

No. 846,379.

PATENTED MAR. 5, 1907.

C. AMBROSE & F. D. SCHWARTZ.

STEAM CONDENSER.

APPLICATION FILED AUG. 28, 1905.

4 SHEETS—SHEET 1.

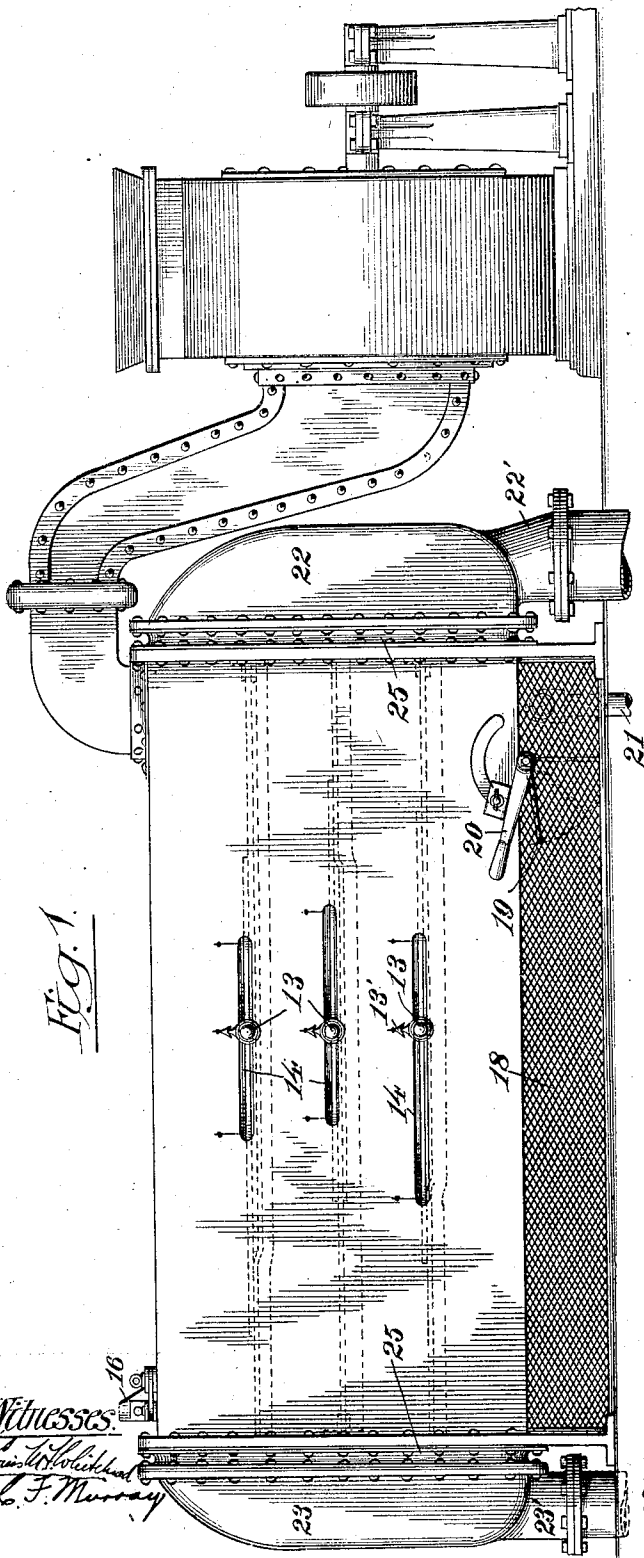


Fig. 1.

Witnesses:

Wm. H. Schickel
L. F. Murray

Fig. 9.

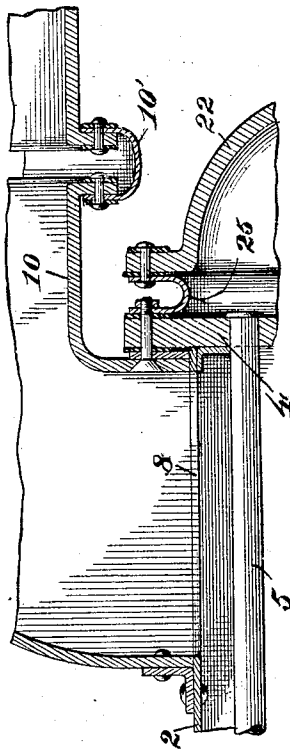
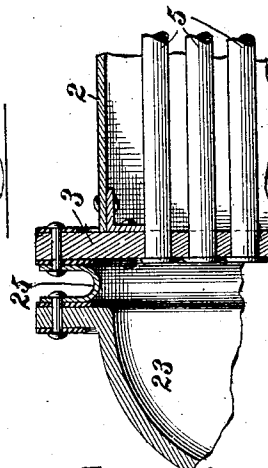


Fig. 8.



Inventors:

Charles Ambrose
and Frank D. Schwartz,
by Charles D. Hawley
Att'y.

No. 846,379.

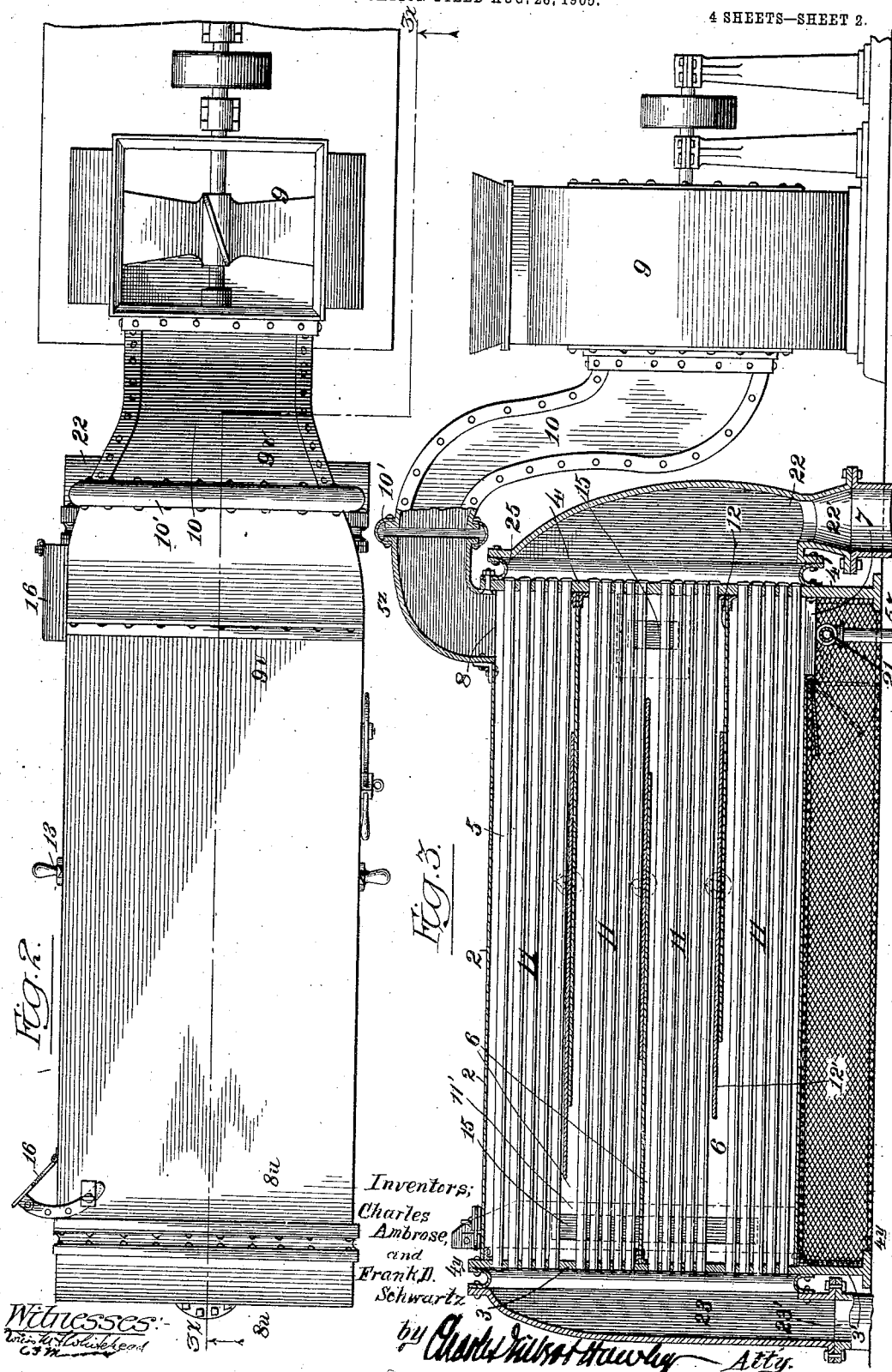
PATENTED MAR. 5, 1907.

C. AMBROSE & F. D. SCHWARTZ.

STEAM CONDENSER.

APPLICATION FILED AUG. 28, 1905.

4 SHEETS—SHEET 2.



No. 846,379.

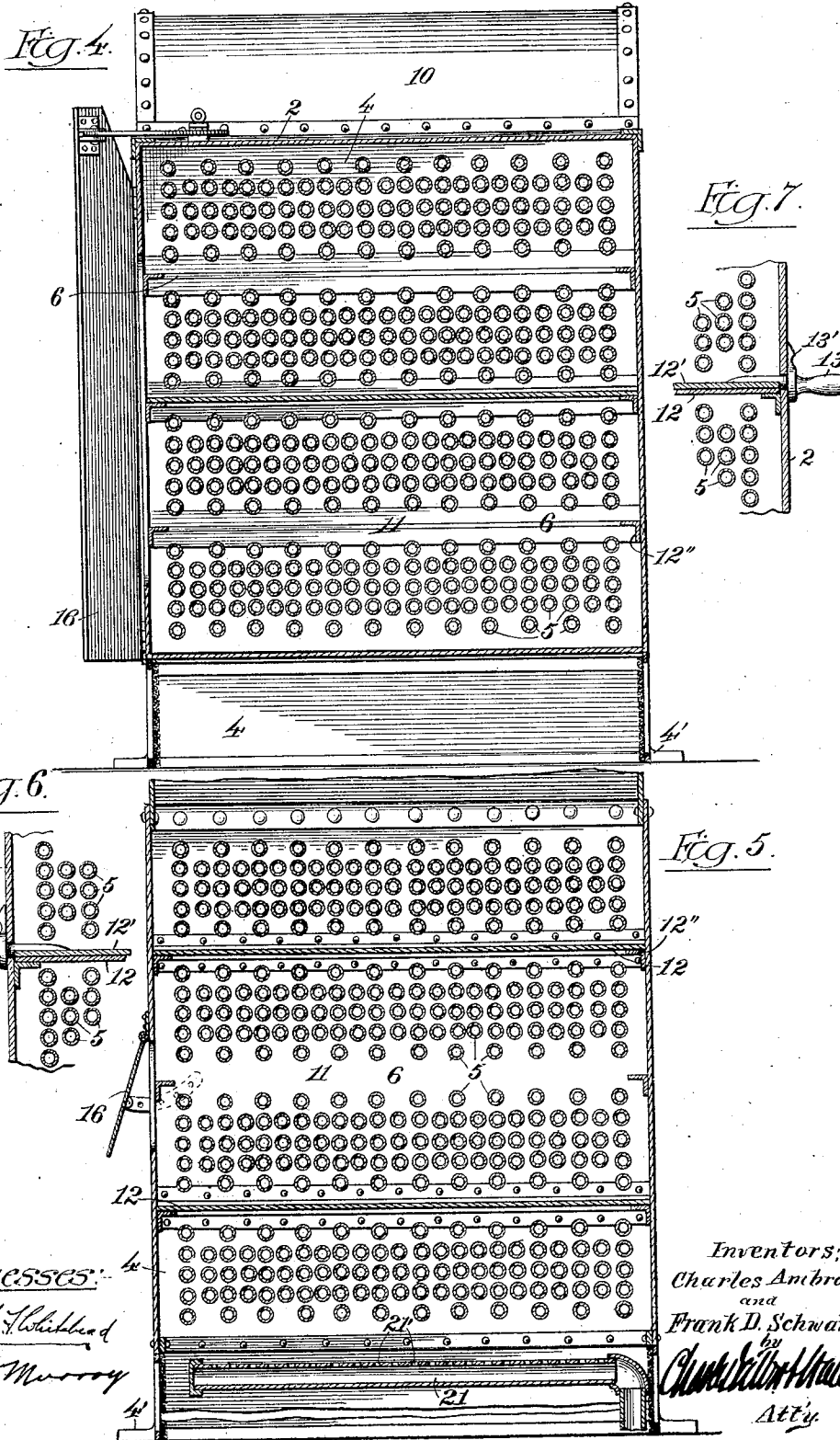
PATENTED MAR. 5, 1907.

C. AMBROSE & F. D. SCHWARTZ.

STEAM CONDENSER.

APPLICATION FILED AUG. 28, 1905.

4 SHEETS—SHEET 3.



Witnesses:

Frank T. Whithead
C. F. Murray

Inventors:
Charles Ambrose
and
Frank D. Schwartz,

by
Charles D. Whithead
Att'y.

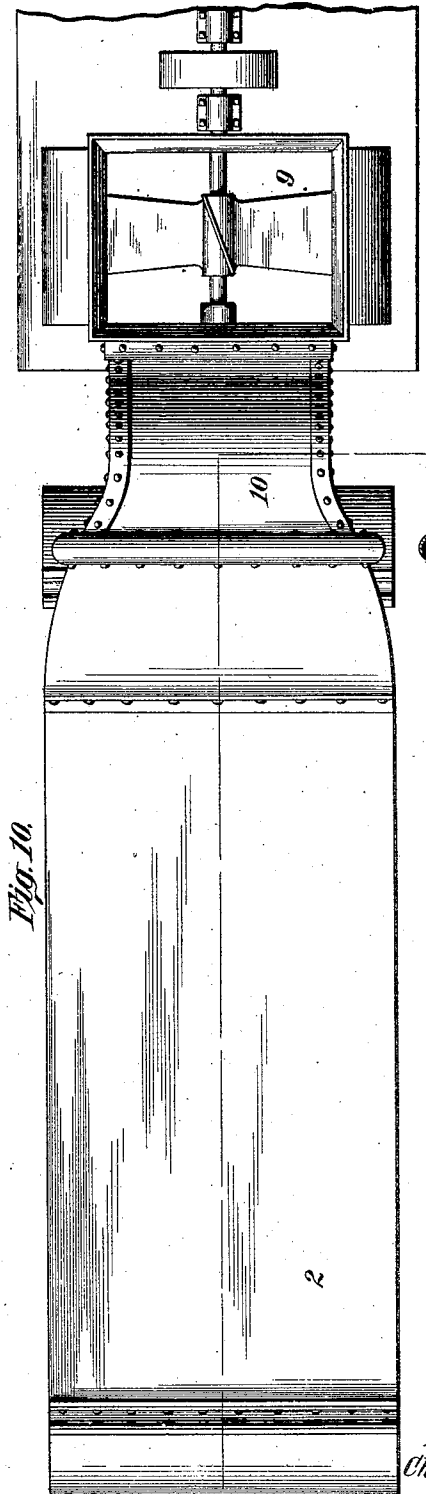
No. 846,379.

PATENTED MAR. 5, 1907.

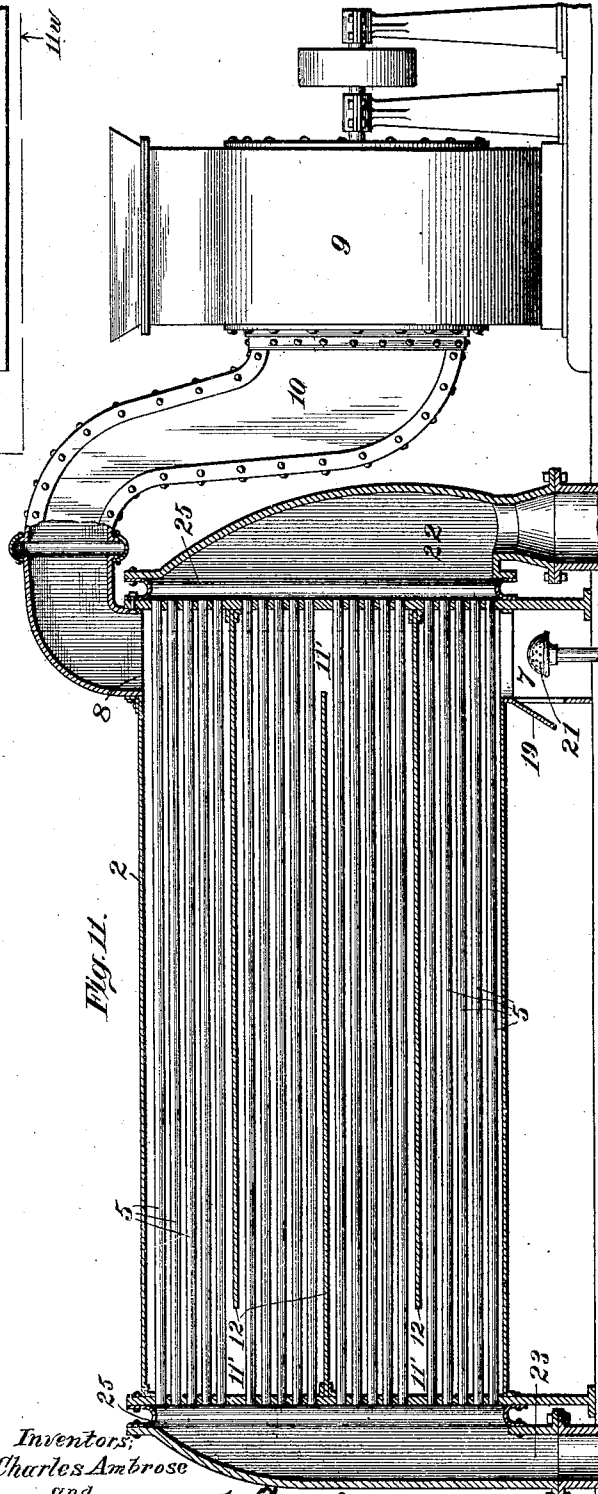
C. AMBROSE & F. D. SCHWARTZ.
STEAM CONDENSER.

APPLICATION FILED AUG. 28, 1905.

4 SHEETS—SHEET 4.



Witnesses:
Chas. Ambrose,
Chas. F. Murray



Inventors,
Charles Ambrose
and
Frank D. Schwartz

by Charles F. Murray
Att'y.

UNITED STATES PATENT OFFICE.

CHARLES AMBROSE AND FRANK D. SCHWARTZ, OF CHICAGO, ILLINOIS.

STEAM-CONDENSER.

No. 846,379.

Specification of Letters Patent.

Patented March 5, 1907.

Application filed August 23, 1905. Serial No. 276,118.

To all whom it may concern:

Be it known that we, CHARLES AMBROSE and FRANK D. SCHWARTZ, citizens of the United States, residing at Chicago, Cook county, Illinois, have invented a certain new, useful, and Improved Steam-Condenser, of which the following is a full, clear, and exact description, such as will enable others skilled in the art to which it appertains to make and use the same.

Our invention relates to improvements in steam-condensers, and has special reference to improvements in condensers of that class properly described as "air-cooled" condensers, wherein air is used as the cooling medium.

The object of our invention is to provide apparatus that shall be adapted to and shall enable the substitution of air for water in the condensation of steam in power plants.

There are in this country many arid and semi-arid regions in which the scarcity of water compels the use of simple direct-exhaust engines because of the excessive cost of the water required for the operation of water-cooled condensers in connection with compound and turbine engines. This fact, coupled with the smaller cost of moving an adequate volume of air, has led us to provide apparatus wherein confined bodies of steam may be condensed by exposure to rapidly-moving currents of air.

We are aware that others have undertaken the solution of the same problem; but within our information and knowledge the results secured have not been wholly satisfactory as to the vacuum maintained, and in every case the apparatus has been objectionable because of its great size in proportion to water-cooled condensers of the same capacity.

The special objects of our invention are to provide an air-cooled steam-condenser that shall be as or more efficient than water-cooled condensers of the same approximate size and capacity; that shall be little, if any, larger than a water-cooled condenser of equal capacity; that shall use the supplied air in the most effective and economical manner possible; that shall be of less cost than water-cooled condensers of the same capacity; that may be operated with less attendant expense than such water-cooled condensers; that shall enable the maintenance of a high vacuum, and which shall be of such construc-

tion and arrangement of parts that its operation may be nicely and accurately regulated and controlled in response to atmospheric changes and variations in the load or work to be performed.

Other objects of our invention will appear hereinafter.

Having in view these general and special objects, our invention consists, broadly, in an air-cooled steam-condenser having as its principal members a large drum or casing, means for creating a rapid flow of air therethrough, suitable flue-sheets at the ends of said drum, a large number of steam tubes extending through the drum and having their ends held in said flue-sheets, partial partitions arranged in said drum and providing therein a plurality of longitudinally-extending communicating air-ducts whereby the air admitted to the drum is caused to move longitudinally upon and about said steam tubes or flues to effectively cool the same, and steam admission and exhaust heads connected with said flue-sheets and in communication through said tubes or flues, whereby steam admitted to said tubes is quickly deprived of its heat and the temperature of the water of condensation is lowered to such point as to insure the maintenance of a high vacuum; and, further, our invention consists in an air-cooled steam-condenser characterized as above which is so constructed that the steam-tubes in different parts of the condenser may be subjected to different treatments for the purpose of equalizing the work performed in the different tubes and also the temperature of said tubes, it being desirable that the tube temperature, and hence the expansion and contraction of the tubes, shall be uniform throughout; and, further, our invention consists in various details of construction and in combinations of parts, all as hereinafter described, and particularly pointed out in the claims.

The invention will be more readily understood by reference to the accompanying drawings, forming a part of this specification, in which—

Figure 1 is a side elevation of an air-cooled steam-condenser embodying our invention. Fig. 2 is a plan view thereof. Fig. 3 is a vertical section on the line 3^x 3^x of Fig. 2. Fig. 4 is an enlarged transverse vertical section on the line 4^y 4^y of Fig. 3. Fig. 5 is a similar

sectional view on the line 5^z 5^z of Fig. 3. Figs. 6 and 7 are enlarged sectional details showing the members which extend through the sides of the air drum or casing and whereby the internal division-plates or partitions may be moved to regulate the operation of the condenser. Fig. 8 is an enlarged sectional detail on the line 8^u 8^u of Fig. 2. Fig. 9 is a similar enlarged section on the line 9^v 9^v of Fig. 2. Fig. 10 is a plan view of a modified form of our machine, and Fig. 11 is a vertical longitudinal section thereof on the line 11^w 11^w of Fig. 10.

The principle of our invention and the essential structural features of the apparatus are such that they admit of embodiment in apparatus or machines of different forms, and it is not our intention to confine our invention to the specific structures herein shown and described. By way of example, it may be here stated that our invention may be carried out with either a suction or a blast fan as a means for moving air through the condenser; yet the structures in the two cases are quite different. We have chosen to present in this application the broad aspects of our invention, together with a specific structure that includes a suction-fan, and have reserved for another application of even date herewith a somewhat different structure specially adapted to and including a pressure or blast fan.

Referring to the drawings, 2 represents the air-drum of our condenser. The ends of this drum are closed by two flue-sheets 3 and 4. The flue-sheets support a large number of steam-tubes 5, preferably arranged in groups one above the other, so that longitudinal horizontal spaces 6 are left between the groups of tubes. We prefer that the casing and the contained tubes shall form a substantially rectangular body; but it is within the scope of our invention to alter this shape in the several cross-sections of the machine, and our invention also includes an arrangement of the several groups of tubes in separate suitably-connected casings or drums. The bottom of the drum contains a narrow entrance-opening 7, and the top is provided with a narrow exit-opening 8. To the latter we connect an exhaust-fan 9, 10 being the exhaust trunk or pipe leading from the top of the drum to the central side opening of said fan. It should be here noted that any convenient means other than the fan may be employed for creating the necessary movement of air through the air-drum. To prevent the direct passage of the air from the entrance-opening 7 to the exit 8 and to secure the maximum effect and benefit of and from the cool air upon the steam-tubes, we divide the drum into a plurality of air-passages 11. This we do by means of the longitudinal horizontal partitions 12, arranged in the spaces 6 and parallel with the steam-tubes 5. The

partitions 12 are staggered or alternated, each extending from a flue-sheet 3 or 4 to a point near the opposite flue-sheet, thereby providing a tortuous longitudinal air-passage between the air entrance and exit openings 7 and 8 of the drum. The partitions 12 extend from side to side of the drum, and each is preferably made in two parts 12 12', the latter being movable. The movable portion or extension of the partition slides in suitable ways formed by the angle-bars 12'' on the sides of the drum, and, further, is provided with operating-handles 13, which project through horizontal slots 14 in the sides of the casing or drum.

It will be seen that the movement of the partition part 12' either enlarges or restricts the opening 11' between the free edge thereof and the opposite or adjacent flue-sheet. The position of the handle 13 in the slot 14 indicates the amount of opening 11' at the end of the partition; but for sake of accuracy we prefer to provide each handle 13 with a pointer 13' and also graduate or mark the side of the drum adjacent to each slot. As a rule no care is used in closing the slots 14 in the drum, as we find it advantageous to admit cool air to the drum-passages at these points. Other currents of air may be directed or admitted into the drum at will through side openings or ports 15, that are arranged near the ends of the drum opposite the junctions 11' of the air-passages 11 11'. Suitable adjustable closures or dampers 16 are placed on the side of the drum for regulating the admission of air at the ports. In the drawings we have shown only one side of the drum provided with ports and dampers; but, if desired, both sides may be thus equipped.

The flue-sheets 3 and 4 must obviously be so arranged as to permit the free expansion and contraction of the steam-tubes. Their lower ends therefore are provided with foot-flanges 3' 4', respectively, not bolted to the bed or floor 17, but slidable thereon in order that the flue-sheets may move with relation to each other. The bottom of the drum 2 is a considerable distance above the floor 17, an air-trunk being formed beneath the machine. This trunk is completed at the sides by fine wire-screens 18, and the air for cooling the tubes within the drum is strained through these screens before it reaches the air-entrance opening 7. Adjacent to the opening 7 and extending nearly or completely across the bottom of the machine is a damper 19, operated by means of a lever 20 on the side of the machine, whereby the entrance of air to the drum may be nicely regulated. It is desirable to moisten the air before it enters the drum, and to this end we arrange a horizontal perforated pipe 21 beneath the drum, and preferably adjacent to the opening 7 between the lower part of the flue-sheet 4 and

the damper 19. The pipe 21 (best shown in Figs. 3 and 5) contains a large number of minute openings 21', and the pipe being supplied with water a great number of fine jets or sprays will be projected into the rapidly-moving current of air just before the air flows into contact with the lower steam-tubes.

22 and 23 are the steam admission and exhaust heads. The faces of these heads are substantially rectangular, and they are open at their inner sides for communication with the steam-tubes 5. Thus the steam-admission chest or space comprises the walls of the head 22 and the flue-sheet 4, while the exhaust chest or cavity is bounded by the flue-sheet 3 and the head 23. The steam is admitted to the head 22 through pipe connection 22', and the pipe 23', leading from the exhaust-head 23, is connected with a vacuum-pump (not shown) operating in the well-known manner. We prefer that the heads 22 and 23 shall be rigidly supported upon the floor or foundation, and in such cases we connect the heads with the flue-sheets by means of expansion-joints or diaphragms 25, which permit the flue-sheets to move or float with respect to the stationary heads, according as the flues expand and contract. It should be here observed that the flue-sheets may, if desired, be supported by the heads 22 and 23 through the medium of the flexible expansion-joints, and, further, that the drum or casing is either formed of thin material, which does not resist the free movement of the flue-sheets, or said drum is attached to the steam-heads. An expansion-joint 10' in the trunk or pipe 10 prevents the latter's interference with the movement of the flue-sheet 4. We have illustrated in Figs. 10 and 11 a somewhat simpler form of our machine or condenser, in which the internal partitions or division-plates are of fixed length, leaving definite openings 11' between the several longitudinal air-passages. These partitions, however, may be of different lengths, after the manner of those hereinbefore described and for the hereinafter-mentioned purpose.

The operation of our invention is as follows: The fan 9 being set in motion, large volumes of air strained by the screens 18 and moistened by the spray 21 will be drawn through the tortuous longitudinal air-passage within the drum 2. The air being at a low temperature will rapidly reduce the temperature of the steam-tubes, which, it is assumed, are being supplied with steam from the head 22. The peculiar advantage attaching to the immersion of the several groups of steam-tubes in a longitudinally-moving current of air is that the tubes of each group are subjected to a substantially uniform temperature throughout their length, and, further, are completely inclosed by the cooler air. The air increases in temperature

as it rises toward the top of the drum, and to control and measure the extent of its flow in the several passages the adjustable partitions are placed at different distances from respective flue-sheets. Thus the lowest partition is farthest from the flue-sheets and the top partition nearest thereto. The effect of this arrangement, which graduates the communicating openings 11', is to gradually increase the linear travel of the air in the air-passages, in consequence of which the tubes in the lower passage are exposed to the moving air for a shorter time and distance than are the tubes in the passage next above, and so on to the top of the drum, where the steam-tubes are exposed throughout their length. In this manner the movable partitions enable the use of the air to the best advantage and provide means for the regulation of the machine to correspond with atmospheric changes of temperature and changes in the load or work to be done. A peculiar and valuable advantage attaching to the structure is that the heat-absorbing effect of the air-currents is or may be equalized throughout the condenser, so that the temperature, the condensing effect, and the expansion of the tubes is made uniform, thereby avoiding the detrimental results observable in other condensers. The arrangement of the group of tubes within a small inclosing drum that is confined to the space between heads 22 and 23 so limits the size of our condenser that it is little, if any, larger than a water-cooled condenser of equal capacity. If desired, the exhaust-fan 9 may be made to deliver the air against the steam-admission head 22. In such cases we provide the head with a large number of wings to increase the radiating-surface thereof.

As numerous modifications of our invention will readily suggest themselves to one skilled in the art, we do not confine the invention to the specific constructions herein shown and described.

Having thus described our invention, we claim as new and desire to secure by Letters Patent—

1. In an air-cooled steam-condenser, an air-drum, in combination with steam admission and exhaust heads at the respective ends of said drum, flue-sheets interposed between said drum and heads, a plurality of steam-tubes extending through said drum and flue-sheets and connecting with said heads, air entrance and exit openings in said drum, and a fan connected with one of said openings, substantially as described.

2. In a steam-condenser, an air-drum provided with air entrance and exit openings, in combination with a plurality of steam-tubes extending through said drum, means at the ends of the drum for admitting and exhausting steam from said tubes, a fan connected with said drum for moving air therethrough,

a plurality of partial partitions arranged within said drum among and parallel with said tubes and dividing the drum into a number of communicating longitudinal air-passages and means for moving air through said passages whereby air is caused to flow longitudinally upon the steam-tubes, substantially as described.

3. In a steam-condenser, an air-drum provided with air entrance and exit openings, in combination with a plurality of steam-tubes extending through said drum, heads closing the ends of the drum, for admitting and exhausting steam from said tubes, a fan connected with said drum for moving air there-through, a plurality of partial partitions arranged within said drum and dividing it into a number of communicating, longitudinal air-passages, and means for moistening the air entering said drum, substantially as described.

4. In a steam-condenser, an air-drum having flue-sheets closing its ends, in combination with a plurality of steam-tubes connected with said sheets, steam admission and exhaust heads applied to said flue-sheets and communicating with said tubes, a plurality of longitudinally-arranged partitions in said drum and providing tortuous longitudinal air-passage, each portion or section of which contains a plurality of said tubes and said drum having air entrance and exit openings at the ends of said tortuous passage, substantially as described.

5. In a steam-condenser, an air-drum having flue-sheets closing its ends, in combination with a plurality of steam-tubes connected with said sheets, steam admission and exhaust heads attached to said flue-sheets and communicating with said tubes, a plurality of longitudinally-arranged partitions in said drum providing a tortuous longitudinal air-passage, each section of which contains a plurality of said tubes, said drum having air entrance and exit openings at the ends of said tortuous passage, and means for moistening air prior to its entrance to said drum, substantially as described.

6. In an air-cooled steam-condenser, an air-drum provided with air entrance and exit openings and having flue-sheets closing its ends, in combination with a plurality of steam-tubes extending through said drum and secured in said flue-sheets, steam admission and exhaust heads attached to said flue-sheets and communicating with said tubes, means forming a tortuous passage within said drum, said passage terminating at the air-openings in said drum and means for causing air to flow rapidly through said drum-passage, substantially as described.

7. In a steam-condenser, an air-drum provided with air entrance and exit openings and having flue-sheets closing its ends, in combination with a plurality of steam-tubes

extending through said drum and secured in said flue-sheets, steam admission and exhaust heads having their inner sides formed by said flue-sheets, longitudinal, partial, alternated partitions providing a tortuous passage between the air-openings of said drum and an air-moving fan connected with one of the openings of the drum, substantially as described.

8. In an air-cooled steam-condenser, an air-drum provided with air entrance and exit openings and having flue-sheets closing its ends, in combination with a plurality of steam-tubes extending through said drum and secured in said flue-sheets, steam admission and exhaust heads communicating with said tubes, means forming a tortuous passage within said drum, between said openings, means for causing air to flow rapidly through said drum-passage, and means adjacent to the drum's air-entrance opening for moistening the air, substantially as and for the purpose specified.

9. In an air-cooled steam-condenser, an air-drum, in combination with flue-sheets closing the ends thereof, steam-tubes connecting said sheets, steam admission and exhaust heads having their inner sides formed by said flue-sheets, suitable expansion-joints connecting the drum, sheets and heads, and means for driving air through said drum between said flue-sheets, substantially as described.

10. In a steam-condenser, an air-drum, in combination with flue-sheets closing the ends thereof, steam-tubes connecting said sheets, steam admission and exhaust heads applied to said flue-sheets and coextensive therewith, suitable expansion-joints connecting the drum, sheets and heads, a plurality of partitions within the drum parallel with said tubes, each said partition extending from one flue-sheet to a point near the other flue-sheet, said partitions providing a tortuous longitudinal passage within said drum and means for driving large volumes of moist air through said passage, substantially as described.

11. In a steam-condenser, a plurality of steam-tubes and admission and exhaust heads therefor, in combination with an air-drum inclosing said tubes and provided with air entrance and exit openings, a plurality of longitudinal, staggered partitions of different lengths arranged between groups of tubes and means for moving air through the tortuous passage thus made, substantially as described.

12. In a steam-condenser, a pair of flue-sheets and a plurality of steam-tubes having their ends secured therein, in combination with alternated longitudinal partitions of less length than said tubes and each abutting a flue-sheet, suitable inclosing walls constituting with said partitions a tortuous air-

passage between said flue-sheets and suitable steam admission and exhaust heads, substantially coextensive with said respective flue-sheets, and joined thereto, substantially as described.

13. In a steam-condenser, a pair of flue-sheets and a plurality of steam-tubes having their ends secured therein, in combination with alternated longitudinal partitions of less length than said tubes and each abutting a flue-sheet, said partitions or sheets being of gradually-increasing length toward the top of the group of tubes, suitable inclosing walls constituting with said partitions a tortuous air-passage between said flue-sheets and suitable steam admission and exhaust heads joined to respective flue-sheets, substantially as described.

14. In a steam-condenser, a pair of flue-sheets and a plurality of steam-tubes having their ends secured therein, in combination with alternated longitudinal partitions of less length than said tubes and each abutting a flue-sheet, said partitions or sheets being of gradually-increasing length toward the top of the group of tubes, suitable inclosing walls constituting with said partitions a tortuous air-passage through the groups of tubes between said flue-sheets and suitable steam admission and exhaust heads flexibly or expansibly joined to respective flue-sheets, substantially as described.

15. In a steam-condenser, a pair of flue-sheets and a plurality of longitudinal steam-tubes having their ends secured therein, in combination with alternated longitudinal partitions or sheets of different lengths, all of less length than said tubes and each abutting a flue-sheet, suitable inclosing walls constituting with said partitions a tortuous air-passage, and suitable steam admission and exhaust heads substantially coextensive with respective flue-sheets and joined thereto by expansion-joints, substantially as described.

16. In a steam-condenser, a plurality of steam-tubes and the flue-sheets belonging thereto, in combination with an inclosing drum having air entrance and exit openings, a plurality of longitudinal partitions providing a tortuous air-passage within said drum between said flue-sheets, means for varying the length of said partitions and the effective length of the different sections of said passage, suitable steam admission and exhaust connections upon said flue-sheets for said tubes and means for moving air through said passage, substantially as described.

17. In an air-cooled steam-condenser, a plurality of parallel tortuously-communicating air-passages, in combination with groups of steam-tubes arranged longitudinally in said passages, means for admitting and exhausting steam to and from said groups of tubes, means for moving large volumes of

air through said communicating passages and devices for varying the sizes of the opening between each pair of said passages, substantially as described.

18. In an air-cooled steam-condenser, an air-drum, in combination with flue-sheets at the ends thereof, steam admission and exhaust heads attached to said flue-sheets, a plurality of longitudinal tubes extending between said flue-sheets, a plurality of externally-operable longitudinal partitions forming a tortuous air-passage within said drum and suitable means for moving the air through said passage, substantially as described.

19. In a steam-condenser, an air-drum provided with air exit and entrance openings, in combination with a plurality of steam-tubes arranged longitudinally in said drum, suitable steam admission and exhaust heads connected with said tubes, a plurality of partial partitions arranged in the drum parallel with said tubes, suitable air-moistening means and an air-straining trunk arranged beneath said drum and communicating with the air-entrance opening therein, substantially as described.

20. In a steam-condenser, an air-drum and flue-sheets closing the ends thereof, in combination with steam admission and exhaust heads upon the outer sides of said flue-sheets, a plurality of longitudinal steam-tubes held in said flue-sheets, a plurality of adjustable two-part partitions arranged longitudinally in said drum, and said drum having slots in its side for the admission of air and through which said partitions may be operated, substantially as described.

21. In a steam-condenser, an air-drum having flue-sheets and steam-heads at its ends, in combination with a plurality of longitudinal steam-tubes extending between said flue-sheets and communicating with said heads, ports and dampers in the side of said drum, said drum being also provided with main air entrance and exit openings, a damper for regulating said entrance-opening, an air-moistening device and a plurality of staggered longitudinally-adjustable partitions provided in the drum, parallel with the tubes therein and separating the latter into groups, substantially as described.

22. In a steam-condenser, a horizontal air-drum, provided with air entrance and exit openings, in combination with flue-sheets forming the ends of said drum, a large number of longitudinal steam-tubes extending between said flue-sheets, steam admission and exhaust heads of segmental form attached to said flue-sheets, an air-moving fan connected with the exit-opening of said drum, means for regulating the admission of air to said drum and three or more horizontal partitions arranged in said drum and

separating said tubes into groups, said partitions being staggered within the drum and each thereof extending from one flue-sheet at a point adjacent to the opposite flue-sheet
5 and means within the drum for varying the effective length of each partition, substantially as described.

In testimony whereof we have hereunto

set our hands, this 17th day of August, 1905,
in the presence of two subscribing witnesses. 10

CHARLES AMBROSE.
FRANK D. SCHWARTZ.

Witnesses:

CHARLES GILBERT HAWLEY,
MOLLIE SIMON.