July 9, 1968 L. HELLER ET AL 3,391,911

MIXING CONDENSERS

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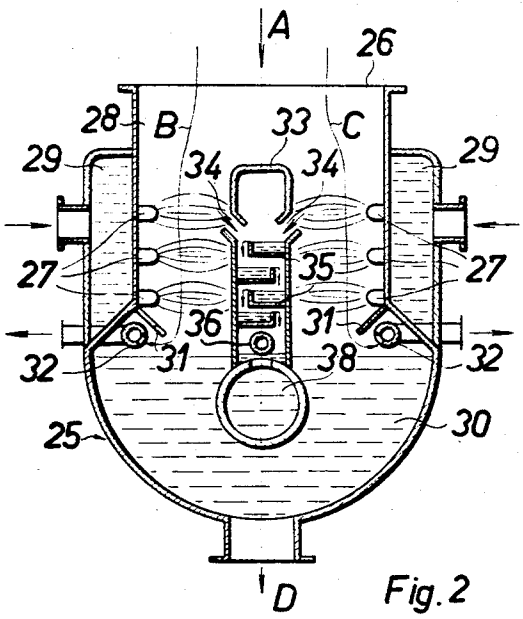


Fig. 2

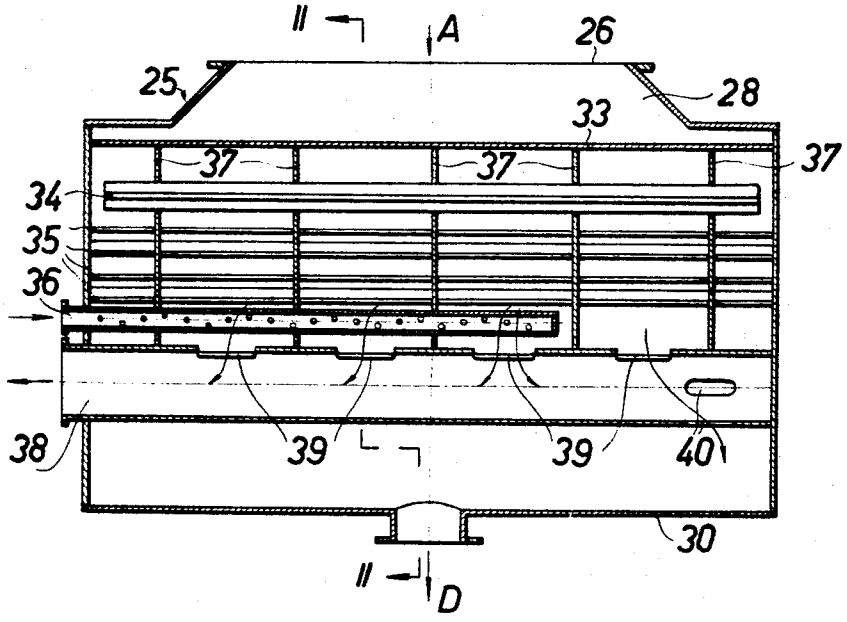


Fig. 1

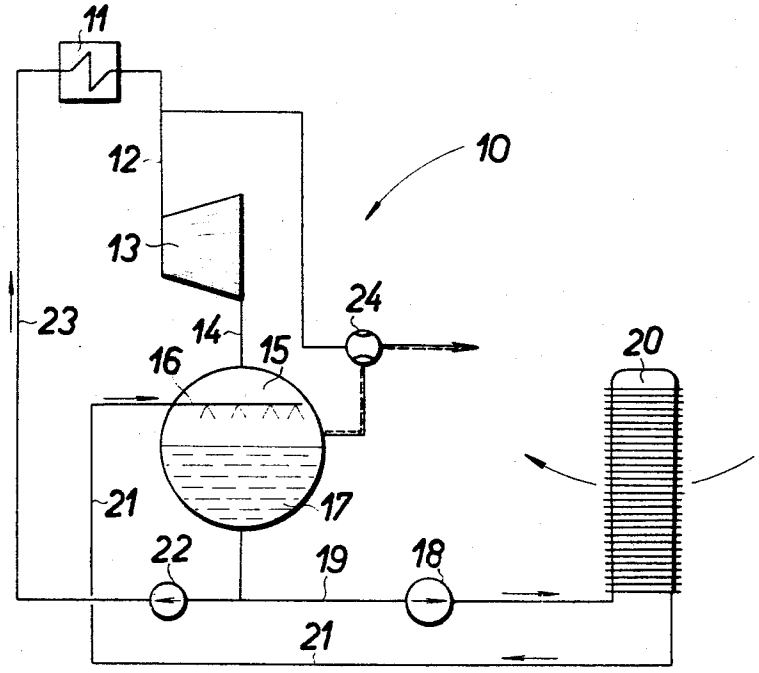


Fig.3

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MIXING CONDENSERS

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ABSTRACT OF THE DISCLOSURE

A mixing condenser for use in steam turbine plants has a feed water collecting vessel in its condenser chamber, so arranged that it receives condensate in the upper parts of the condenser chamber at a region of relatively low air concentration. For this purpose, the vessel has its intake located at the upper part of the condenser chamber in the neighborhood of the steam exhaust of the turbine opposite to the topmost water nozzles of a series of such nozzles.

This invention relates to mixing condensers, i.e. condensers in which a vapor is condensed by contact with the liquid phase of the same substance.

It is known that for heat-engine generating stations for producing electric energy wherein the generally conventional water cooling arrangements are employed for cooling the condensers of the generating stations, it has recently been proposed to provide a condenser system in which the cooling is effected by means of atmospheric air. These air-cooled condenser systems are principally characterized by the fact that they are equipped with so-called mixing condensers in lieu of the heretofore universally employed surface condensers. In such systems, the mixing condensers must be adapted to and capable of satisfying all the requirements and conditions which are of importance as far as consideration of the steam cycle is concerned.

Among these requirements and conditions may be mentioned the following:

At the time it leaves the condenser system, the cooling water which serves to condense the exhaust steam coming from the turbine of the heat-engine generating station should have a temperature equal, as far as possible, to the temperature of saturated steam at the steam pressure existing in the condensers. This is important for reasons of economy in the steam cycling operation.

A further requirement is that the condensate derived from the exhaust steam of the turbine should leave the condenser system suitably degassed, so that corrosion of the equipment located between the condensers and the boiler or evaporator system, as well as corrosion of the evaporator system itself, can be avoided.

Provision should also be made for the actuation of the condenser system, concurrently with the starting of the steam turbine and prior to the attainment of normal operating conditions, in a manner corresponding to the starting requirements of the steam turbine and the boiler or evaporator operation.

It is an object of the present invention, therefore, to provide a mixing condenser construction enabling the foregoing requirements and conditions to be efficaciously satisfied.

A more particular object of the present invention is the provision of a mixing condenser construction in which exhaust steam condensate to be recycled to the evaporators or boilers is extracted from the condenser system at a region of relatively low air concentration.

A related object of the present invention is the provision of a mixing condenser construction as aforesaid having incorporated therein means for subjecting the incoming exhaust steam to a condensing water spray near the condenser inlet, and means for receiving and collecting the resultant initially formed condensate and condensing water in such a manner as to render the boiler feed water as free of air and impurities as possible.

In general, these objectives are attained in accordance with the present invention through the provision, in a mixing condenser wherein the exhaust steam of the steam turbines which enters the condenser through an intake opening is condensed by means of cooling water injected through nozzles or spray heads, of a water collecting vessel having an outlet duct and at least one inlet opening, with the said inlet opening being disposed at the end of the water collecting vessel facing the said intake opening of the condenser and being directed toward the nozzles.

The foregoing and other objects, characteristics and advantages of the present invention will be more clearly understood from the following detailed description of a representative embodiment of the invention when read in conjunction with the accompanying drawings, in which:

FIG. 1 is a longitudinal sectional view of a mixing condenser constructed in accordance with one embodiment of the principles of the present invention;

FIG. 2 is a sectional view taken along the line II—II in FIG. 1; and

FIG. 3 is a diagrammatic representation of a power generating station including a conventional mixing condenser the cooling water of which is air-cooled, and serves to illustrate the operating principles of such installations.

Referring now first to FIG. 3 for a general description of operating principles, in a power generating station **10** steam is formed in a boiler or evaporator **11** and is fed via conduit means **12** to a steam turbine **13**. The exhaust steam from the turbine flows via conduit means **14** into a mixing condenser **15** in which it is condensed by means of cooling water injected or sprayed thereinto through nozzles **16**. A part of the condensate and cooling water **17** accumulated in the condenser **15** is caused by means of a cooling water circulating pump **18** to flow through conduit means **19** to and over air-cooled heat exchange elements **20**, from whence the cooled water is recycled to the nozzles **16** in the mixing condenser **15** via conduit means **21**. Another part of the water accumulated in the mixing condenser, in an amount corresponding to the quantity of condensed steam, is fed by means of a condensate pump **22** via conduit means **23** to the boiler **11**. After the cooling water and condensate become intermingled to form the liquid body **17** in the mixing condenser **15**, of course, the boiler feed water (in conduit means **23**) and the cooling water (in conduit means **19**) are identical.

The problem of adhering to the above referred to operating requirements and conditions in such a condenser system employing air-cooled cooling water leads to difficulties, however, in matters of construction and maintenance of the system. One of these difficulties is that the joint between the relatively large outlet port of the steam turbine **13** and the inlet port of the mixing condenser **15**, cannot be manufactured completely air-tight. As a result, air constantly leaks into the mixing condenser due to the existence of the pressure differential between the inner sub-atmospheric pressure and the surrounding atmospheric air pressure. To remove such leaked-in air, a vacuum pump **24** is generally employed. A particular consequence of the presence of this air in the condenser, however, is the fact that at different parts of the condenser chamber respectively different air concentrations arise, in such a manner that the air content of the con-

denser is relatively smaller at the steam intake location and relatively greater at the air exhaust location.

Another consequence of the presence of air in the condenser is that the temperature in the condenser chamber varies from place to place, corresponding at any given point to the temperature associated with the partial steam pressure existing at that point. This temperature is always less than the temperature of saturated steam the pressure of which corresponds to the total pressure existing in the condenser chamber. From this it follows that the cooling water sprayed or injected into the condenser chamber can only reach a temperature which corresponds to the temperature of the steam at the point in question. Actually, even this degree of heating cannot be achieved, since the heat transfer capacity between the injected water and the steam at each given point in space is considerably impaired by the air located at that point.

In the presently conventional mixing condensers, therefore, the cooling water temperature at each given location never reaches the saturated steam temperature corresponding to the condenser pressure. Moreover, at these locations a certain quantity of air is absorbed by the cooling water. The higher the concentration of air at the location in question, of course, the greater is the quantity of air absorbed. Accordingly, inasmuch as the air concentration constantly increases from the steam intake location in the direction of the air exhaust location, it is found that the quantity of air absorbed by the cooling water is at a minimum at the steam intake location and at a maximum in the vicinity of the air exhaust location.

In the conventional mixing condensers, the injected cooling water and the condensate formed from the condensed steam form a mixture which collects at the bottom of the condenser, i.e. in the "water space" thereof. From here it is fed in part as feed water to the boilers of the generating station and in part as cooling water to the heat exchangers of the condenser system. The boiler feed water thus is the same as the cooling water in terms of the gas content thereof.

One of the important aims of the present invention, therefore, is to provide an arrangement which will enable the feed water fed to the boilers or evaporators from the mixing condensers to contain substantially lesser quantities of air than the cooling water fed to the heat exchangers. As mentioned hereinbefore, in accordance with the present invention, this is achieved by virtue of the fact that the feed water to be conducted to the boilers is extracted from the condensation chamber at a location where the concentration of air is at a minimum, so that the temperature of the cooling water injected into the condenser chamber approaches to the greatest possible extent the temperature of saturated steam corresponding to the condenser pressure. Inasmuch as at this location the concentration of air is at a minimum, while also the water temperature is practically the same as the temperature of saturated steam, the absorbed quantity of air is substantially less than the quantities of air which are absorbed by the quantities of water injected into the condenser at the other locations.

A mixing condenser according to the present invention can also be employed in installations in which the oxygen content of the boiler feed water is to be held especially low. To this end, according to a further aspect of this invention, means are provided to enable the extracted condensate to be still further heated by added steam, thereby to decrease the oxygen content of the condensate.

Referring now in particular to FIGS. 1 and 2, the mixing condenser **25** according to the present invention there illustrated has an intake opening **26** through which the exhaust steam from the steam turbine (not shown) flows in the direction of the arrows A, B and C into the condenser. Along the path of flow of the steam are arranged two sets of opposed nozzles **27** which are arranged in a plurality of substantially parallel rows, as viewed in the direction of flow of the steam, and through which cooling water can be sprayed or injected into the upper section **28** of the condenser chamber from supply spaces **29**. As will be readily apparent, the cooling water sprays serve to condense the steam flowing past them, and the arrangement is such that by the time the steam has traversed all of the nozzles it is almost entirely condensed. The condensate and water reaching the lower half **30** of the condenser chamber accumulates there and ultimately flows out in the direction of the arrow D to be fed to heat exchangers (such as **20** in FIG. 3) under the action of a suitable circulating pump (such as **18** in FIG. 3).

Arranged behind the last or bottom rows of nozzles **27** at the oposite sides of the condenser chamber section **28**, as viewed in the direction of steam flow, are two baffles **31** which over hang a pair of perforated exhaust ducts or pipes **32**. It will be understood that since a certain amount of air will be entrained in the steam entering the condenser **25** through the intake opening **26**, the air concentration per volume of the uncondensed steam flowing past the nozzles constantly increases, until the air concentration just above the body of liquid condensate in the chamber section **30** is at a maximum. The mixture of still uncondensed steam and air reaching this region thus leaves the condenser through the exhaust pipes **32**, which ensures that such air will not be absorbed by the accumulated condensate.

Positioned centrally within the condenser **25** is a water collecting vessel **33** which is closed at the top end facing the steam intake opening **26** of the condenser. On its opposite sides, which are generally imperforate, the vessel **33** is provided with two elongated openings **34** extending parallel to each other longitudinally of the condenser and facing the respective uppermost rows of nozzles **27** in the chamber section **28**. Below these openings in the vessel **33** are arranged staggered troughs **35** the lowermost one of which overlies a perforated steam feed-in pipe **36** extending partly through the vessel and parallel to the openings **34**. The interior of the vessel **33** is further subdivided into a plurality of compartment-like sections by partitions **37** which are disposed perpendicularly to the pipe **36** and openings **34**. The bottom end of the vessel **33** is disposed in the condensate-receiving chamber section **30** of the condenser and is defined by a longitudinal duct **38** which is provided with a plurality of apertures **39** at that part of its periphery directed upwardly to the interior of the vessel **33**. Adjacent one end, beyond the innermost end of the steam feed-in pipe **36**, the duct **38** is further provided with a plurality of openings **40** which establish communication between the interior of the duct and the surrounding condenser chamber section **30**. The open end of the duct **38** exteriorly of the condenser is, of course, connected with a condensate pump (such as **22** in FIG. 3) leading to the boilers or evaporators of the generating station.

The manner of operation of the mixing condenser **25** according to the present invention in a power generating station is as follows:

The exhaust steam from a turbine enters the condenser via the intake opening **26** and condensation starts as the steam is contacted by the uppermost sprays of cooling water emanating from the top nozzles **27**. Some of the condensate thus formed, together with some of the water from these nozzles, enters the water collecting vessel **33** through the longitudinal openings **34**. As will be readily understood, therefore, since the water collecting vessel **33** is so arranged in the condenser chamber that only the condensate or water at the level of the uppermost row of nozzles enters the vessel, and since the air concentration in the steam in the region of the uppermost row of nozzles is at a minimum, the water or condensate entering the vessel at this level also contains the least possible quantity of air.

The condensate which has entered the water collecting vessel **33** flows downwardly therethrough over the troughs

35, during which time it comes in contact with steam introduced through the steam feed-in conduit **36**, whereby the air concentration of the condensate is reduced still further. The water which accumulates in the bottom of the collector vessel flows directly from the duct **38** to a condensate pump, such as illustrated at **22** in FIG. 3.

The inlet openings **34** of the water collecting vessel are so dimensioned that they permit a flow of water therethrough which exceeds the quantity of feed water required to be fed to the boilers. The condensate pump, however, extracts only a predetermined quantity of water which is identical with the quantity of steam condensed in the condenser. The excess water flows through the openings **40** into the chamber section **30** of the condenser. Thus, in view of the fact that more water than is required flows into the collecting vessel **33**, an adequate water supply for the condensate pump during operation of the system is always ensured.

When the system is being started up, of course, it is possible that there may not be sufficient quantities of water being fed by the condensate pump or the circulating pump (such as **18** in FIG. 3), so that it might under ordinary circumstances be impossible to secure an adequate flow of water through the inlet openings **34**. At such time, however, a corresponding quantity of water flows out of the chamber section **30** of the condenser into the duct **38** at the bottom of the water collecting vessel **33** via the openings **40** in the duct. In this manner, an adequate supply of water for the condensate pump is assured even when no water from the atomizer nozzles **27** enters the collecting vessel. As a concomitant thereof, the oxygen content of the water flowing through the condensate pump may rise. Nevertheless, inasuch as this can occur only for the relatively short duration of each starting period, the increase in oxygen content is not inimical to the operation of the system.

The added steam fed into the collecting vessel **33** through the perforated pipe **36** enables a further degassing of the water accumulated in the collecting vessel to be achieved. It should be noted that for economic reasons it is advantageous to feed this added heating steam in such a manner that only the required quantity of condensate is heated. As has already been stated, in order to provide a margin of safety, more condensate than is necessary is accumulated in the vessel **33**, the quantity of the water being proportional to the length of the inlet openings **34**, and these inlet openings correspondingly being longer than would be necessary for the actual condensate requirements. Accordingly, the steam feed-in pipe **36** is shorter than the said inlet openings, its length being determined in such a manner that it will heat only the quantity of condensate or water flowing to the boilers. It is for this purpose that the pipe **36** is perforated over its entire length, so that the outflowing water is uniformly warmed over a region corresponding to the length of the pipe. At the same time, the partitions **37** serve to prevent the steam from coming into contact with the outflowing condensate over the entire length of the water collecting vessel **33**.

For steam turbines provided with multi-stage boiler feed water preheaters, it is possible in accordance with the present invention to derive the steam employed for degassing from that quantity of steam which is fed in through the pipe **36** and evaporated from the water. The condensate accumulated in the lowest pressure feed water preheater stage is suited for this purpose, since its pressure and temperature are always higher than the condenser pressure or the temperature existing in the condenser. By means of such an arrangement, the degassing of the condensate can be more economically effected than when bled steam is fed in through the pipe **36**.

It is to be understood that the foregoing disclosure of a preferred embodiment of the present invention is for purposes of illustration only, and that a number of changes and modifications may be made in the structural features and relationships set forth without any departure from the spirit and scope of the present invention as defined in the hereto appended claims.

Having thus described the invention, what is claimed and desired to be secured by Letters Patent is:

1. In combination with a mixing condenser having an intake opening for admitting exhaust steam from a steam turbine into a condenser chamber, said condenser chamber having an upper section and a lower section, said condenser chamber lower section defining a water accumulation space, and nozzle means disposed in said condenser chamber upper section for spraying cooling water into said condenser chamber for condensing said steam, a portion of said condensate and cooling water being recycled as boiler feed water, the improvement comprising a water collecting vessel disposed in said condenser chamber having a top wall and side walls, said water collecting vessel top wall facing said condenser chamber intake opening, said condensing chamber being formed with an aperture in the wall thereof, said water collecting vessel having an outlet duct extending through said aperture for discharging water from said water collecting vessel outside said condenser chamber for recycling as boiler feed water and at least one inlet in a side wall facing said nozzle means proximate to said condenser chamber intake opening, said water collecting vessel inlet being operative to admit a portion of said cooling water and condensate, said condenser camber water accumulation space being adapted to receive the balance of said cooling water and condensate, and a perforated steam feed-in pipe arranged in said water collecting vessel for admitting steam into said water collecting vessel to enhance degassing of water collected in said water collecting vessel, whereby the water admitted at said water collecting vessel inlet for discharge from said outlet duct as relatively air-free boiler feed water is retained apart from the water accumulated in said water collecting vessel.

2. In combination with a mixing condenser as recited in claim **1**, said outlet duct being disposed in said lower section of said condenser chamber and having a discharge outlet outside said chamber, said outlet duct having at least one aperture therein spaced from said discharge outlet to establish fluid communication between the interior of said duct and the surrounding water accumulation space.

References Cited

UNITED STATES PATENTS

458,540	8/1891	Ross	261—113 X
877,445	1/1908	McPherson	261—113 X
1,805,635	5/1931	Primrose	261—113
2,558,222	6/1951	Parkinson	261—113
2,667,433	5/1954	Kretzschmar	55—39
2,712,929	7/1955	Wilson	261—113
2,903,251	9/1959	Thrift	261—114
3,158,666	11/1964	Heller et al.	261—118
3,260,036	7/1966	De Bellis	261—118 X

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