D. B. MORISON.

APPARATUS FOR CONDENSING STEAM.

APPLICATION FILED MAR. 19, 1910.

979,540. Patented Dec. 27, 1910.

5 SHEETS—SHEET 1.

Fig. 1.

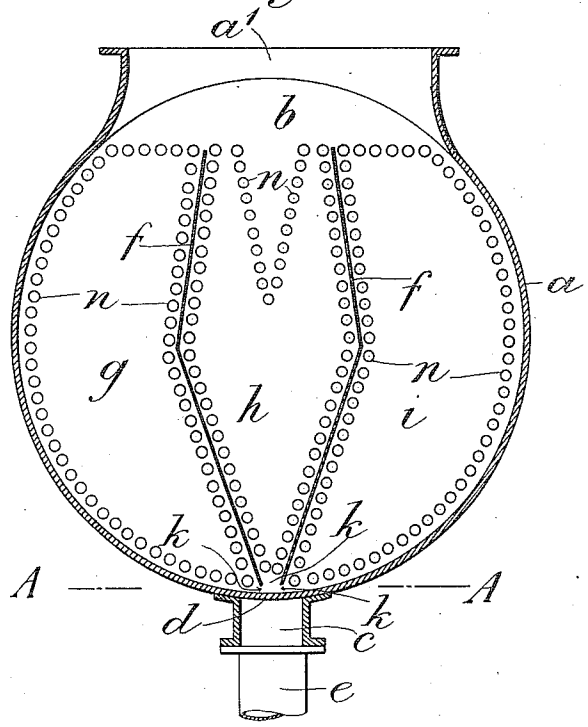
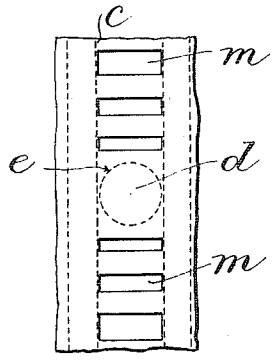


Fig. 2.



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5 SHEETS—SHEET 2.

Fig. 3.

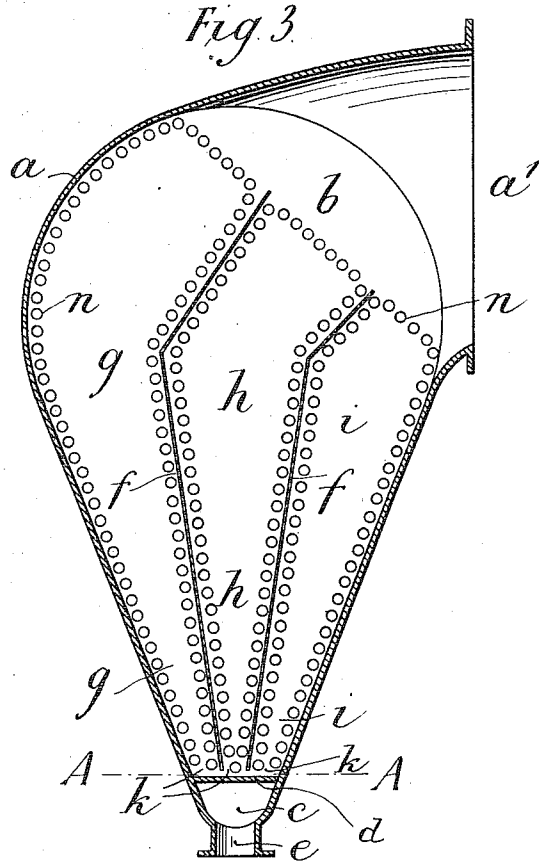
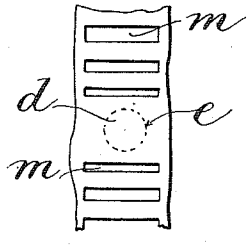


Fig. 4.



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5 SHEETS—SHEET 3.

Fig. 5.

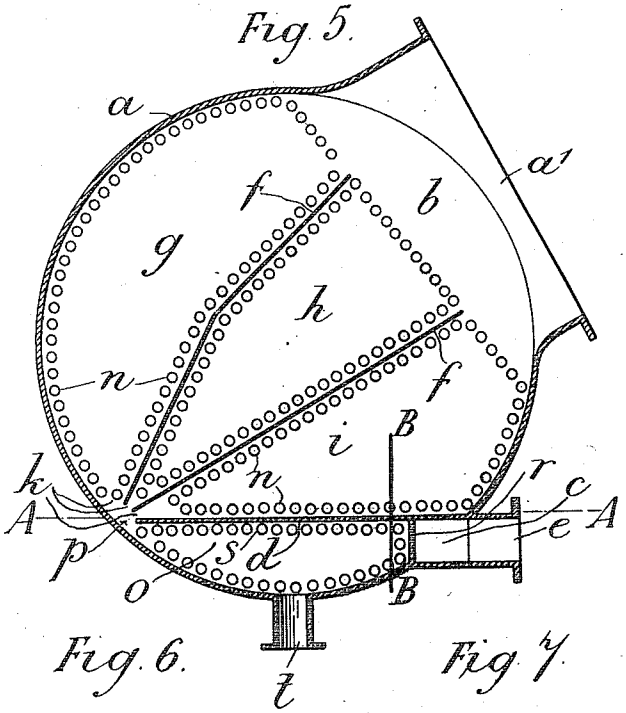


Fig. 6.

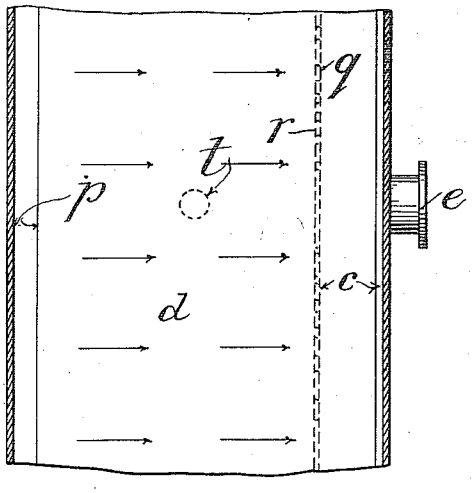
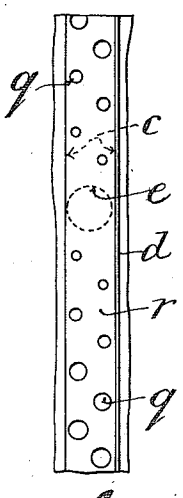


Fig. 7.



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5 SHEETS—SHEET 4.

Fig. 8

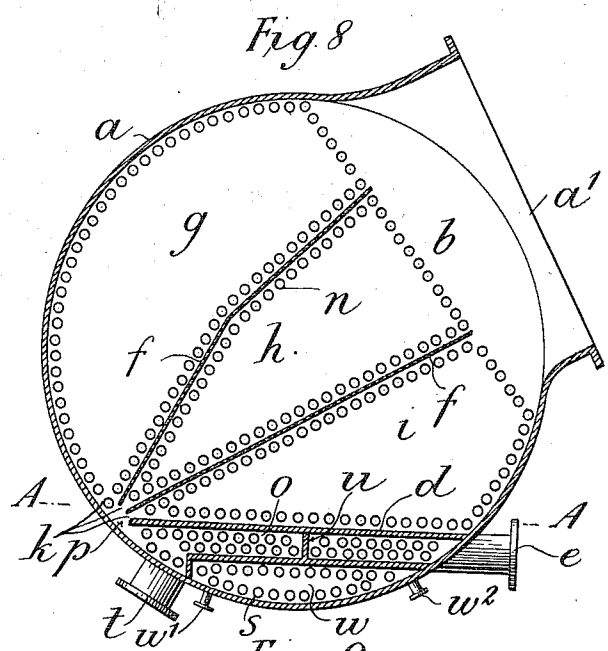
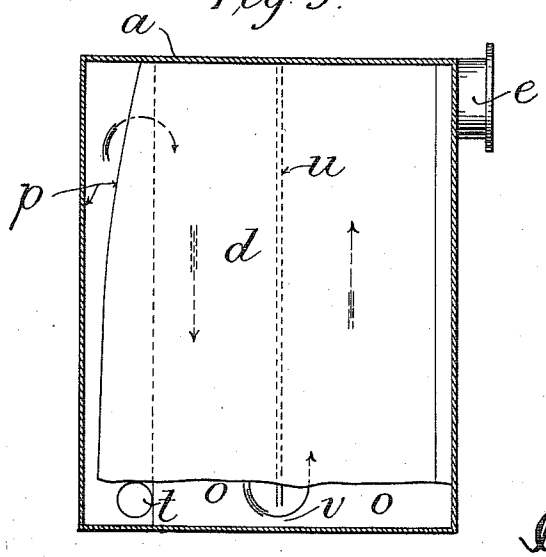


Fig. 9.



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5 SHEETS—SHEET 5.

Fig. 10.

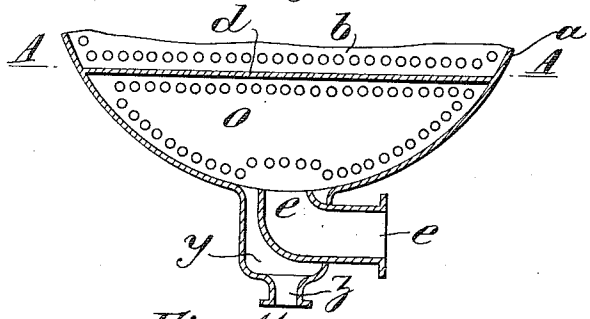
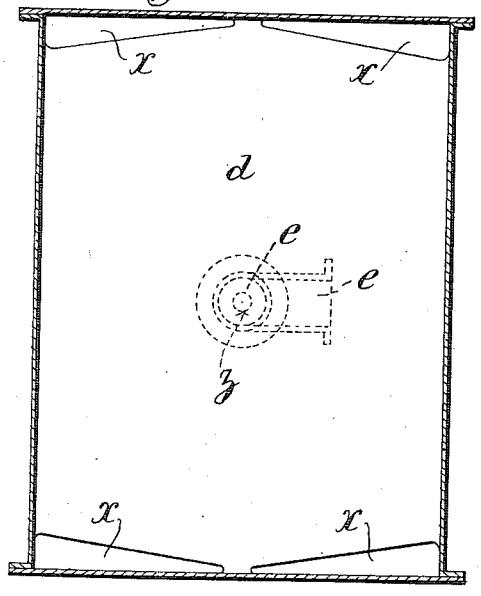


Fig. 11.



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UNITED STATES PATENT OFFICE.

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APPARATUS FOR CONDENSING STEAM.

979,540. Specification of Letters Patent. Patented Dec. 27, 1910.

Application filed March 19, 1910. Serial No. 550,336.

To all whom it may concern:

Be it known that I, DONALD BARNS MORISON, a subject of the King of Great Britain and Ireland, residing at Hartlepool, in the county of Durham, England, have invented Improvements in and Connected with Apparatus for Condensing Steam, of which the following is a specification.

I have found by careful investigation and experiment that heat transfer from the aerated vapor in a steam condenser to the water in the condenser tubes is promoted by the gradual decrease in the temperature of the aerated vapor from the exhaust steam inlet to the point at which it is withdrawn by the air withdrawing apparatus and that for a given air leakage into the condenser, the difference in temperature between these two points should be a maximum in order to favorably influence the air withdrawing capacity of the pump or other withdrawing apparatus. Also, that in condensers of considerable size, and especially in heavily loaded condensers, the area necessary for the passage of the steam, in order to minimize back pressure, is so great, that the creation, by uniform distribution, of uniform flow over the condensing surface is necessary for high efficiency. Moreover, it is also necessary, for high efficiency, that the aerated vapor should flow uniformly and continuously, directly toward the inlet or inlets of the next condensing compartment in the case of a multi-compartment condenser, or continuously and uniformly over the whole condensing surface of the water tubes near the outlet of the condensing compartment in a single compartment condenser, and that it should not be caused to produce eddies or be deflected backward, so as to repass the condensing surface, in any plane transverse to the general direction of flow, past which it has already once flowed, in order that the amount of air in any such plane should be maintained at a minimum and that the efficiency of the surface in that plane, as determined by the presence of air, should be prejudiced to the least possible extent. Furthermore, when the mixture of air and vapor passes downwardly through a condenser, the vapor being gradually condensed, the quantity of the mixture remaining is gradually lessened and its air richness gradually increased, but the greater the air richness of the mixture, the more difficult it becomes to lower its temperature, and as the volume toward the bottom of the condenser is relatively small, it becomes necessary, in order to obtain greater efficiency of the final condensing surface, to cause the mixture to circulate uniformly over the available condensing surface. It is therefore particularly advantageous to avoid confusion of flow, and to promote concentration of flow of aerated vapor at or near to the point where the aerated vapor is withdrawn, either from one condensing compartment to the next, or finally from the condenser, and that the air withdrawing effect of the air withdrawing device used should be as nearly equal as possible over the whole tube area from which the aerated vapor finally flows and particularly over the final condensing area.

As the various portions of a condenser are interdependent, the feature of obtaining the lowest final temperature of the aerated vapor by apparatus causing uniformity of flow over the tube surface without undue confusion of flow, and also of causing concentration of flow in the manner described, may, with great practical advantage, be extended to the condenser as a whole, whether it comprises one condensing compartment, or more than one condensing compartment, and also whether a final compartment contains tubes or is tubeless, and whether the condensing compartments, in the case of multiple compartments, are in series, or in parallel, or both in combination. For this purpose, the condenser, or a main condensing compartment, or the condensing compartment immediately preceding a final condensing compartment, is provided with guide plates so arranged as to divide the cross section into sections that are arranged in parallel and each of which terminates in a narrow area in cross section, as at the thin edge of a wedge, so that the aerated vapor in each section is caused to flow in a practically uniform and even manner through the sections and is guided directly toward and delivered uniformly into the next condensing compartment, or into the outlet chamber, as the case may be. The guide plates

may be arranged in a more or less horizontal or inclined position, or in a more or less vertical or upright position, from near the steam inlet of the compartment, or suitably lower down, to the outlet or outlets therefrom, and be of flat, curved or angular shape to suit the requirements of the particular condensing compartment in which they are placed. By these means, the aerated vapor is not only equally distributed but is uniformly guided to and concentrated at the point of discharge with a minimum of confusion or eddying.

My invention enables an important technical effect to be obtained in steam condensation in surface condensers, by providing for a minimum weight of air normally in the condenser, by means of multiple streams of flow in parallel toward and concentrated at the area of discharge from which air is evenly withdrawn, and also by providing for a maximum natural difference in temperature between the inlet and outlet of the condenser in order to favorably influence the withdrawing capacity of the air withdrawing device used.

In the accompanying drawings, Figure 1 is a vertical cross section and Fig. 2 a part sectional plan on the line A A of Fig. 1, showing one construction of steam condenser embodying the present invention. Figs. 3 and 4 are similar views to Figs. 1 and 2 respectively, showing a modified construction. Figs. 5 and 6 are similar views to Figs. 1 and 2 respectively and Fig. 7 a sectional elevation on the line B B of Fig. 5, showing another modified construction. Figs. 8 and 9 and Figs. 10 and 11 are similar views to Figs. 1 and 2 respectively showing further modified constructions of condensers according to the invention.

In the example shown in Figs. 1 and 2, the condenser *a*, of circular cross section, comprises a main condensing compartment *b* having an inlet at its upper end for exhaust steam and a final tubeless compartment *c* arranged below and separated from the main compartment by a perforated wall or diaphragm *d* and having an outlet *e* for connection to an air pump or other air and water withdrawing device. The condensing compartment *b* is provided with guide plates *f*, two in the example shown, which are so arranged as to divide the condensing compartment into a number of sections *g*, *h*, *i*, that are arranged in parallel with each other and each of which terminates in a narrow longitudinal or wedge-like passage *k* of small cross sectional area above the wall or diaphragm *d*. The perforations *m* in the wall or diaphragm *d* are made of gradually increasing cross sectional area from the central portion of the chamber *o* where the outlet *e* is placed, toward the ends of the condenser, in order that the aerated vapor may readily enter all parts of the said chamber from those parts of the sections *g*, *h*, *i* of the main condensing compartment *b* that are farthest from the outlet *e*. By the arrangement described the aerated vapor is caused to flow, together with the water of condensation, in a practically uniform and even manner through the condenser sections and be guided directly toward and be delivered uniformly into the compartment *c* from which it is withdrawn through the outlet *e*. Furthermore, the use of guide plates *f* as described tends not only to produce uniformity of flow over the surface of the condensing tubes *n* but also to effect a gradual concentration of flow into the discharge openings *m* and thence into the chamber *c*, thereby preventing or minimizing any eddying or mixing up of the aerated vapor in its passage through the condenser in order to obtain the most uniform flow and the greatest temperature reduction of the aerated vapor that the prevailing conditions will permit of. Such valuable practical results cannot be obtained with the constructions of condenser now usually employed.

Figs. 3 and 4 show a similar construction of condenser to that shown in Figs. 1 and 2 except that the main condensing chamber *a* has its inlet for exhaust steam at one side and is made of gradually decreasing cross sectional area in a downward direction, that is to say wedge shape, so that the lower ends of the outer sections *g* and *i* of the condensing compartment *b* are more contracted at their lower ends than with the circular form of condensing chamber shown in Figs. 1 and 2, the plates *f* being suitably shaped to suit the condensing chamber.

In Figs. 5, 6 and 7, the condenser *a*, of circular section, comprises a main condensing compartment *b* divided up into parallel sections *g*, *h*, *i* by division plates *f*, as in Fig. 1, a second and relatively smaller condensing compartment *o* in which the aerated vapor is further devaporized, and a final tubeless compartment *c* having an air outlet *e*. The second condensing compartment *o* is separated by a wall or diaphragm *d* from the sections *g*, *h*, *i* of the main condensing compartment with which it communicates at one side through a longitudinal opening *p* and the narrow longitudinal passages *k*, the other side of the said second compartment *o* being in communication with the final outlet chamber *c* through a series of holes *q* in a dividing wall *r*. The longitudinal opening *p* is of uniform width or area but the holes *q* are of increasing area as they proceed from the central portion of the wall *r*, opposite the outlet *e*, toward the ends of the chamber *o*, in order to induce

the aerated vapor to flow as nearly as possible transversely through the chamber *o* from the inlet *p* to the outlet chamber *c*, as indicated by arrows, so that practically the whole of the cooling surface of the water tubes *s* in the condensing chamber *o* may be utilized for the purpose of condensing vapor and cooling the air to the greatest possible degree. The water of condensation is discharged from the condensing sections *g*, *h*, *i* together with aerated vapor through the contracted passages *k* and opening *p* into the second condensing compartment *o* from which it is discharged through a separate outlet *t* while the aerated vapor is drawn transversely through the said chamber *o* into the outlet chamber *c* and thence passes to the air pump or equivalent.

In the modified construction shown in Figs. 8 and 9, the second and smaller condensing compartment *o* is provided with a longitudinal guide plate *u* that extends from one end of the condenser to within a short distance of the other end thereof so as to form two parallel passages connected by an opening *v*. One of the parallel passages communicates with the sections *g*, *h*, *i* of the main condensing chamber through an opening *p* in the wall or diaphragm *d*, such opening being more or less of wedge shape, with the widest part farthermost from the opening *v* with a view of promoting uniform flow of aerated vapor throughout the whole length of the condensing sections into the first portion of the second condensing compartment *o* for the purpose set forth; the aerated vapor entering one end of the second portion of such second condensing compartment through the opening *v* and leaving it at the other end through the outlet *e*. The water of condensation leaves the second condensing chamber through a separate outlet *i*, as in Figs. 5 and 6. In this example the second condensing chamber *o* is arranged above a water cooler *w* in the base of the condenser through which water can be passed from the inlet w^1 to the outlet w^2 and cooled and thence delivered into the air pump, or air pump suction pipe, for further cooling the air and vapor delivered to such pump for a purpose well understood.

In the modified construction shown in Figs. 10 and 11 the final condensing compartment *o* is placed in the base of the condenser *a* and separated from the main condenser portion *b* by the diaphragm or division plate *d* which is provided with holes *x* through which the mixture of air and vapor passes to the final condensing compartment *o*. The holes *x* are of wedge shape, the widest part of each wedge being nearest to the adjacent side of the condenser and the narrowest part at the center line of the plate *d*. Or the plate *d* may be provided with a larger number of circular holes of varying size, leading to the final compartment *o*, the area of such inlets increasing the greater the distance they are from the outlet *e*, which, in this example, is shown as a bent pipe extending from the center of the bottom of the compartment *o* to one side thereof. The water of condensation, if withdrawn by a separate water pump, drains into a receptacle *y* provided with an outlet *z*. Although the division plate *d* is shown horizontal, it is to be understood that it may be inclined, or it may be convex or concave, so as to drain water of condensation falling thereon to the sides or center of the condenser, depending on any particular conditions and requirements.

The most suitable height of the guide plates *f* arranged in a condenser according to my invention, depends on the conditions prevailing and may be varied as desired.

As the outlet *k* of each sectional condensing compartment *g*, *h*, *i* is of small cross sectional area relatively to the area of exhaust steam inlet a^1, as the cross sectional area diminishes gradually, and the guide plates *f* tend to obviate confused flow, the aerated vapor is gradually lowered in temperature and flows uniformly and continuously forward to the final chamber *c* or *o*, as the case may be, in a condition best adapted for its withdrawal by an air pump and in a manner best adapted to minimize the quantity of air remaining normally in the condenser.

The obtaining in a condenser of an approximately equal vacuum throughout, of a minimum weight of air normally in the condenser, and also a minimum temperature at the air suction pipe at the base of the condenser, relatively to the temperature of the exhaust steam at the inlet at the top of the condenser, constitute a technical effect of great practical value, in that the condensing efficiency of the entire condenser is very advantageously effected thereby.

The importance of the invention hereinbefore described will be best understood and realized by the knowledge that the presence of air in steam in a surface condenser has a highly prejudicial effect on the heat transference efficiency of the condensing tube surface in the condenser. There is also a definite temperature corresponding to any pressure of saturated steam, and there is also a definite and lower temperature corresponding to every proportion of air to steam in saturated air at every pressure, so that it follows that for a given amount of air entering a condenser, the less the weight of air remaining normally in the condenser, or any compartment thereof, and the lower the final temperature relatively to the inlet temperature, the greater will be the amount of heat transference from the steam to the cool-

ing water in the condenser tubes and the more efficient will be the condenser. Therefore, steam condensing apparatus constructed, arranged and operating as hereinbefore described, enables a greater heat transference efficiency through the tubes in a condenser to be obtained than is obtainable by steam condensing apparatus at present in use or hitherto proposed.

What I claim is:—

1. In steam condensing apparatus, a steam condensing compartment having guide plates arranged to form therein a plurality of condensing sections arranged in parallel and through which steam admitted to the compartment will simultaneously flow toward the outlet of said compartment.

2. In steam condensing apparatus, a steam condensing compartment having therein a series of condensing sections arranged in parallel and of decreasing cross sectional area toward the outlet thereof.

3. In steam condensing apparatus, a steam condensing compartment having therein a plurality of wedge shaped condensing sections arranged in parallel.

4. In steam condensing apparatus, a steam condensing compartment having therein a plurality of guide plates arranged to divide the cross section of said compartment into a plurality of parallel condensing sections the outlet portions of which are of decreasing cross sectional area.

5. In steam condensing apparatus, a steam condensing compartment having therein a plurality of guide plates arranged to divide the cross section of said compartment into a plurality of wedge shaped condensing sections arranged in parallel and the narrowest ends of which are nearest the outlet from the compartment.

6. In steam condensing apparatus, a steam condensing compartment provided with condensing tubes, and a series of guide plates arranged between some of the tubes to form a plurality of condensing sections arranged in parallel and of decreasing cross sectional area toward the outlet of said compartment.

7. In steam condensing apparatus, a steam condensing chamber provided with condensing tubes, an outlet chamber in communication with said condensing chamber and having an outlet for fluid, and a series of guide plates arranged between some of the tubes to form a series of condensing sections arranged in parallel and of decreasing cross sectional area, the smaller ends of said sections being near to the outlet chamber.

8. In steam condensing apparatus, a steam condensing chamber provided with condensing tubes, an outlet chamber in communication with said condensing chamber and having an outlet for fluid, and a series of guide plates arranged between some of the tubes to form a series of wedge shaped condensing sections the smaller ends of which are next the outlet chamber.

9. In steam condensing apparatus, a steam condensing compartment provided with condensing tubes, an outlet chamber, a diaphragm between said compartment and chamber adapted to afford communication between said compartment and chamber for passage of fluid from one to the other, and guide plates arranged in the condensing compartment to form a plurality of condensing sections arranged in parallel and the outlets of which terminate in proximity to the communication between said compartment and chamber.

10. In steam condensing apparatus, a steam condensing compartment, guide plates arranged therein to form a plurality of condensing sections arranged in parallel and of decreasing cross sectional area toward their outlets, an outlet chamber in communication with said condensing sections, an air outlet in communication with said outlet chamber and a division arranged between said condensing compartment and air outlet and formed with an airway the cross sectional area of those parts of which that are farthest from the air outlet is greater than that of the parts thereof nearest the said air outlet.

11. In steam condensing apparatus, a steam condensing compartment, an outlet chamber in communication with the said condensing compartment and having an outlet for air, guide plates arranged in said steam condensing compartment to form a plurality of condensing sections arranged in parallel and having narrow outlets terminating near to the inlet to the outlet chamber and means for promoting uniformity of flow of air from the condensing sections through said outlet chamber to said air outlet.

12. In steam condensing apparatus, a steam condensing compartment, an outlet chamber arranged in communication with said condensing compartment and having an outlet for air, guide plates arranged in said condensing compartment to form a plurality of condensing sections arranged in parallel and having narrow outlets near to the communication between the compartment and chamber and a diaphragm arranged between the condensing compartment and the outlet of the said chamber and adapted to provide an airway between said condensing sections and the said air outlet, the parts of said airway that are farthest from the said outlet being of larger cross sectional area than parts that are nearer to the said outlet, for the purpose set forth.

13. In steam condensing apparatus, a steam condensing compartment, an outlet chamber arranged in communication with

said condensing compartment and having an outlet for air, guide plates arranged in said condensing compartment to form a plurality of wedge shaped condensing sections arranged in parallel and having their small exit ends near to the inlet to said chamber, and a diaphragm arranged between the condensing compartment and the outlet of the said chamber and adapted to provide an airway between said condensing sections and the said air outlet, the parts of said airway that are farthest from the said outlet being of larger cross sectional area than parts that are nearer to the said outlet, for the purpose set forth.

14. In steam condensing apparatus, a steam condensing compartment, an outlet chamber arranged in communication with said condensing compartment and having an outlet for air, guide plates arranged in said condensing compartment to form a plurality of wedge shaped condensing sections arranged in parallel and having their small exit ends near to the inlet to said chamber, and a perforated diaphragm arranged between the condensing compartment and the outlet of said outlet chamber, the perforations in said diaphragm being arranged to provide airways of greater cross sectional area the farther they are from the said outlet, substantially as described for the purpose set forth.

15. In steam condensing apparatus, a main steam condensing compartment provided with condensing tubes, an outlet chamber arranged in communication with said condensing compartment and provided with condensing tubes to form a supplementary condensing chamber, and guide plates arranged between tubes in the main condensing compartment to form a plurality of condensing sections arranged in parallel and having their smaller ends terminating near to the communication with the supplementary condensing section.

16. In steam condensing apparatus, a main steam condensing compartment provided with condensing tubes, an outlet chamber arranged in communication with said condensing compartment and provided with condensing tubes to form a supplementary condensing chamber, said chamber being in communication at one side with said main compartment and provided at the opposite side with an air outlet, and guide plates arranged between tubes in the main condensing compartment to form a plurality of condensing sections arranged in parallel and having their smaller ends terminating near to the communication with the supplementary condensing chamber.

17. In steam condensing apparatus, a main steam condensing compartment provided with condensing tubes, an outlet chamber arranged in communication with said condensing compartment and provided with condensing tubes to form a supplementary condensing chamber, guide plates arranged between tubes in the main condensing compartment to form a plurality of condensing sections arranged in parallel and having their smaller ends terminating near to the communication with the supplementary condensing section, and means for promoting uniformity of flow of fluid from the main condensing compartment to and through the supplementary condensing chamber to the outlet of said chamber.

18. In steam condensing apparatus, a main steam condensing compartment provided with condensing tubes, an outlet chamber arranged in communication with said condensing compartment and provided with condensing tubes to form a supplementary condensing chamber, guide plates arranged between tubes in said condensing compartment to form a plurality of condensing sections that are arranged in parallel, are of gradually decreasing cross sectional area and terminate near to the inlet of the supplementary condensing chamber, and means for promoting uniformity of flow of fluid from the main condensing compartment to and through the supplementary condensing chamber to the outlet of said chamber.

19. In steam condensing apparatus, a main steam condensing compartment provided with condensing tubes, guide plates arranged between tubes in said compartment to form a plurality of condensing sections of gradually decreasing cross sectional area, the outlet of said condensing sections converging and terminating near together, a supplementary condensing chamber provided with condensing tubes and communicating at one side with the main condensing compartment through an opening below the outlet ends of said condensing sections, and provided at the other side with an air outlet for air, and a perforated division plate arranged at the outlet side of said supplementary condensing chamber so as to form therewith an outlet chamber, the perforations in said plate being arranged to form airways of gradually increasing cross sectional area the farther they are from said outlet, for the purpose set forth.

20. In steam condensing apparatus, a main steam condensing compartment provided with condensing tubes, guide plates arranged between tubes in said compartment to form a plurality of condensing sections of gradually decreasing cross sectional area, the outlet of said condensing sections converging and terminating near together, a supplementary condensing chamber provided with condensing tubes and communicating at one side with the main condensing

compartment through an opening below the outlet ends of said condensing sections, and provided at the other side with an outlet for air and at its lower side with an outlet for water of condensation, and a perforated division plate arranged at the outer side of said supplementary condensing chamber so as to form therewith an outlet chamber, the perforations in said plate being arranged to form airways of gradually increasing cross sectional area the farther they are from said outlet, for the purpose set forth.

Signed at Hartlepool England this eleventh day of March 1910.

DONALD BARNS MORISON.

Witnesses:

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HUBERT BOWEN.