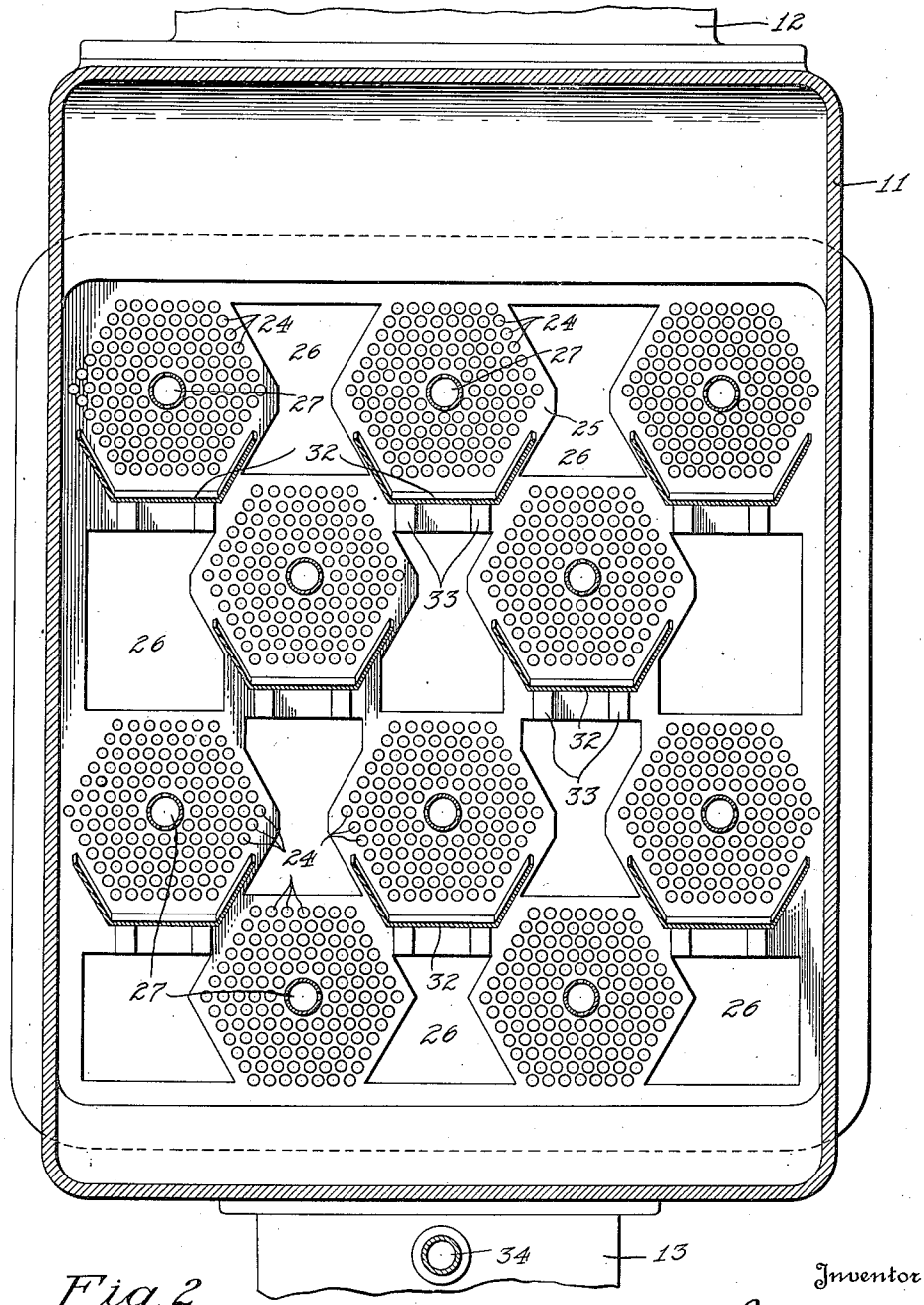

Fig. 2.

Inventor

William Lonsdale

By Dodge Mud Dms.

Attorneys

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W. LONSDALE

CONDENSER

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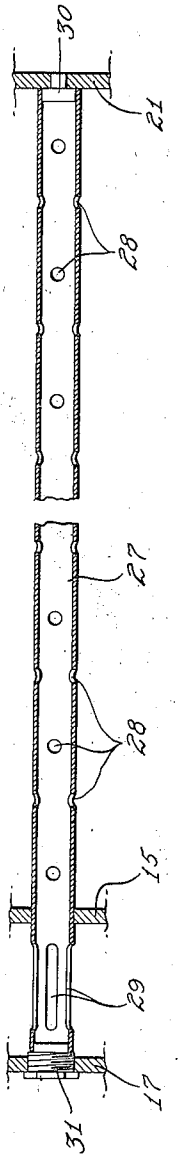

Fig. 3.

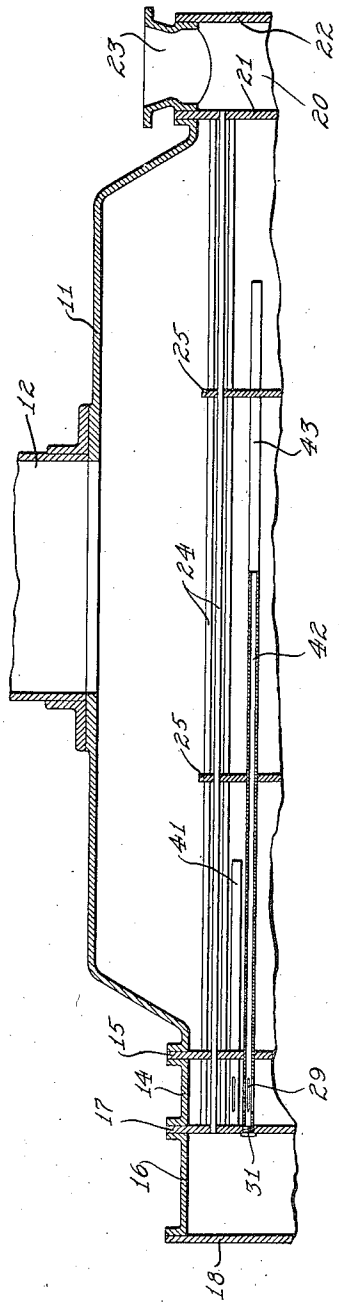

Fig. 4.

Inventor

William Lonsdale

By Osdyr and Ins.

Attorneys

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W. LONSDALE

CONDENSER

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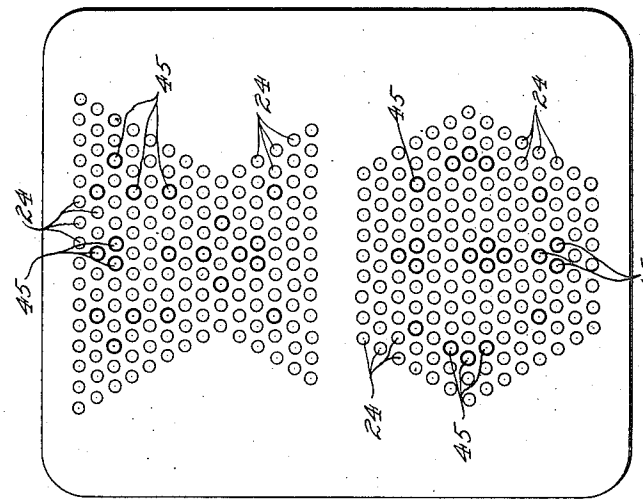

Fig. 6.

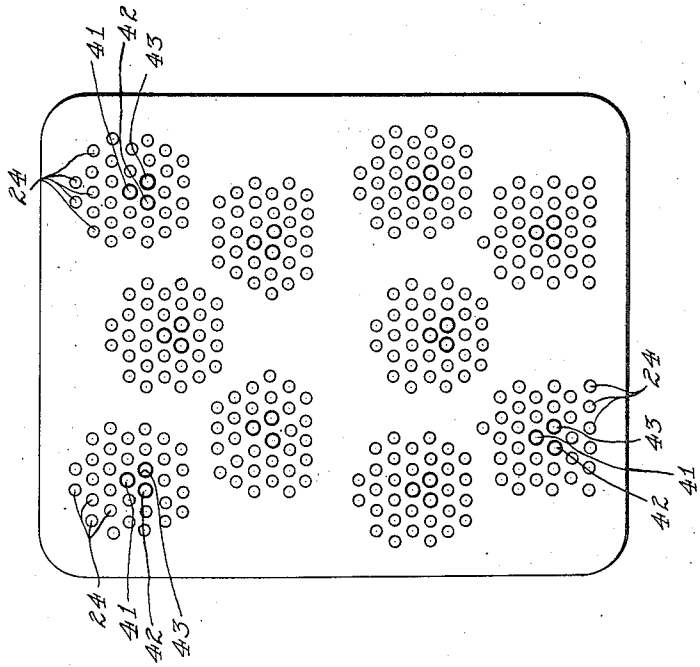

Fig. 5.

Inventor

William Lonsdale

By Dodge Bug & Sons

Attorneys

Patented July 22, 1924. 1,502,256

UNITED STATES PATENT OFFICE.

WILLIAM LONSDALE, OF ROSELLE PARK, NEW JERSEY, ASSIGNOR TO WHEELER CONDENSER & ENGINEERING COMPANY, OF CARTERET, NEW JERSEY.

CONDENSER.

Application filed October 3, 1922. Serial No. 592,174.

To all whom it may concern:

Be it known that I, WILLIAM LONSDALE, a citizen of the United States, residing at Roselle Park, in the county of Union and State of New Jersey, have invented certain new and useful Improvements in Condensers, of which the following is a specification.

This invention relates to surface condensers, the fundamental object of the invention being to approximate the results secured by the theoretically ideal, single tube condenser.

In surface condensers it has been found difficult and, in fact, practically impossible to secure uniform flow of the exhaust steam entering the condenser to all parts of the cooling surface. Furthermore, it has been found difficult to prevent undue cooling of the condensate if sufficient cooling surface is provided to insure adequate cooling of the non-condensible gases always present in exhaust steam.

The present invention involves subdivision of the cooling surface in the condenser into a plurality of units, each of which is designed to condense the steam received by it completely, without unduly chilling the condensate. Each such unit is provided with individual means for withdrawing the non-condensible gases, and may be further provided with individual means for collecting the condensate. The condensate so collected can thus be discharged into the hot well, with little or no further contact with any cooling surface in the condenser. The non-condensible gases are withdrawn through a cooler which, in the broad aspects of the invention, may form a part of the condenser itself or may be entirely external thereto.

The effect is so to coordinate the flow of condensible vapor, non-condensible gases and condensate within the condenser that the exhaust steam is subjected to cooling action only sufficient to produce complete condensation, the condensate and the non-condensible gases being immediately separated and each subjected to characteristically different treatment consonant with high thermal efficiency.

Differently considered the improved condenser may be said to comprise a single shell which houses a plurality of units, each made up of a cooling element, a closely associated offtake for air and, in some cases, also a condensate collecting tray, the various trays discharging into the hot well of the condenser and the air offtakes being connected through a common manifold to the air pump. This insures short flow-paths for the condensible vapor, and consequently also for the condensate, in contact with the cooling elements, precludes the accumulation of condensate in contact with cooling elements, insures the immediate separation of the air and the condensate and hence permits cooling of the air without abstraction of heat from the condensate. This last feature is of importance because, the heat of the liquid of the condensate is not wasted, and yet the air is chilled on its way to the air pump securing the well recognized gain in air pump efficiency.

In the drawings, I illustrate several specifically different embodiments of the invention.

Fig. 1 is a side view of a condenser partly in elevation and partly in section. In this view only one tube cluster is shown in order to avoid confusion.

Fig. 2 is a section on the line 2—2 of Fig. 1 and in this view all the tube clusters are shown.

Fig. 3 is an enlarged fragmentary view, showing one vacuum tube in longitudinal section.

Fig. 4 is a fragmentary view, similar to Fig. 1, illustrating an alternative construction in which three vacuum tubes, differing in length, are used.

Fig. 5 is a tube sheet diagram, illustrating the arrangement of the water and vacuum tubes in the structure of Fig. 4.

Fig. 6 is a tube sheet diagram for a condenser of the type in which only two tube clusters are used. Each cluster is provided with a plurality of vacuum tubes some of which are arranged individually and others of which are arranged in clusters.

Referring first to Figs. 1, 2 and 3, the condenser shell is indicated at 11, the exhaust steam inlet at 12 and the hot well at 13. The parts above mentioned are all of usual construction. Annular casting 14 is the shell of the vacuum chamber, which serves as the manifold of the vacuum tubes hereafter described. This chamber is separated from the interior of the condenser shell by the separator plate 15, which, as

hereafter described, is drilled to permit the water tubes and the vacuum tubes to extend through the plate. The inlet water-box shell is shown at 16, and at 17 is shown the tube sheet in which the ends of the water tubes are fixed and through which they communicate with the interior of the water-box. The plate 18 is the head closing the end of the water-box. The cooling water enters at 19. At the opposite end of the condenser is the outlet water-box, whose shell is indicated at 20. The tube sheet is shown at 21 and the head at 22. The cooling water flows out at 23.

The water tubes, which are of the usual form, are shown at 24. They are fixed at their ends in the tube sheets 17 and 21 and pass through holes provided for the purpose in the separator plate 15. They need not make tight fits with this plate as the complete isolation of the vacuum chamber within the shell 14 from the condensing space within the shell 11 is not necessary. The tubes 24 are supported at their mid-lengths by means of a supporting plate 25, and in the particular embodiment chosen for illustration the tubes are arranged in clusters hexagonal in contour.

In the spaces intervening between the clusters of tubes the supporting plate 25 is provided with openings or ports 26 so that the plate 25 does not separate the ends of the condenser from each other.

At or near the center of each cluster of tubes 24 is what I call a vacuum tube 27. These tubes, at their right ends (with reference to Fig. 1), fit over a plug or stud 30 fixed in the tube sheet 21, and at their left ends are similarly held by a threaded plug 31 screwed into the tube sheet 17. The tubes 27, at short intervals throughout their length within the condensing chamber, are provided with ports or openings 28 which are shown round but may be of any shape preferred. It is important that the openings 28 be of sufficient size to prevent their being blinded by condensate flowing over the exterior of the tube. Between the tube sheet 17 and the separator plate 15 the tubes 17 are formed with elongated slot-like ports 29. Thus the tubes form connections leading from the interior of each cooling tube cluster within the condensing space to the vacuum chamber or air pump manifold.

Mounted beneath each tube cluster except the lowest is a tray 32, which is supported in longitudinally inclined position by angle brackets 33 riveted respectively to the separator plate 15, the supporting plate 25 and the tube sheet 21. These troughs may be inclined, as shown, to feed the condensate toward the ends of the condenser or, if preferred, they may be reversely inclined to feed the condensate toward the middle of the condenser. In either case the trough is made short enough to leave an interval at its lower end through which the condensate discharges, so that it flows down to the bottom of the condenser shell 11 and to the hot well. It will be observed that where the water tube clusters are in staggered relation, as shown in Fig. 2, part of the condensate will flow against the end portions of the water tubes of lower clusters, but this contact is comparatively slight and is not sufficient to have any appreciable cooling effect on the condensate. Obviously any desired means might be adopted to prevent such contact, if deemed desirable.

In order to return to the hot well any condensed steam which might otherwise tend to collect in the vacuum chamber or air pump manifold, the connection 34, having the siphon trap 35, is provided between the bottom of the vacuum chamber and the hot well. The air pump (not shown) is connected at 36 so that the pump draws directly from the interior of the vacuum chamber which as stated serves as a manifold for the vacuum tubes. The condensate pumps are connected at 37 to draw condensate from the hot well 13.

The general operation of the condenser above described will be obvious to those skilled in the art and hence it is necessary only to point out important novel operative characteristics.

The exhaust steam entering through the connection 12 flows around the clusters of tubes 24 and since the air pump is withdrawing air from the vacuum chamber through the connection 36 and since the interior of the vacuum chamber is in connection with the middle of each tube cluster by means of the perforated vacuum tubes 27, there is a constant tendency for the mixture of steam and air entering through the exhaust connection 12 to flow to the center of each tube cluster.

In this flow the condensible vapor or steam is condensed and showers into the corresponding trough 32. At the same time the air is cooled and is withdrawn through the vacuum tube 27. The condensate discharging from the low end of the troughs 32 flows to the bottom of the condenser shell 11 and thence to the hot well 13 so that the condensate does not remain in contact with any cooling surface in the condenser for any material length of time after it has showered from the tube cluster in which it was condensed. Therefore, it becomes possible to proportion the tube clusters, as to size of tube and the number of tubes in each cluster, so as to condense the steam completely without materially over-cooling the condensate.

The use of clusters of a generally circular or hexagonal contour with the vacuum tube at the center of the cluster is advan-

tageous. It reduces the number of vacuum tubes by increasing the number of cooling tubes which one vacuum tube will serve. It provides a diminishing flow path for fluids flowing toward the vacuum tube and undergoing progressive condensation. It affords convenient intercluster flow paths and allows the clusters to be accurately proportioned to the duty imposed on each.

Furthermore, it is possible to cool the non-condensible gases as they flow from the condenser. This cooling action is pronounced at or near the point of entrance to the vacuum tube 27, for the vacuum tube, being at the center of the cooling cluster, is at a point of low temperature. Furthermore, since the vacuum chamber is adjacent to the inlet water-box and, in a single pass condenser such as is illustrated, is traversed by the entrance end of all the water tubes, it is necessarily maintained at a very low temperature. Consequently the outflowing air is subjected to a further and pronounced cooling action within the vacuum chamber, as it flows to the outlet connection 36. A similar, but perhaps less pronounced, cooling effect would be had in condensers in which the water makes two or more passes and no limitation to single-pass arrangement is implied.

Obviously, various different arrangements of the vacuum tubes may be made, and I wish particularly to call attention to that illustrated in Figs. 4 and 5. Here I make use of a plurality of vacuum tubes, three being shown. These tubes are indicated by the reference numerals 41, 42 and 43. These tubes are not perforated but each is open only at its end to the interior of the shell 11. If desired, however, the sides of the tubes might be perforated in whole or in part, in the manner characteristic of Fig. 1. Within the vacuum chamber, each tube is provided with a slot 29 so that the cluster of three tubes is, as a whole, functionally substantially identical with the single perforated tube 27 already described.

Various other types of tube will suggest themselves and the ones illustrated are chosen merely for purposes of explanation.

It is also to be noted that in the construction of Fig. 4 more than one supporting plate 25 is used, two being shown in this figure. These plates are provided with ports similar to the ports 26, described with reference to Figs. 1 and 2, so that they do not permit the formation of pockets at the ends of the condenser.

Fig. 5 shows clusters of three vacuum tubes, arranged at or near the centers of corresponding clusters of water tubes.

While I prefer to arrange the water tubes in a relatively large number of clusters, the cluster arrangement is not always essential and, in certain cases, it may be necessary to arrange the tubes in one or two large groups. Such an arrangement is shown in Fig. 6. Because of the size of the tube groups, it is desirable to use a large number of vacuum tubes. These tubes may be of the laterally perforated type, described with reference to Figs. 1, 2 and 3, or may be of the open-ended type, described with reference to Figs. 4 and 5, or both types of tubes may be used conjointly, the exact form of the vacuum tube not being material.

In Fig. 6 the water tubes are indicated by the reference numeral 24 and the vacuum tubes by the reference numeral 45. The vacuum tubes 45 are shown larger, and are indicated by heavier lines, than are the water tubes, and hence may be readily distinguished. It is contemplated that with the arrangement shown in Figs. 4, 5 and 6, as well as in the arrangement shown in Figs. 1, 2 and 3, use may be made of the condensate collecting trays 32 for upper clusters. Inasmuch as Figs. 5 and 6 are simply tube sheet diagrams, these trays do not appear in these figures and their use is not essential though commonly desirable.

While vacuum tubes, such as described are the best means known to me for accomplishing the desired result, it should be borne in mind that their chief function is to draw the non-condensible gases from a number of points throughout the length of the cooling tube clusters and thus distribute the cooling duty evenly throughout the lengths of the clusters and balance the duty as between different clusters. Any equivalent means for performing this function may be substituted.

It will be observed that condensers constructed according to my invention conform closely to standard practice so that it is possible to modify existing designs, or even existing condensers, to convert them to the improved type forming the subject of the present application.

What is claimed is:—

1. A surface condenser of the water tube type comprising in combination a shell, water tubes arranged in a plurality of clusters within said shell and spaced therefrom and from each other to permit the entrance of gases and vapors from all sides of the various clusters; a plurality of offtakes for non-condensible gases, said offtakes being surrounded by and positioned centrally among the tubes of corresponding clusters, and having inlet ports at points substantially throughout the length of said water tubes; and a manifold for said offtakes mounted within said condenser shell and arranged to be cooled by said tubes.

2. The combination with a condenser including a shell and water tubes traversing the space within said shell and arranged in clusters, of means dividing said space into a condensing chamber and a vacuum cham-

ber; both transversed by said tubes a suction connection leading from the vacuum chamber; and a plurality of relatively small ducts leading to the vacuum chamber from a plurality of points within the various tube clusters.

3. In a condenser, the combination of a closed shell having an inlet for exhaust steam and an outlet for condensate; a plurality of cooling tubes arranged in clusters within said shell; means for conducting cooling liquid to and from said tubes; individual condensate-collecting trays for each cluster of tubes arranged to feed condensate to the condensate outlet without substantial further contact with cooling tubes; a vacuum chamber having an outlet connection to an air pump; and vacuum tubes connected with said vacuum chamber, extending longitudinally within corresponding clusters of cooling tubes, and having entrance openings from the space within said shell at different points in the length of the cooling tubes.

4. In a condenser, the combination of a closed shell having an inlet for exhaust steam and an outlet for condensate; a plurality of cooling tubes arranged in clusters within said shell; means for conducting cooling liquid to and from said tubes; a vacuum chamber having an outlet connection to an air pump; cooling means in said chamber; and vacuum tubes connected with said vacuum chamber, extending longitudinally within corresponding clusters of cooling tubes, and having entrance openings from the space within said shell at different points in the lengths of the cooling tubes.

5. In a condenser, the combination of a closed shell having an inlet for exhaust steam and an outlet for condensate; a plurality of cooling tubes mounted within said shell; means for conducting cooling liquid to and from said tubes; a vacuum chamber having an outlet connection to an air pump; cooling means in said chamber; and vacuum tubes connected with said vacuum chamber and extending longitudinally in intervals between cooling tubes, and having entrance openings from the space within said shell adjacent different points in the lengths of the cooling tubes.

6. In a condenser, the combination of a closed shell having an inlet for exhaust steam and an outlet for condensate; a plurality of cooling tubes arranged in clusters within said shell; means for conducting cooling liquid to and from said tubes; a vacuum chamber having an outlet connection to an air pump; cooling means in said chamber; and vacuum tubes connected with said vacuum chamber, extending longitudinally within corresponding clusters of cooling tubes, and having entrance openings from the space within said shell at different points in the lengths of the cooling tubes.

7. In a condenser, the combination of a shell constructed and arranged to form chambers in the following order, water-box chamber, vacuum chamber, condensing chamber, water-box chamber; water tubes extending between the water-box chambers and through the vacuum chamber and condensing chamber; ducts leading from a plurality of points in the condensing chamber to the vacuum chamber; a steam inlet to the condensing chamber; a condensate outlet serving to conduct condensate from the condenser; an air pump connection leading from the vacuum chamber; and water connections for the water-boxes.

8 In a condenser, the combination of a shell constructed and arranged to form chambers in the following order, water-box chamber, vacuum chamber, condensing chamber, water-box chamber; water tubes extending between the water-box chambers and through the vacuum chamber and condensing chamber; ducts leading from a plurality of points in the condensing chamber to the vacuum chamber; a steam inlet to the condensing chamber; a condensate outlet serving to conduct condensate from the condenser; an air pump connection leading from the vacuum chamber; and water connections to and from the water-boxes, constructed and arranged to produce flow from the first named water-box to the second whereby the vacuum chamber is maintained at the lowest available temperature.

9. In a condenser, the combination of a shell constructed and arranged to form chambers in the following order, water-box chamber, vacuum chamber, condensing chamber, water-box chamber; water tubes extending between the water-box chambers through the vacuum chamber and condensing chamber and arranged in clusters spaced from each other and from said shell; ported offtake pipes communicating with said vacuum chamber and extending longitudinally within corresponding clusters near the centers thereof; a steam inlet to the condensing chamber; a condensate outlet from the condenser; an air pump connection leading from the vacuum chamber; and water connections for the water-boxes.

In testimony whereof I have signed my name to this specification.

WM. LONSDALE.