Nov. 21, 1933. T. TINKER ET AL 1,935,864

SURFACE CONDENSER

Filed Jan. 13, 1932 4 Sheets-Sheet 1

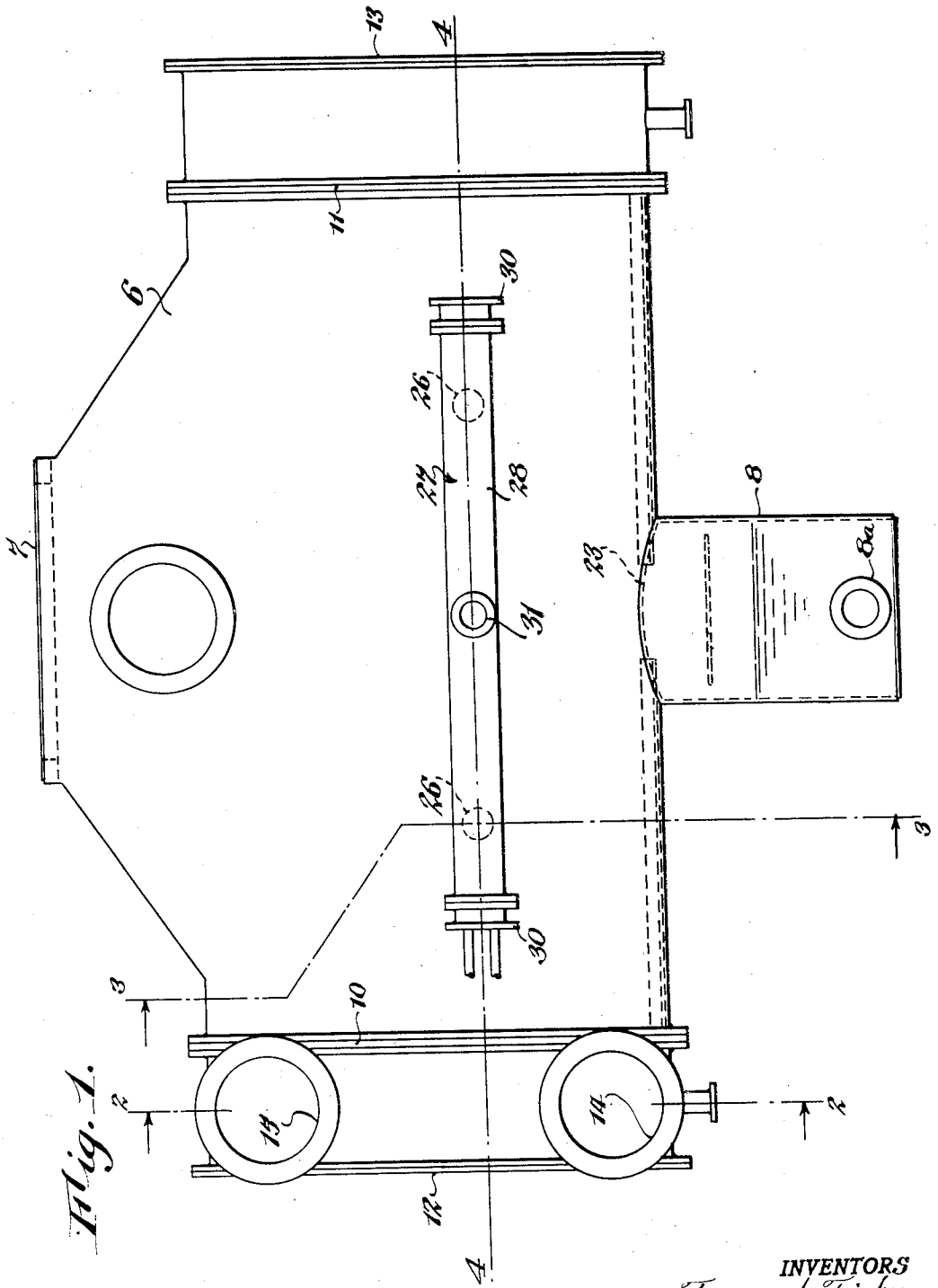

Fig. 1.

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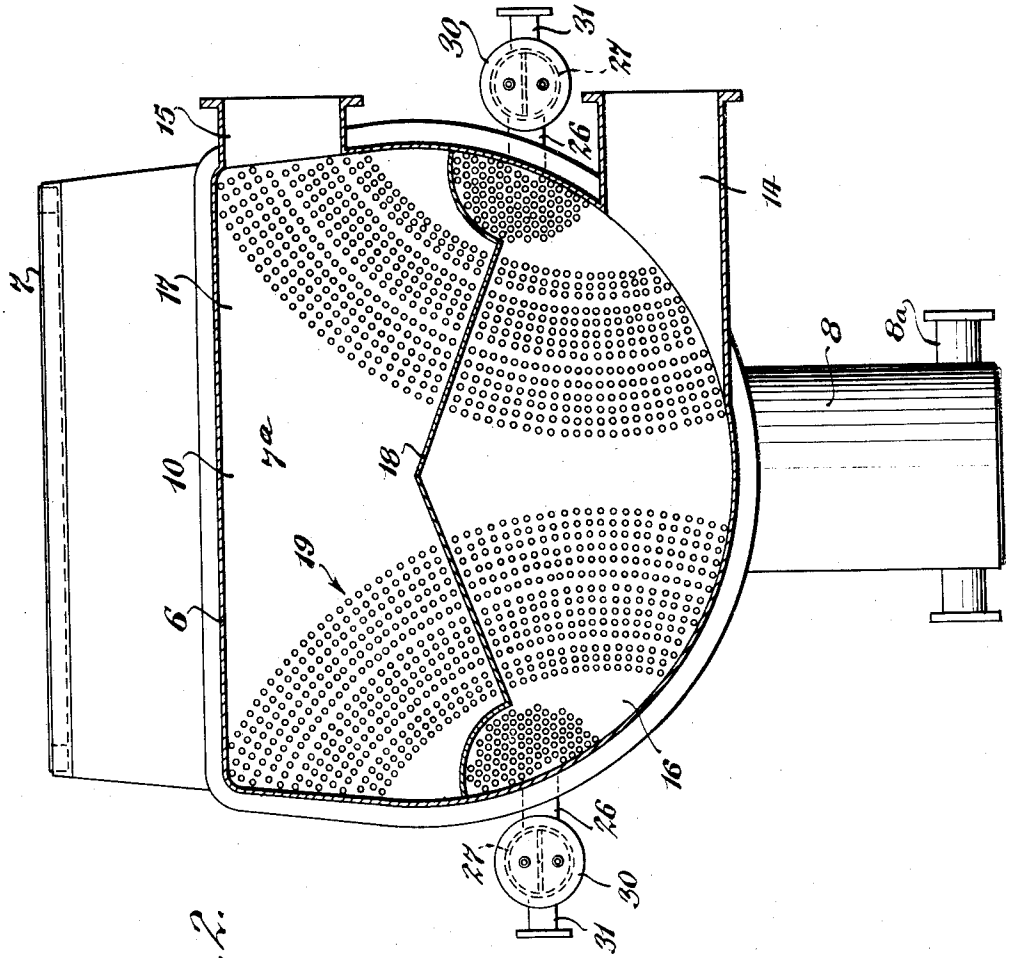

Fig. 2.

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SURFACE CONDENSER

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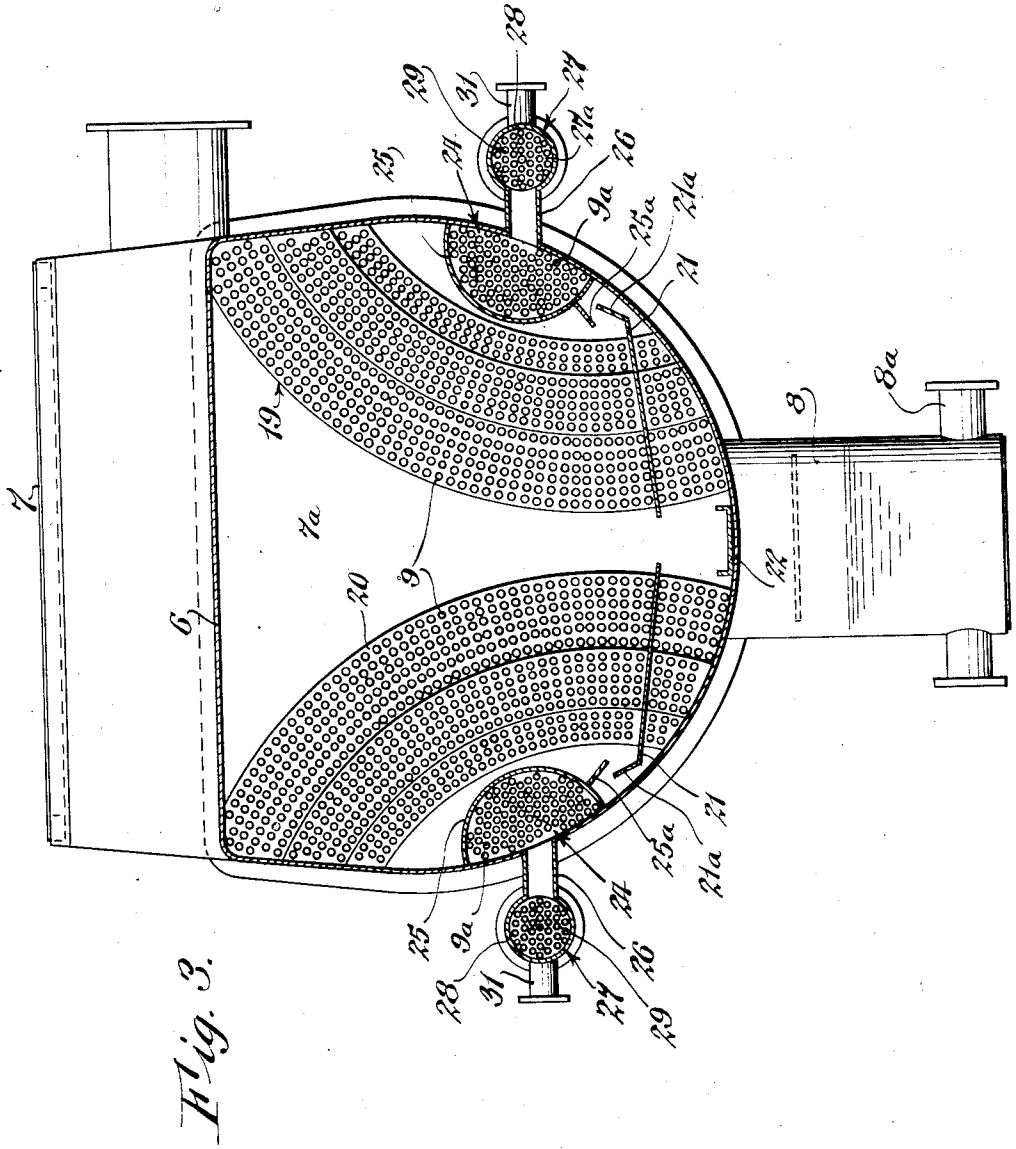

Fig. 3.

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SURFACE CONDENSER

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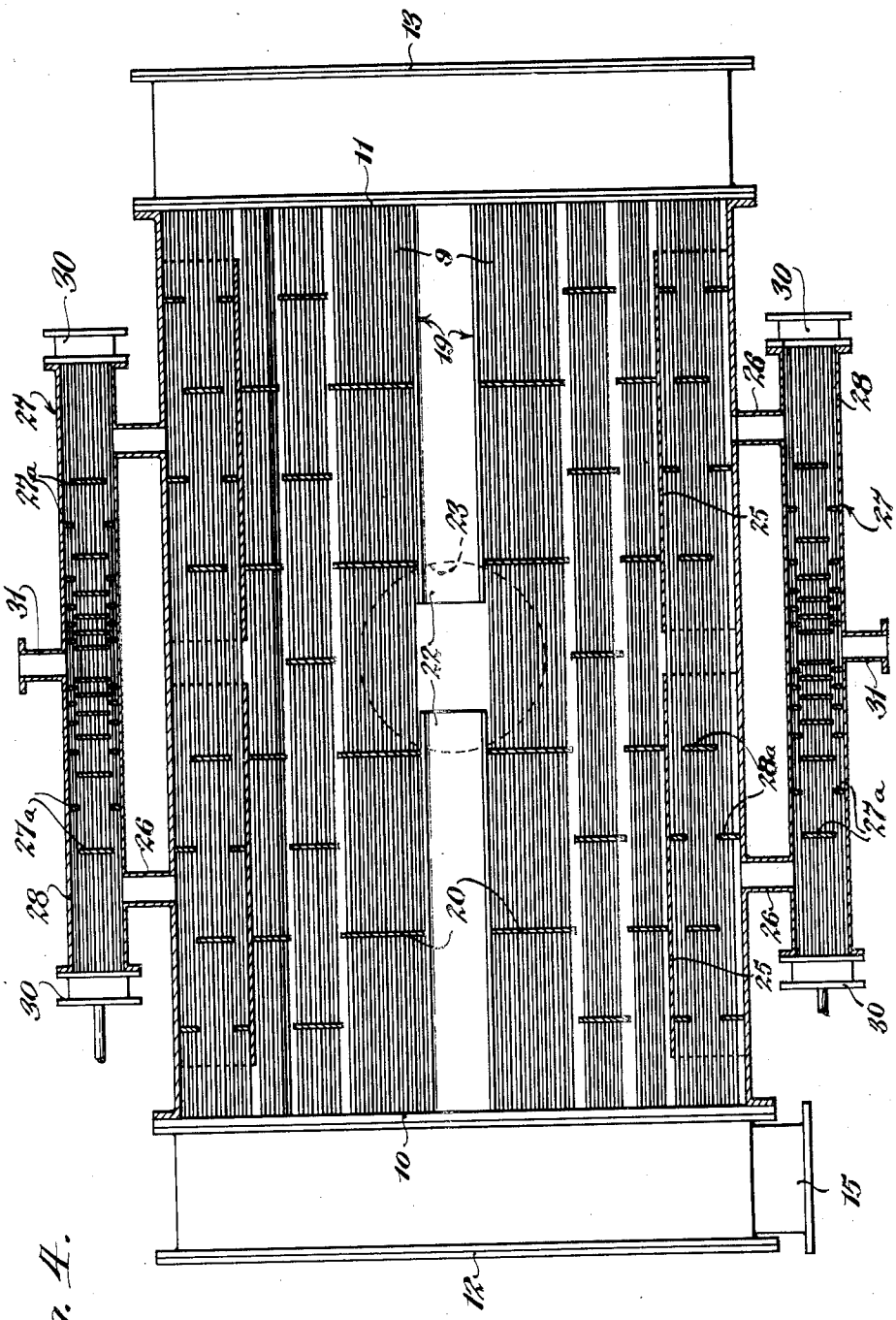

Fig. 4.

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UNITED STATES PATENT OFFICE

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SURFACE CONDENSER

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Application January 13, 1932. Serial No. 586,344

13 Claims. (Cl. 257—43)

This invention relates to improvements in surface condensers of the type in which condensing or cooling tubes are arranged longitudinally in a condensing chamber through which the vapor is caused to flow.

One object of the invention is a novel construction and arrangement of the parts of the condenser whereby the efficiency of the latter is of a high value owing to the relatively high temperature at which the condensate is withdrawn from the condenser, this object contemplating the use of the condensate as a cooling medium for a portion of the vapor which is delivered to the condensing chamber.

A further object is to provide a large cooling surface over which the vapor is substantially uniformly distributed.

A still further object is to provide for the recovery of a substantial part of the condensible constituents entrained by the air and other uncondensable vapors in order to enable the maintenance of a high vacuum in the condensing chamber.

The invention is illustrated in the accompanying drawings, in which:

Figure 1 is a side elevation of a condenser constructed in accordance with the invention.

Figure 2 is a vertical section taken along line 2—2 of Figure 1.

Figure 3 is a vertical section taken along line 3—3 of Figure 1.

Figure 4 is a longitudinal section taken along line 4—4 of Figure 1, the heads of the condenser being shown in elevation.

The condenser, as illustrated, includes an outer shell 6 of conventional form having a steam inlet 7 and a hot well 8 with an outlet connection 8*a* for the withdrawal of the condensate. The condensing chamber which is provided by the shell is traversed by tubes 9 and 9*a* which are connected at their outer ends to tube sheets 10 and 11. Heads 12 and 13 are secured against the tube sheets 10 and 11 respectively, the former being provided with an inlet 14 (see Figure 2) and an outlet 15 for the cooling medium. The inlet 14 communicates with an inlet chamber 16 which is separated from the outlet chamber 17 by a partition 18. The head 13 provides the usual single chamber. The tubes 9 extend through the condensing chamber and connect the chambers 16 and 17 of the head 12 to the single chamber provided by the head 13.

In accordance with the invention the tubes 9 are arranged in the condensing chamber in such a manner as to present a large cooling surface over which the vapor is substantially uniformly distributed. To this end the said tubes are arranged in two opposed arched banks 19. The latter are spaced from each other at the opposite sides of the condensing chamber and provide an inlet passage or chamber 7*a* which is in direct communication with the steam inlet and from which the steam may enter the spaces between the tubes in the banks. The banks 19 are so arranged that the width of the inlet passage or chamber is greatest at the sides of the banks adjacent the steam inlet, the said passage converging generally in the direction of the opposite sides of the banks. This arrangement has the advantage that the resistance offered to the flow of the steam is substantially uniform throughout the extent of the banks. Hence, the steam is apportioned substantially uniformly over the cooling surface provided by the tubes.

As best shown in Figures 3 and 4, the tubes of the two banks are supported within the shell by arcuate baffles 20. The latter are arranged to provide alternate pairs of spaced baffles between which single baffles are arranged, the latter being positioned opposite the spaces between the spaced baffles of the adjacent pairs so as to provide a tortuous path of flow for the vapor.

Among other factors, the efficiency of a condenser depends upon the temperature at which the condensate is withdrawn from the condensing chamber, it being advantageous that the temperature of the condensate be of a value as close to boiling point as practical. In the construction shown a part of the steam which is condensed by contact with the cooling tubes 9 is of a relatively low temperature. In accordance with the invention, this condensate is caused to come into intimate contact with a portion of the incoming vapor. To this end a baffle 21 is included in each bank of the tubes 9. The said baffles extend lengthwise of the condensing chamber and preferably slope downwardly in the direction of their adjacent sides so as to facilitate the flow of the condensate toward the inlet passage 7*a*. The adjacent sides of the baffles 21 extend into the inlet passage and the condensate, therefore, which falls upon the said baffles is conducted by the latter into the said passage and hence into the path of the incoming vapor. That portion of the vapor, therefore, which approaches the bottom of the passage 7*a* comes into contact with the condensate flowing from the baffles and heats the latter.

The adjacent sides of the baffles 21 extend over channel shaped troughs 22 which are arranged in the bottom of the condensing chamber in the

inlet passage 7a. At their inner ends, the troughs 22 terminate over the outlet opening 23 of the condenser (see Figures 1 and 4). In the operation of the condenser, the condensate from the baffles 21 is conducted to the troughs 22 and from the latter flows through the outlet opening into the hot well 8. The condensate thus collected may be withdrawn from the hot well through suitable connections 8a. It will be apparent that the troughs 22 provide the bottom of the passage 7a. Hence, that portion of the steam or vapor which approaches the bottom of the said passage comes into contact not only with the condensate flowing from the baffles 21 but also into contact with the condensate flowing along the troughs. The efficiency, therefore, of the condenser will be high owing to the high temperature of the condensate conducted to the hot well 8.

In the use of a condenser it is desired to maintain as high a vacuum as is practical in the condensing chamber and it is preferred, therefore, to effect the withdrawal of the air and uncondensed vapors from the condensing chamber as fast as they are introduced. The value at which the vacuum may be maintained is dependent among other factors upon the percentage of condensable vapors entrained by such air and uncondensable vapors. Those vapors which pass through the banks 19 include a substantial portion of condensable vapors. In order to recover such constituents means is provided within the condensing chamber for further treatment of such vapors. The said means, as illustrated, includes secondary tube banks 24, one of which is arranged behind each of the arched banks 19. The tubes 9a of the banks 24 are arranged throughout the greater portion of their length in passages provided by arcuate baffles or shields 25. As illustrated, two such baffles or shields are employed in connection with each secondary bank, the baffles or shields being spaced at their outer ends from the adjacent tube sheets and being spaced apart at their adjacent inner ends thereby providing entrances through which the air and uncondensed vapors enter the passages provided by the baffles. Deflectors 25a are carried by the arcuate baffles or shields 25. The said deflectors project over the outer sides of the baffles 21 and hence any condensate dripping from the upper tubes in the banks 19 upon the shields 25 is conducted by the deflectors to the baffles 21. The latter are preferably upturned at the outer sides as at 21a so as to insure flow of the condensate toward the passage 7a.

Outlet connections 26 are provided upon the shell intermediate the ends of the baffles or shields 25. By virtue of this construction the air and uncondensed vapors which have passed through the tube banks 19 in a direction substantially transverse of the condensing chamber are caused to flow through the passages provided by the baffles 25 in a direction substantially lengthwise of the said chamber. A tortuous course through the said passages is preferably provided by transverse baffles 28a, the latter being arranged in substantially the same manner as the baffles 20. From the passages provided by the shields 25 the uncondensed vapors pass by way of the outlet connections 26 to vapor coolers 27 which are carried upon the outer sides of the shell 6 and wherein a part of the remaining moisture is condensed.

Each of the vapor coolers, as illustrated, includes a cylindrical shell 28 which provides a cooling chamber in which cooling tubes 29 are arranged. The coolers also include the usual heads 30 by which the cooling medium is caused to flow through the tubes.

The coolers 27 are formed or provided with outlets 31 which are adapted to be connected to suitable evacuators for withdrawing the air and uncondensed vapors from the condensing chamber and for maintaining the desired vacuum in the said chamber. Baffles 27a are arranged in groups at each side of the outlet 31 between the latter and the connections 26, the said baffles comprising alternate rings between which are arranged the remaining baffles which are in the form of discs. It is preferred that the distance between the baffles in each of the groups progressively decrease from the connections 26 toward the outlet 31. By virtue of this construction the air and uncondensed vapors are maintained at a high velocity in their passage to the outlet 31, thereby facilitating the removal of a substantial part of the condensable constituents entrained in such vapors. The arrangement, therefore, has the advantage that it enables the maintenance of a high vacuum in the condensing chamber, thereby increasing the efficiency of the condenser.

From the foregoing, it will be apparent that the steam or vapor which is delivered to the condenser is distributed over a relatively large cooling surface, the efficiency of the condenser being increased by utilizing the condensate thus formed as a cooling medium for a portion of the incoming steam and by treating the uncondensed vapors to cool them and remove any entrained condensable constituents.

We claim as our invention:

1. A surface condenser including a casing which provides a condensing chamber and which is formed with an inlet to said chamber, banks of tubes arranged at opposite sides of said chamber, the tubes in said banks being arranged to provide a central passage which is in direct communication with said inlet and which in cross-section converges from the sides of the banks adjacent said inlet in the direction of their opposite sides, whereby the resistance to flow offered by said tubes to the vapor entering said chamber is substantially uniform throughout the extent of said banks and oppositely inclined baffles arranged lengthwise of said chamber for conducting condensate into said passage at a point above the bottom of said chamber so that it is utilized as a cooling medium for a portion of the incoming vapor, said baffles being located adjacent the bottom of said chamber and being inclined at such an angle that the condensate flows over them in a sheet-like film prior to its discharge into said passage.

2. A surface condenser including a casing which provides a condensing chamber and which is formed with an inlet to said chamber, opposed arched banks of tubes arranged in said chamber, the tubes in said banks being arranged to provide a central passage which is in direct communication with said inlet and which in cross-section converges from the sides of the banks adjacent said inlet in the direction of their opposite sides, whereby the resistance to flow offered by said tubes to the vapor entering said chamber is substantially uniform throughout the extent of said banks and oppositely inclined baffles arranged lengthwise of said chamber which are adapted to conduct condensate into said passage at a point above the bottom of said chamber so that it is utilized as a cooling medium for a portion of the in-

coming vapor, said baffles being located adjacent the bottom of said chamber and being inclined at such an angle that the condensate flows over them in a sheet-like film prior to its discharge into said passage.

3. A surface condenser including a casing which provides a condensing chamber and which is formed with an inlet to said chamber, banks of tubes arranged at opposite sides of said chamber, the tubes in said banks being arranged to provide a central passage which is in direct communication with said inlet and which in cross-section converges from the sides of said banks adjacent said inlet in the direction of their opposite sides, whereby the resistance to flow offered by said tubes to the vapor entering said chamber is substantially uniform throughout the extent of said banks, oppositely inclined baffles arranged lengthwise of said chamber for conducting condensate into said passage at a point above the bottom of said chamber so that it is utilized as a cooling medium for a portion of the incoming vapor and outlets in said casing behind said banks through which the air and uncondensed vapor are withdrawn from said condensing chamber, said baffles being located adjacent the bottom of said chamber and being inclined at such an angle that the condensate flows over them in a sheet-like film prior to its discharge into said passage.

4. A surface condenser including a casing which provides a condensing chamber and which is formed with an inlet to said chamber, banks of tubes arranged at opposite sides of said chamber, the tubes in said banks being arranged to provide a passage which is in direct communication with said inlet and which in cross-section converges from the sides of the banks adjacent said inlet in the direction of their opposite sides, whereby the resistance to flow offered by said tubes to the vapor entering said chamber is substantially uniform throughout the extent of said banks, baffles arranged lengthwise in said condensing chamber which are adapted to conduct condensate into said passage so that it is utilized as a cooling medium for a portion of the incoming vapor, said casing being formed with an outlet for the condensate and a trough arranged beneath said baffles for receiving the condensate from said baffles, said trough being adapted to conduct the condensate to said condensate outlet.

5. A surface condenser including a casing which provides a condensing chamber and which is formed with an outlet to said chamber, banks of tubes arranged at opposite sides of said chamber, the tubes in said banks being arranged to provide a passage which is in direct communication with said inlet and which in cross-section converges from the sides of said banks adjacent said inlet in the direction of their opposite sides, whereby the resistance to flow offered by said tubes to the vapor entering said chamber is substantially uniform throughout the extent of said banks, baffles arranged lengthwise of said condensing chamber which are adapted to conduct condensate into said passage so that it is utilized as a cooling medium for a portion of the incoming vapor, said casing being formed with an outlet for the condensate, a trough arranged beneath said baffles for receiving the condensate from said baffles, said trough being adapted to conduct the condensate to said condensate outlet, the condensate in said trough being exposed to the incoming vapor and other outlets formed in said casing behind said banks of tubes through which the air and uncondensed vapor are withdrawn from said condensing chamber.

6. A surface condenser including a casing which provides a condensing chamber and which is formed with an inlet to said chamber, opposed arched banks of tubes arranged at opposite sides of said chamber, the tubes in said banks being arranged to provide a passage which is in direct communication with said inlet and which in cross-section converges from the sides of said banks adjacent said inlet in the direction of their opposite sides, whereby the resistance to flow offered by said tubes to the vapor entering said chamber is substantially uniform throughout the extent of said banks, baffles arranged lengthwise of said condensing chamber which are adapted to conduct condensate into said passage so that it is utilized as a cooling medium for a portion of the incoming vapor, said casing being formed with an outlet for the condensate, a trough arranged beneath said baffles for receiving the condensate conducted to said passage and for conducting the condensate to said condensate outlet, the condensate in said trough being exposed to the incoming vapor and other outlets formed in said casing behind said banks of tubes through which the air and uncondensed vapor are withdrawn from said condensing chamber.

7. A surface condenser including a casing which provides a condensing chamber and which is formed with an inlet to said chamber, primary banks of tubes arranged at opposite sides of said chamber, the tubes in said banks being arranged to provide a passage which is in direct communication with said inlet and which in cross-section converges from the sides of said banks adjacent said inlet in the direction of their opposite sides, whereby the resistance to flow offered by said tubes to the vapor entering said chamber is substantially uniform throughout the extent of said banks, secondary banks of tubes arranged in said casing behind said primary banks, outlets behind said secondary banks through which the air and uncondensed vapor are withdrawn from said condensing chamber, shields encasing portions of said secondary banks of tubes for providing passages extending lengthwise of said condensing chamber, said outlets being so positioned relative to said shields that the vapor remaining after passage through said primary banks of tubes is caused to flow through said passages lengthwise of said chamber to said outlets.

8. A surface condenser including a casing which provides a condensing chamber and which is formed with an inlet to said chamber, primary banks of tubes arranged at opposite sides of said chamber, the tubes in said banks being arranged to provide a passage which is in direct communication with said inlet and which in cross-section converges from the sides of said banks adjacent said inlet in the direction of their opposite sides, whereby the resistance to flow offered by said tubes to the vapor entering said chamber is substantially uniform throughout the extent of said banks, secondary banks of tubes arranged in said casing behind said primary banks, outlets behind said secondary banks through which the air and uncondensed vapors are withdrawn from the condensing chamber, shields encasing portions of said secondary banks of tubes for providing passage which extend lengthwise of said condensing chamber, said outlets being so positioned relative to said shields that the vapor remaining after passage through said primary banks of tubes is caused to flow through said passages lengthwise of said

chamber to said outlets and baffles in said passages for causing the vapor to traverse a sinuous course therethrough.

9. A surface condenser including a casing which provides a condensing chamber and which is formed with an inlet to said chamber, opposed arched banks of tubes arranged at opposite sides of said chamber, said banks of tubes providing a passage which is in direct communication with said inlet and which in cross-section converges from the sides of said banks adjacent said inlet in the direction of their opposite sides, whereby the resistance to flow offered by said tubes to the vapor entering said chamber is substantially uniform throughout the extent of said banks, secondary banks of tubes arranged in said casing behind said arched banks of tubes, outlets in said casing behind secondary banks of tubes through which the air and uncondensed vapor are withdrawn from said condensing chamber and shields over said secondary banks of tubes for providing passages extending lengthwise of said chamber, said outlets being so arranged relative to said shields that the vapor remaining after passage through said arched banks of tubes is caused to flow through said passages lengthwise of said chamber to said outlets.

10. A surface condenser including a casing which provides a condensing chamber and which is formed with an inlet to said chamber, opposed arched banks of tubes arranged at opposite sides of said chamber, said banks being arranged to provide a passage which is in direct communication with said inlet and which in cross-section converges from the sides of said banks adjacent said inlet in the direction of their opposite sides, whereby the resistance to flow offered by said tubes to the vapor entering said chamber is substantially uniform throughout the extent of said banks, secondary banks of tubes arranged in said casing behind said arched banks, outlet openings in said casing behind said secondary banks through which the air and uncondensed vapors are withdrawn from said chamber, shields over said secondary banks of tubes for providing passages extending lengthwise of said condensing chamber, said outlets being so arranged relative to said shields that the vapor remaining after passage through said arched banks of tubes is caused to flow through said passages to said outlets and baffles arranged in said passages for causing the vapor to traverse a sinuous course.

11. A surface condenser including a casing which provides a condensing chamber and which is formed with an inlet to said chamber, primary banks of tubes arranged at opposite sides of said chamber, the tubes in said banks being arranged to provide a passage which is in direct communication with said inlet and which in cross-section converges from the sides of said banks adjacent said inlet in the direction of their opposite sides, whereby the resistance to flow offered by said tubes to the vapors entering said chamber is substantially uniform throughout the extent of said banks, secondary banks of tubes arranged in said casing behind said primary banks, outlets in said casing behind said secondary banks through which the air and uncondensed vapor are withdrawn from said condensing chamber, shields over said secondary banks of tubes for providing passages extending lengthwise of said chamber, said outlets being so positioned relative to said shields that the vapor remaining after passage through said primary banks of tubes is caused to flow through said passages to said outlets and vapor coolers in communication with said passages through said outlets.

12. A surface condenser including a casing which provides a condensing chamber and which is formed with an inlet to said chamber, opposed arched banks of tubes arranged at opposite sides of said chamber, the tubes in said banks being arranged to provide a passage which is in direct communicteion with said inlet and which in cross-section converges from the sides of said banks adjacent said inlet in the direction of their opposite sides, whereby the resistance to flow offered by said tubes to the vapor entering said chamber is substantially uniform throughout the extent of said banks, secondary banks of tubes arranged in said casing behind said arched banks, outlets in said casing behind said secondary banks through which the air and uncondensed vapor are withdrawn from said condensing chamber, shields over said secondary banks of tubes for providing passages extending lengthwise of said condensing chamber, said outlets being so positioned relative to said shields that the vapor remaining after passage through said arched banks of tubes is caused to flow through said passages to said outlets and coolers in communication with said condensing chamber through said outlets.

13. A surface condenser including a casing which provides a condensing chamber and which is formed with an inlet to said chamber, opposed arched banks of tubes arranged at opposite sides of said chamber, the tubes in said banks being arranged to provide a passage which is in direct communication with said inlet and which in cross-section converges from the sides of said banks adjacent said inlet in the direction of their opposite sides, whereby the resistance to flow offered by said tubes to the vapor entering said chamber is substantially uniform throughout the extent of said banks, secondary banks of tubes arranged in said casing behind said arched banks, outlets in said casing behind said secondary banks through which the air and uncondensed vapor are withdrawn from said condensing chamber, shields over said secondary banks of tubes which provide passage extending lengthwise of said condensing chamber, said outlets being so positioned relative to said shields that the vapor remaining after passage through said arched banks of tubes is caused to flow through said passages to said outlets, coolers in communication with said condensing chamber through said outlets and baffles in said coolers arranged to maintain the flow of the vapor at a high velocity during its passage to the outlets of said coolers.

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