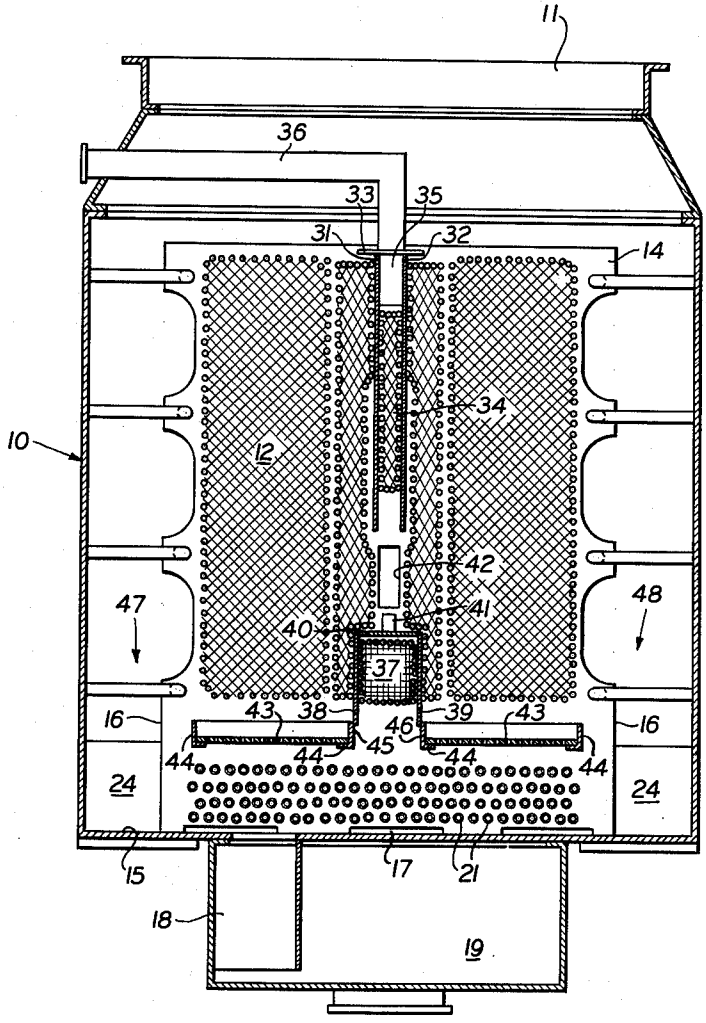
June 18, 1963 LE ROY A. DROESCHER 3,094,165

DEAERATING SYSTEM FOR CONDENSERS

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FIG. 1.



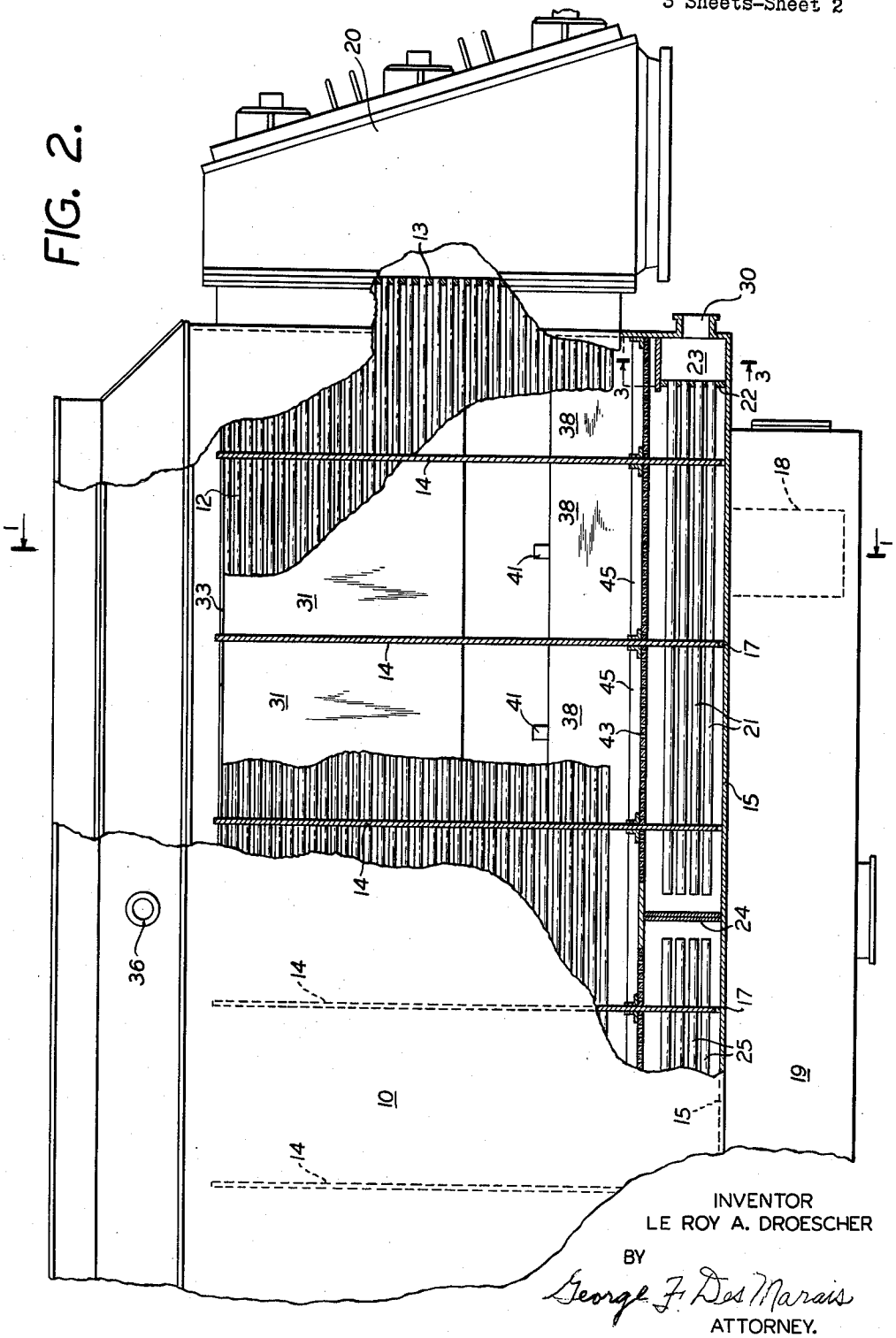
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DEAERATING SYSTEM FOR CONDENSERS

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FIG. 2.



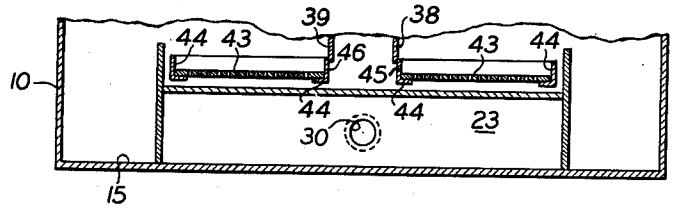
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DEAERATING SYSTEM FOR CONDENSERS

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FIG. 3.



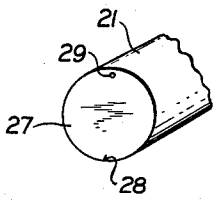


FIG. 4.

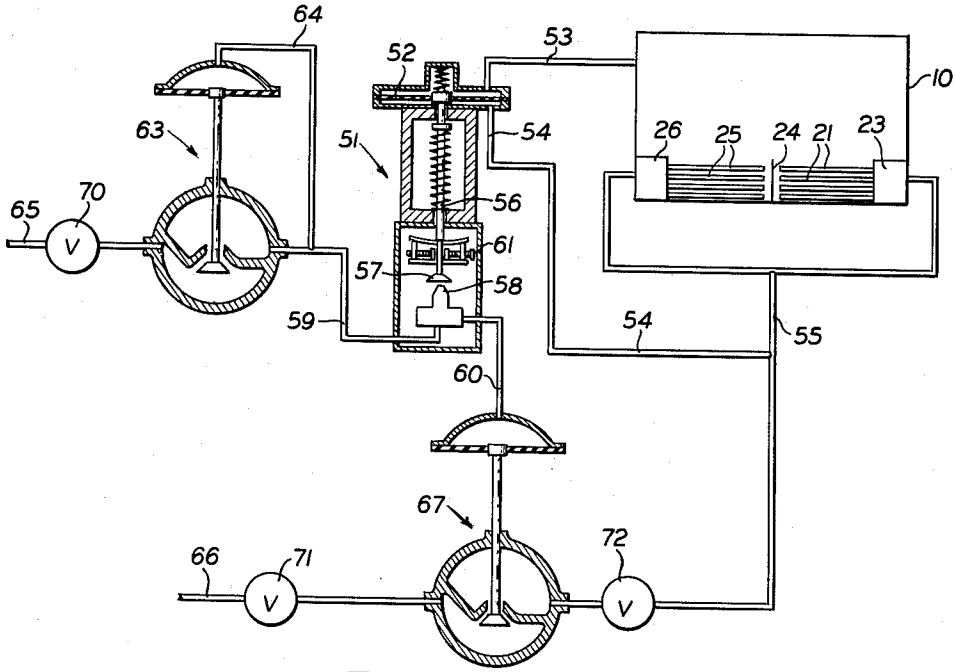


FIG. 5.

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DEAERATING SYSTEM FOR CONDENSERS

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5 Claims. (Cl. 165—39)

This invention relates to condensers and more particularly to a deaerating system for attaining a high degree of elimination of air and of other non-condensable gases which are dissolved in and contained in condensate and in other water which is received in condensers from outside sources in various plant operations.

Among the purposes of the invention is to provide a deaerating system within a condenser which obviates any need for an external deaerating apparatus for minimizing the oxygen content in the water delivered to a boiler plant. The system provides for heating and partially evaporating condensate with steam heated tubes at a heat level higher than the boiling point under the prevailing vacuum conditions in the condenser to produce a predetermined amount of evaporation whereby to reduce the over-all oxygen level which would otherwise be obtained by heating the condensate only to the boiling point corresponding to the prevailing condenser vacuum conditions. The steam heated tubes are contained in a deaerating section located below the condensing tubes and a blanket or stream of steam from the condenser steam space is induced to flow across the section. The outside surfaces of the steam heated tubes in the section are constantly swept with steam from the steam space of the condenser and thin streams of condensate dripping through the deaerating section and from one tube row to the next row below intermingle the condensate and the condenser steam by direct contact. Perforated trays are preferably used to collect condensate from the condenser tube banks and to distribute the condensate in thin streams or films over the steam heated tubes. Oxygen and other non-condensable gases are expelled from the condensate and the maximum degree possible of heat recovery and deaeration is achieved.

The steam heated tubes of the dearating section are heated by steam from an outside source. Small holes in the ends of the heating tubes oppoiste the steam inlet ends provide for the discharge of condensed steam therefrom and the venting of the heating steam to the condenser steam space eliminates non-condensables whereby the tubes are uniformly heated throughout their entire lengths and constant evaporation is achieved over the entire heated surface. The pressure of the steam inside of the deaerating tubes is automatically controlled by a differential pressure regulating apparatus including a control pilot valve responsive to the difference in pressure of the steam inside of the heating tubes and the vacuum pressure within the condenser.

The control pilot valve functions in conjunction with a pressure-operated pilot valve in an air supply line to increase or decrease the steam supply to the heating tubes as required to provide the latent heat necessary to effect the desired evaporation of the condensate. The differential pressure regulating apparatus is settable for automatically maintaining the differential required to effect the lowering of the oxygen level of the condensate to close to zero level.

The oxygen level may be reduced an amount sufficient for usual requirements without using steam in the tubes of the deaerating section, because the steam from open steam lanes in the condenser heats the condensate dripping over the tubes up to the boiling point. However, when the plant requirements are such as to call for a lower level

of oxygen content, heating steam is admitted to the tubes of the deaerating section and, by means of the additional evaporation effect thus obtained, additional oxygen is released and a lower level of oxygen content in the condensate is thereby made possible.

A principal advantage of the invention lies in its flexibility of control by an operator and in its capability of attaining efficient oxygen removal under all load and operating conditions encountered throughout the year.

Other objects and attainments of the present invention will appear more fully from a description of an application of the invention to a condenser having a single bank of condensing tubes, but it will be understood that the invention is applicable to condensers having multiple banks and is also adapted for use in condensers other than radial flow condensers.

In the drawing, FIG. 1 is a vertical cross-section of a condenser on the line marked 1—1 in FIG. 2;

FIG. 2 is an elevational view of one side of the condenser with part of its shell broken away to show condensing tubes which are in turn broken away to show interior structure;

FIG. 3 is a vertical section taken through the steam chest on line 3—3 of FIG. 2;

FIG. 4 is a view illustrating the apertured dead end of a steam heating tube of the deaerating section;

FIG. 5 is a schematic illustration of the differential pressure control system for controlling the supply of steam for deaerating purposes.

Th structure of the condensing-deaerating unit shown in FIGS. 1 and 2 includes a shell **10** having a steam inlet **11** for receiving exhaust steam from a turbine. The shell encloses a steam space containing a bank or nest of steam-condensing tubes **12** which extend from a tube sheet **13** at one end of the condenser to a similar tube sheet (not shown) at the other end. In the structure illustrated the tubes are supported intermediate their lengths by a plurality of supporting plates **14** which stand on the floor **15** of the condenser, but in a shorter condenser these supporting plates are reduced in number to suit the tube support deemed necessary. Condensate collecting on the floor of the condenser flow around the side edges **16** of the supporting plates and through openings **17** at their lower edges to one or more down pipes, one of which is shown at **18**, from which it is received in a hotwell **19**. Cooling water is passed through the condensing tubes from and into water boxes, one of which is shown at **20**, FIG. 2. The invention is applicable to single and multiple pass condensrs. In the interest of simplicity the invention will be described with reference to a condenser containing a single bank of condensing or cooling tubes.

The deaerating section comprises a plurality of heating tubes located within the condenser below the condensing tubes. The heating tubes are so disposed and arranged that all of the condensate draining from the condensing tubes will come in contact therewith. In the structure illustrated they are divided into two groups. As shown in FIG. 2, the heating tubes **21** are secured in a side wall **22** of a steam chest **23** from which steam is supplied to the tubes. The heating tubes are also supported by the supporting plates **14**. These heating tubes extend approximately one-half of the length of the condenser shell. A dividing partition **24** sets the tubes **21** apart from a similar group of heating tubes **25** which receive steam from a similar steam chest **26**, FIG. 5, located at the other end of the condenser.

Each of the several heating tubes **21**, **25** has a dead end closed by a wall **27** except for a suitable opening **28** for draining condensed steam, and another opening **29** through which steam is vented on the steam space of the condenser. Steam is supplied to the steam chest **23**

through an inlet 30 and is supplied in equal amount to the steam chest 26 through a similar connection.

A group of the condensing tubes is set apart at the center of the bank of condensing tubes 12 by vertically disposed plates 31, 32, which are arranged to intersect and abut either side of each supporting plate and the tube sheets to partition the condenser laterally from end to end. These vertical plates, together with capping plates 33, enclose the air-cooling section 34 on three sides. An opening 35 in each of the respective supporting plates effects pressure equalization throughout the length of the air cooler 34, and air and non-condensable gases are exhausted from the air cooler through an air vapor offtake conduit 36.

An induced draft or suction section 37 containing cooling tubes is partitioned from the condensing tubes at either side by vertical plates 38 and 39 which likewise extend between the tube-supporting plates 14 and to the condenser tube sheets. A horizontal plate 40 extends between the upper edges of each pair of plates 38 and 39 in a manner to form a hood totally enclosing the top of the induced draft section. Each horizontal plate 40 is provided with a vent 41 in each compartment formed by the supporting plates for the discharge of air and vapor to the air-cooling section. Each of the tube-supporting plates 14 has an opening 42 which permits communication between the spaces of the draft-inducing section at either side of each supporting plate. It is desirable that the height of the bank of cooling tubes contained in the draft-inducing section 37 be maintained relatively low in order to reduce the frictional resistance of the steam flowing through this section.

Perforated trays 43 are located below the condensing tubes and above the steam heated tubes 21, 25. They are supported by angle irons 44 which extend between the supporting plates 14 and also between the end walls of the shell and the nearest supporting plate. The upstanding flanges 45, 46 along their inner edges form barriers with the plates 38 and 39 so that a portion of the steam descending in the open steam lanes 47, 48 is caused to travel beneath the trays and across the steam heated tubes in its advance to the induced draft section 37. The amount of steam passing through the deaerating section and the induced draft section bears approximately the same relation to the total amount of steam entering the condenser as the number of tubes in the induced draft section bears to the total number of condensing tubes. In the illustrated embodiment approximately 3 to 5 percent of the total steam is diverted through the deaerating section.

The perforated trays receive all of the condensate draining from the condensing tubes. Make-up water and water from heater returns and trap returns may also be discharged into the trays, so that all of the water passing from the condenser will be deaerated. The perforated trays are provided with small holes spaced relatively far apart as, for example, ⅛ inch holes spaced one inch apart. The distribution of the water in widely spaced streams effects a relatively thin film of water evenly distributed over the outside surfaces of the tubes 21, 25 so that every particle of the condensate is exposed to steam flowing through the deaerating section. Condensate is thereby obtained with very little or no depression of temperature below the boiling point corresponding to the condenser vacuum. The saving of heat results in improving the over-all efficiency of a plant.

The deaerating effect obtained by the small percentage of the total steam entering the condenser which is diverted to the deaerated section is supplemented by the additional deaerating effect obtained from the heat given off by steam supplied to the tubes 21, 25 at a higher heat level than the steam in the condenser. Steam can be supplied to the steam heated tubes from a bleed point on a turbine or from an auxiliary exhaust or other source where the level of heat is higher than that obtaining in the condenser. Saturated or wet steam is preferable. A uniform evaporation effect is maintained throughout the lengths of the heating tubes by the continuous draining and venting of the tubes through the drain openings 28 and the vents 29. If the evaporative effect produced by the steam within the heating tubes amounts to, say, 2% of the condensate draining from the trays, then approximately the same amount of the steam supplied to the heating tubes will condense and drain through the drain openings 28 into the main condenser space.

The pressure of the steam inside of the heating tubes is controlled to maintain the degree of evaporation desired. This is attained with a differential pressure control system by which the difference in pressure between the vacuum of the condenser and the pressure of the steam in the heating tubes is automatically maintained substantially constant. Such a pressure regulating system is schematically illustrated in FIG. 5. This system includes a differential pressure control valve 51 having a diaphragm 52, one side of which is connected to the steam space of the condenser by a pipe 53, and the other side of which is connected to the steam chests 23 and 26 by piping 54 and 55. The diaphragm 52 is secured to a valve stem 56 which carries a disk 57 aligned opposite a bleed nozzle 58 to which air lines 59 and 60 are connected. A manually adjustable device 61 is provided for adjusting the spring loading on the diaphragm.

A decrease of differential pressure on the diaphragm 52, such as results from a decrease in the pressure within the heating tubes 21, 25, assuming no change in the vacuum of the condenser, causes the disk 57 to lower and to thereby restrict the flow of air from the nozzle 58, whereupon the pressure in the line 60 is increased. The pressure in the line 60 subsides as the disk 57 is raised in response to increase of differential pressure, as when the pressure in the heating tubes 21, 25, increases without change in the vacuum of the condenser.

63 is a pilot-operated pressure-reducing valve which fluctuates to increase or reduce the flow of air from a supply line 65, depending upon the pressure of the operational air in the downstream line 59 and in the pilot line 64 as controlled by the action of the differential pressure control valve 51. Valve 63 tends to close in response to falling pressure in the lines 59 and 64, and tends to open in response to rising pressure in the lines 59 and 64, so that a more or less constant pressure of operational air is maintained in the line 59 within whatever predetermined limits are imposed on the operation of the valve 63 in combination with the control valve 51.

The steam supply for the heating tubes in the deaerating section is conducted through a pipe 66, a steam regulating valve 67 and the piping 55. The differential pressure valve 51 is responsive to the difference between the pressure inside of the heating tubes and the pressure in the steam space of the condenser. As the differential pressure lowers, valve 51 operates to restrict the bleeding of air from the nozzle 58 and thus produce an increase in pressure in the line 60 which causes the steam regulating valve 67 to permit more steam to flow from the steam supply line 66, through the valve 67 and pipe 55 to the heating tubes 21 and 25.

As the differential pressure rises, the differential pressure control valve 51 functions to allow decrease in air pressure in the line 60 and on the main steam regulating valve 67 which is accordingly operated to restrict the flow of steam to the pipe 55 and to the heating tubes 21 and 25. The differential pressure control valve 51, the air-operated pilot 63 and the main steam regulating valve 67 are standard instruments, but any other suitable instruments or system for controlling the supply of steam to the heating tubes may be employed. Conventional shut-off valves 70, 71 and 72 are provided to enable shutting down the system by which steam is supplied to the deaerating section.

A differential control pilot which can be set to maintain a pressure difference between the inside of the steam heated tubes and pressure within the condenser space ranging from 0 to 25 inches of mercury pressure is satisfactory for most installations. For any given area of heat transferring surface the differential pressure maintained determines the amount of evaporating effect obtainable. Differential pressures ranging from 2 to 10 inches of mercury pressure are capable of producing an evaporation effect of from about 2 to 5 percent of the condensate falling over the heating tubes. An operator is enabled to set the differential control pilot **51** to obtain condensate with the lowest oxygen content desired.

A condenser provided with the deaerating system of the present invention is capable of reducing the oxygen content of the condensate to 0.002 or less parts of oxygen per million parts of water. It has also been found that a condenser may be operated under less than full steam load conditions and even below half load conditions and/or any vacuum condition with no substantial diminution in the effectiveness of the removal of oxygen from the water.

While the form of apparatus herein shown and described is admirably adapted to fulfill the objects primarily stated, it is to be understood that it is not intended to confine the invention to the one form of embodiment herein disclosed, for it is susceptible of embodiment in various forms all coming within the scope of the claims which follow.

What is claimed is:

1. In a condenser for condensing the exhaust steam of a heat engine, a condenser shell having an inlet for the admission of exhaust steam to a steam space within said shell and an outlet for condensate, condensing tubes in said steam space, a deaerating section in said shell, said deaerating section comprising a plurality of tubes disposed below said condensing tubes, said tubes of said section having dead ends with drainage and venting openings adjacent their dead ends, said dead ends terminating within said shell, means for supplying steam to the tubes of said section, differential pressure regulating means responsive to the vacuum in said steam space and to the pressure of steam supplied to the tubes of said deaerating section for controlling the pressure of steam in the tubes of said deaerating section, said differential pressure regulating means operable to maintain a substantially constant pressure difference between the pressure in said steam space and the pressure of steam in said tubes of said deaerating section, means for inducing steam to flow from said steam space and across the outsides of the tubes of said deaerating section, and means for evacuating air released from the condensate falling through said deaerating section.

2. In a condenser for condensing the exhaust steam of a heat engine, a condenser shell having an inlet for the admission of steam to a steam space within said shell, an outlet for condensate and air-vapor take-off means for evacuating air and other non-condensable gases, condensing tubes in said steam space, a deaerating section below said condensing tubes, said section containing a plurality of heating tubes, each of said heating tubes having openings providing for leakage of condensed heating steam and for the escape of small quantities of the heating steam from said heating tubes to the interior of said shell, means for supplying steam to said heating tubes, means intermediate said condensing tubes and said heating tubes for collecting condensate draining from said condensing tubes and for distributing the condensate in streams over the outsides of said heating tubes, said heating tubes being arranged to allow steam from said steam space to flow over the outsides of the heating tubes and through streams of condensate falling through the deaerating section, and differential pressure regulating means responsive to the sub-atmospheric pressure prevailing within said shell and to the pressure of steam supplied to said heating tubes for controlling the supply of steam to said heating tubes, said differential pressure regulating means operable to maintain a substantially constant pressure difference between the pressure of steam in said steam space and the pressure of heating steam in said heating tubes.

3. In a condenser for condensing the exhaust steam of a heat engine, a condenser shell having an inlet for the admission of exhaust steam to a steam space within said shell and an outlet for condensate, condensing tubes in said steam space, an air cooling section comprising a group of cooling tubes within a chamber having walls setting said cooling tubes apart from said condensing tubes, said walls providing an opening for the admission of air to said air cooling chamber, means for evacuating air from said air cooling chamber, a hood having an opening for discharging air towards the opening of said air cooling chamber, said hood comprising walls partially enclosing a plurality of said condensing tubes, a deaerating section in said shell, said deaerating section comprising a plurality of tubes disposed below the condensing tubes, said tubes of said deaerating section having dead ends provided with draining and venting openings opening into said shell, means for receiving condensate falling from said condensing tubes and for distributing said condensate over the tubes of said deaerating section, said receiving and distributing means comprising perforated trays disposed below said condensing tubes and above said deaerating section, means for supplying steam to the entrance ends of the tubes of said deaerating section, and means for controlling the pressure of the steam in the tubes of said deaerating section to maintain a substantially constant pressure difference between the pressure of steam in said steam space and the pressure of the steam in said tubes of said deaerating section.

4. In a condenser for condensing the exhaust steam of a heat engine, a condenser shell having an opening for the admission of exhaust steam to a steam condensing space within said shell and an outlet for condensate, condensing tubes in said steam condensing space, an air cooling chamber contained in said shell but set apart from said steam condensing space, means for removing air and vapor from said air cooling chamber, a deaerating section contained in said shell and comprising a plurality of tubes, means for collecting condensate falling from said condensing tubes and for distributing the condensate in fine streams over said tubes of said deaerating section, a draft-inducing section intermediate said air cooling chamber and said deaerating section for drawing a portion of the exhaust steam from said steam condensing space across the tubes in said deaerating section so that water falling from said condensate distributing means and dripping from the tubes of said deaerating section is heated and partially evaporated by contact with the exhaust steam flowing across the tubes of the deaerating section, means for supplying heating steam to the tubes of said deaerating section, said steam-supplying means including piping connected to the tubes of said deaerating section and a source of steam supply, a steam pressure regulating valve in said piping, means for operating said valve to vary the pressure of steam delivered through said piping to the tubes of said deaerating section, said operating means including a differential pressure valve having a flexible diaphragm separating enclosed chambers at either side of the diaphragm, a pipe line connecting one of said chambers to said steam-condensing space, a pipe line connecting the other of said chambers to said piping on the downstream side of said steam pressure regulating valve, and means for transmitting the effect of differential pressure on said diaphragm to position said pressure-regulating valve, whereby a change in pressure in said steam space effects a change in the pressure of heating steam delivered to said tubes of said deaerating section to control the evaporating effect of said tubes of said deaerating section with respect to the sub-atmospheric pressure in said steam space.

5. In a condenser for condensing the exhaust steam of a heat engine, a condenser shell having an inlet for the admission of exhaust steam to a steam space within said shell, said shell providing a floor for said steam space and an outlet for condensate in said floor, condensing tubes in said steam space, a deaerating section including a group of heating tubes located within said shell below said condensing tubes and above said floor, a steam supply line for supplying heating steam to said heating tubes, conduit means connecting said steam supply line to said heating tubes, said heating tubes terminating in said deaerating section and having openings at their terminal ends for the escape of fluids into the deaerating section, said deaerating section in open communication with said steam space at at least one side for the entry and flow of steam substantially horizontally across the deaerating section and about the respective tubes of said group of heating tubes, said heating tubes distributed in special relationship in said deaerating section and above said floor in a manner to expose the outsides of the heating tubes to contact by streamlets of condensate coming from the condensing of steam about said condensing tubes and falling within an area substantially coextensive with the horizontal area encompassed by said group of heating tubes, means for inducing flow of steam from above said deaerating section into and across said deaerating section about the outsides of said heating tubes, whereby said streamlets of condensate and condensate received on and forming films on said heating tubes are directly contacted by said flow of steam across said deaerating section, a valve mounted in said conduit means, means for operating said valve in response to the difference in pressure between the pressure in said steam space and the pressure in said heating tubes whereby said valve controls the pressure of the steam in said heating tubes in respect to the pressure in said steam space, and means for evacuating air and non-condensable gases released from the condensate dripping down through said deaerating section.

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