CONDENSER WATER CIRCULATING SYSTEM

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4 Sheets-Sheet 4
My invention relates to condensing systems and particularly to condensing systems of the character embodying a surface condenser for liquefying or condensing steam or other gaseous media and a pump for circulating cooling water, whereby the condenser, and it has for an object to provide a system of the character designated which shall be more compact, entail less weight, be more reliable and efficient in operation, and less costly to manufacture and install than the systems of this character heretofore provided.

As provided in the past, steam condensing systems such as installed, for example, in both land and marine power plants embody a condenser, usually of the surface type, and a pump for circulating cooling water through the tube nest of the condenser, the condenser and the pump being constructed as separate pieces of apparatus and installed as separate entities in the power plant. In such arrangements, the pump is connected between the condenser and the source of water supply by suitable pipes, valves, fittings, etc., all of which entail considerable weight, occupy considerable space, impair the efficiency and increase the manufacturing cost of the system.

In the copending application of J. P. Lidack, Serial No. 482,881, filed September 18, 1930, entitled Condensing system and assigned to the Westinghouse Electric and Manufacturing Company, there is disclosed and claimed a condensing system wherein the condenser and the condenser circulating pump are both coordinated into a single structural assembly. As disclosed in the latter application, a pump of the propeller type is employed, which pump is disposed within the confines of one of the water boxes and has its driving motor supported upon the other water box, the drive shaft connecting the motor and the propeller extending longitudinally through the condenser shell. While such an arrangement is applicable to condensers of both the vertical and horizontal types, the specific arrangement disclosed in the aforesaid copending application is especially applicable to condensers of the vertical type. I have, therefore, conceived of an arrangement of condenser circulating system wherein the circulating pump, its driving motor and one water box of the condenser are coordinated into a single structure and which inventive idea, although applicable to both horizontal and vertical types of condensers, is especially applicable to condensers of the horizontal type.

In accordance with my invention, I locate the propeller in the inlet conduit joining with the water box and I mount the motor for driving the propeller exteriorly of and upon the same water box. The drive shaft extends from the motor and is secured to the propeller in the intake conduit, the drive shaft projecting into the water box and extending across the latter. In this way, all of the pumping apparatus is incorporated in one of the water boxes of the condenser, the propeller being located directly within the intake conduit to the condenser and the drive motor for the propeller being located exteriorly where it is readily accessible. In addition, the arrangement is such that the drive motor and the propeller are so supported upon the water box that they may be readily removed, as a single assembly, from the condenser. The arrangement is such that cleaning or plugging of any of the condenser tubes is not interfered with.

It is, therefore, a more particular object of my invention to provide a condenser circulating system wherein both the pump and its driving motor are so coordinated with one of the water boxes of the condenser that the water box and the pump form a single structural assembly.

These and other objects are effected by my invention as will be apparent from the following description and claims, taken in connection with the accompanying drawings and forming a part of this application, in which:

Fig. 1 is a view, partly in section and partly in elevation, of one form of condenser circulating system arranged in accordance with my invention, which form is especially applicable to land installations;

Fig. 2 is an enlarged, partial, sectional...
view of the pump portion of the system shown in Fig. 1. Fig. 3 is a view, in side elevation, of another form of condenser circulation system arranged in accordance with my invention, which form is applicable to both land and marine installations.

Fig. 4 is a view, partly in cross-section, and partly in elevation, taken on the line IV—IV of Fig. 3.

Fig. 5 is a cross-sectional view of another embodiment of my invention which is similar to that shown in Figs. 3 and 4 with the exception that the axis of the circulating pump is disposed angularly.

Fig. 6 is a cross-sectional view of still another embodiment of my invention which is similar to the embodiments shown in Figs. 3 and 4 with the exception that the axis of the circulating pump is disposed horizontally.

Fig. 7 is a cross-sectional view of a condenser of the divided water box type equipped with a single pump for circulating cooling water through both sections of the tube nest, the pump being arranged in accordance with my invention.

Fig. 8 is a partial, sectional view, taken on the line VIII—VIII of Fig. 7.

Fig. 9 is a cross-sectional view of a condenser of the divided water box type wherein a separate pump is provided for each section of the tube nest, the pumps being arranged in accordance with my invention.

Fig. 10 is a cross-sectional view from another embodiment of my invention wherein the intake conduit which supplies the cooling water to the condenser projects within the water box.

Fig. 11 is a view, in longitudinal sectional elevation, of the condenser circulating system shown in Fig. 10.

Fig. 12 is a view, in longitudinal sectional elevation, of another embodiment of my invention wherein the axis of the circulating pump is disposed angularly with respect to the condenser tube sheet.

Fig. 13 is a view, in longitudinal sectional elevation, which shows the application of my improved circulating system to a condenser of the multi-pass type.

Fig. 14 is a partial, sectional view taken on the line XIV—XIV of Fig. 13.

Fig. 15 is a partial sectional view, taken on the line XV—XV of Fig. 14.

Fig. 16 is a view, in transverse sectional elevation, of another embodiment of my invention wherein the axis of the circulating pump is disposed laterally of the condenser.

Fig. 17 is a view, partly in section and partly in elevation, showing the structure employed in several of the foregoing embodiments for supporting the prime mover from the condenser.

Referring now to Fig. 1, I show a steam condenser 9 embodying a shell structure 10 and a tube nest 11 disposed longitudinally within the shell structure and supported at its ends in suitable tube sheets 12. Suitable supports for the condenser are indicated at 13 and 13'. An inlet water box 14 is fixedly secured to the tube sheet 12 and to the shell 10, all as is well understood in the art. The water box 14 is provided in its front wall with a detachable cover 15 and with a lower depending inlet connection 16.

Disposed below the floor of the power plant is a suitable intake tunnel 18 which forms the source of water supply for the condenser. Secured to the inlet connection 16 and projecting downwardly below the level of the water in the intake tunnel 18 is a casing 19 having a converging inlet portion 21, a cylindrical throat portion 22 and a discharging portion 23. The casing 19 may be said to form, with the water box 16 of the water box, the intake conduit for the condenser.

Located in the cylindrical throat portion 22 of the casing 19 is a screw propeller 24 having secured thereto a vertically-extending drive shaft 25. Disposed adjacent to the propeller and on the discharge side thereof is a guide vane structure 26 embodying, as shown in Fig. 2, a plurality of circumferentially spaced, radially-extending guide vanes 28' for removing the twist or swirl from the water discharged by the propeller. The guide vane structure 26 is freely seated in the discharging portion of the casing so as to be readily removable from the casing upon upward withdrawal of the propeller and the drive shaft. It embodies a central bearing portion 30 (Fig. 1) which serves to retain the drive shaft in radial alignment.

The drive shaft 25 projects downwardly through the casing 19 and a water box 14 and projects out of the upper side of the latter through an opening 27. The drive shaft 25 extends transversely across the water box and may, as shown in the drawings, be provided with a cylindrical protective casing 28. Supported upon the upper side of the water box 14 is a prime mover, such as, for example, an electric motor 29 which is coupled to and supports the weight of the drive shaft 25.

As shown particularly in Fig. 17, the opening 27 in the side wall of the water box 14 is provided with a detachable cover plate 31 fitted with a water sealing gland 31'. A stool 32 is in turn supported upon the cover 31 in a detachable manner, the stool 32 transferring the weight of the motor 29 to the water box. The motor is preferably detachably secured to the stool 32, as by bolts 32'. It is provided with a motor shaft 33 which depends into the stool 32 and is connected to the propeller shaft 25 by a suitable coupling 34, the latter being located between the mo
tor and the cover 31. The stool 32 has adequate openings to afford ready access to the coupling.

The motor shaft 33 is provided with the thrust collar 35 engaging a suitable thrust bearing 34 which is embodied in the motor 29. The thrust bearing 34 serves to retain the drive shaft structure as well as the propeller secured thereto in their proper axial position. In addition, the steady bearing 30 of the guide vane structure 26 maintains the lower end of the drive shaft structure in radial alignment.

Should it be desired to remove the pumping apparatus from the system, the motor 29 may be detached by removal of the bolts 32. At the same time, the stool 32 and the cover 31 may be detached from the water box, whereupon the entire assembly may be withdrawn upwardly through the opening 27, the latter being of sufficient diameter to permit the guide vane structure 26 and the propeller 24 to pass therethrough.

Water is discharged from the condenser 9 through a discharge water box 35 having an outlet conduit 36 extending downwardly into a discharge tunnel 37.

From the foregoing description, the operation of my invention will be apparent. Upon driving the motor 29 being energized, the propeller 24 is rotated, and water is circulated from the intake tunnel 18 through the casing 19 and inlet connection 16 to the water box 14. Within the latter, the water is distributed to the tube nest 11 and circulates through the latter into the discharge water box 33 from whence it is conveyed to the discharge tunnel 37 by the conduit 38.

The water circulated by the propeller 24 passes through the guide vanes 26 which serve to remove the twist or swirl imparted to the water by the propeller. In passing through the diverging portion 23 of the casing, some of the velocity energy of the water is converted into energy in the form of increased static pressure.

From inspection of Fig. 1, it will be apparent that the circulating water is conveyed from the intake tunnel 18 to the water box 14 without any abrupt changes in the direction of flow. The circulation is as straight and direct as possible and, hence, friction losses are reduced to a minimum. Furthermore, the propeller may be disposed below the level of the water in the intake tunnel where it can operate most effectively. The propeller and its drive shaft are entirely housed within the condenser and the condenser intake conduit while the driving motor is disposed in such a position as to be readily accessible. The entire circulating pumping equipment may be supported in part or entirely upon the condenser and the provision of all pump foundations, valves, fittings, piping, etc. between the circulating pump and the condenser is dispensed with. As a result, the arrangement is extremely compact, light in weight and relatively less expensive to manufacture.

Referring now to Figs. 3 and 4, I show an arrangement wherein the propeller need not depend into an intake tunnel. The propeller in this case is disposed relatively close to the condenser, the pump casing 41 being made relatively short in length and having a flange portion 42 for connecting to an intake pipe. Such an arrangement is especially adapted for marine installations wherein the entire condenser arrangement is usually disposed below the water line. In this embodiment, the casing 41 embodies only the converging inlet portion 43 and the cylindrical throat portion 44, the inlet connection 45 of the water box 14 serving as the divergent portion of the pump casing. In this embodiment, the guide vane structure 46 is freely disposed in the bore of the inlet connection 45 so as to be readily removable with the propeller and the drive shaft assembly. The casing 41 and the inlet connection 45 define the intake conduit for the condenser. The motor is supported in the manner illustrated in Fig. 17.

Referring now to Fig. 5, I show an arrangement wherein the axis of the propeller, its drive shaft and driving motor are disposed angularly. Such an arrangement is especially applicable where the installation conditions are such that the inlet 46 of the intake conduit is located laterally of the condenser. Under such conditions, the pump casing embodies an elbow portion 47. The motor is supported in the manner illustrated in Fig. 17.

The latter embodiment is also especially applicable to installations where the headroom is limited. In this connection, it is noted that, with condensing systems arranged in accordance with my invention, it is not necessary to remove the pumping unit from the condenser by withdrawing the entire pumping structure vertically upwards, as described in relation to Fig. 1. Another method may be utilized which consists in loosening the coupling 34 (Fig. 17) and removing the motor 29, the stool 32, the cover 31 and the gland 31' from the condenser as well as detaching the front cover plate 15 from the water box. After this, the propeller 24 and the guide vane structure 26 may be withdrawn toward the opening 27 until the propeller and the guide vane structure are in front of the tube nest, the drive shaft 25 projecting outwardly through the opening 27. After this, the propeller drive shaft may be displaced angularly with respect to the tube sheet and drawn out through the front of the water box by the opening afforded by the removal of the cover plate 15. It will, therefore, be apparent that the pumping unit may be removed from the condenser in
installations where the headroom above the water box is limited.

In Fig. 6, the axis of the propeller and its driving motor are disposed in a horizontal position, the water inlet 48 being located laterally of the condenser. In this embodiment, the pump casing has an elbow portion 49 connecting with a horizontally-extending inlet connection 50 provided on the water box.

In Fig. 7, the water box 51 is provided with a central division wall 51' so that one half of the condenser may be operated while the tubes of the other half are being cleaned, all as is well understood in the art. In order that a single circulating pump may supply water to either or both sides of the condenser, there is interposed between the propeller casing and the water box a Y-fitting 52 with suitable cut out valves 53 installed between the branches of the fitting and the respective inlet connections 54 of the water box. The cooling water outlets are indicated at 55. In this embodiment, the drive shaft of the propeller extends upwardly through the central division wall 51', the latter being provided, as shown in Fig. 8, with a cylindrical boss 56 through which the shaft extends.

In Fig. 8, I also show a divided form of water box 58 having a central division wall 59 but, in the latter, separate and independent pumps 61 and 62 are provided for the respective sections of the tube nest.

In the previous described embodiments, the intake conduit terminated at the point where it joined the side wall of the water box. However, in accordance with my invention, the intake conduit may project through into the water box, as shown in Figs. 10 and 11. Referring to the latter, the water box 14 is provided with an inlet connection 65. The pump casing 66 is telescoped within the opening 65, it being detachably secured to the latter by a suitable flange 67 and bolts 68. The inlet connection 65 has ample bore so that the pump casing 66 may be withdrawn downwardly therethrough. As in the previous embodiment, the propeller 24 and the guide vane structure 26 are disposed in the casing 66 except, in this embodiment, they are disposed in front of the tube nest. However, as will be apparent from Fig. 11, the pump casing 66 is spaced, longitudinally, away from the tube nest 11 and the tube sheets 12 a sufficient distance as will not interfere with the admission of cooling water to that portion of the tube nest which is adjacent to the pump casing. In this embodiment, the drive motor 29 is supported upon the water box of the condenser in the manner shown in Fig. 17.

Referring now to Fig. 12, this embodiment shows a circulating system arranged in accordance with my invention wherein the axis of the shaft structure connecting the prime mover 29 to the propeller 24 is disposed angularly with respect to the tube sheet 12. This arrangement is especially applicable to installations wherein the intake conduit extends toward the water box in an inclined direction with respect to the axis of the condenser.

Referring now to Figs. 13 to 15, this shows a condenser 71 which is of the multi-pass type in that it is equipped with a water box 72 having an inlet connection 73 and an outlet connection 74. The water box 72 embodies a division wall 75 so as to form two passages of circulating water. At the other end of the condenser, the usual form of return water box 76 is provided. The propeller 24 and the guide vane structure 26 are located in the intake conduit and the cooling water is circulated through the lower half of the tube nest 11 after which it enters the return water box 76 and circulates in the opposite longitudinal direction, through the upper half of the tube nest 11, the water being finally discharged from the condenser through the outlet 74. The motor 29 is supported in the manner shown in Fig. 17.

In this embodiment, the drive shaft structure 77 connecting the propeller 24 to the prime mover 29 extends through an opening in the division wall 75 and, in order that the propeller 24 and the guide vane structure 26 may be removable with the drive shaft structure 77 through the opening afforded by the removal of the front cover 15, the division wall 75 is provided with an opening or cut away portion 78 extending inwardly from the front of the division wall a sufficient distance to accommodate the drive shaft structure 77. For closing this opening, a slide 79 is provided which extends between the drive shaft structure and the cover plate 15. Upon removal of the latter, this slide may be withdrawn from the water box, thereby leaving an opening in the division wall 75 sufficient to permit the drive shaft structure 77 to be withdrawn angularly through the front opening afforded by removal of the cover plate 15, such a method of disassembly having been previously described in reference to Fig. 5.

Referring now to Fig. 16, this shows an embodiment of my invention wherein the driving motor 29, the drive shaft structure 77 and the propeller 24 are disposed laterally of, that is, to one side of the tube nest 11. In this embodiment, the inlet connection 51 of the water box forms the casing for the pump, the inlet connection extending laterally from the side wall of the water box and depending in a downward direction, having at its lower end a suitable flange 82 for connection to the source of supply. This embodiment has the advantage that no portion of the pumping structure is disposed in front of the tube nest.
From the foregoing, it will be apparent that I have evolved a very compact and improved form of circulating system for a surface condenser wherein the pump is carried within one of the water boxes. It will be further obvious that the arrangement is susceptible of application to various installation requirements as is evident from the various embodiments illustrated. While, in each illustration, I support the driving motor for the propeller upon the water box, nevertheless it will be obvious that the driving motor may be disposed exteriorly of the water box and be connected to the propeller inside without involving this specific form of supporting means.

While I have shown my invention in several forms, it will be obvious to those skilled in the art that it is not so limited, but is susceptible of various other changes and modifications without departing from the spirit thereof, and I desire, therefore, that only such limitations shall be placed thereupon as are imposed by the prior art or as are specifically set forth in the appended claims.

What I claim is:
1. The combination with a heat exchanger including a tube nest and a water box disposed at one end of the tube nest, of means including said water box for conveying extraneous cooling water for the tube nest, a pumping element disposed in said conveying means for circulating the cooling water through the tubes of the nest and out of the heat exchanger, and a shaft of the pumping element to the prime mover, said drive shaft extending transversely of the water box.

2. The combination with a heat exchanger including a tube nest and a water box disposed at the end of the tube nest, said water box having front and side walls, means including said water box for conveying extraneous cooling water for the tube nest, a pumping element disposed within said conveying means for circulating the cooling water through the tubes of the nest and out of the heat exchanger, a prime mover disposed exteriorly of said conveying means, and a drive shaft connecting the prime mover and the pumping element, said drive shaft projecting through one of the side walls of the water box.

3. The combination with a heat exchanger including a tube nest and a water box disposed at each end of the tube nest, of means including one of said water boxes for conveying extraneous cooling water for the tube nest, a pumping element disposed within said conveying means for circulating the cooling water through the tubes of the nest and out of the heat exchanger, a prime mover disposed adjacent to the same water box and connected to the pumping element for driving the same, and means for supporting the prime mover from the adjacent water box.

4. The combination with a heat exchanger including a tube nest and a water box disposed at each end of the tube nest, of means including one of said water boxes for conveying extraneous cooling water for the tube nest, a pumping element disposed within said conveying means for circulating the cooling water through the tubes of the nest and out of the heat exchanger, a prime mover disposed adjacent to the same water box and connected to the pumping element for driving the same, and means for supporting the pumping element and the prime mover from the same water box.

5. The combination with a heat exchanger including a tube nest and a water box disposed at one end of the tube nest, of an intake conduit for cooling water extending upwardly and joining said water box, a propeller disposed in the intake conduit for circulating the cooling water through the tubes of the nest and out of the heat exchanger, a prime mover mounted over and adjacent to the same water box, and a drive shaft depending from the prime mover and connected to the propeller, said drive shaft traversing a portion of said water box.

6. The combination with a heat exchanger including a horizontally-extending tube nest and a water box disposed at one end of the tube nest, of an intake conduit for cooling water extending vertically upwards and joining said water box, a propeller for circulating extraneous cooling water through the tubes of the nest and out of the heat exchanger, said propeller being disposed in the intake conduit, a prime mover mounted on top of and adjacent to said water box, and a vertical drive shaft depending from the prime mover and secured at its lower end to the propeller in the intake conduit, said drive shaft traversing said water box.

7. The combination with a steam condenser including a tube nest and a water box having enclosing walls disposed at one end of the tube nest, of means including said water box for conveying extraneous cooling water for the tube nest, a prime mover disposed exteriorly of the water box, means supporting the prime mover in spaced relation from the water box, said prime mover having a drive shaft projecting toward the water box, a propeller disposed in said conveying means for circulating the extraneous cooling water through the tubes of the nest and out of the condenser, a drive shaft secured to the propeller and projecting through a wall of the water box toward the drive shaft of the prime mover, and a coupling for connecting the prime mover drive shaft and the propeller drive shaft, said coupling being disposed in the space intervening between the water box and the prime mover.

8. The combination with a heat exchanger...
including a tube nest and a water box disposed at the end of the tube nest, of means including said water box for conveying extraneous cooling water for the tube nest, a pumping element disposed in said conveying means laterally of one side of the tube nest, a prime mover disposed laterally of the tube nest and outside of the water box, and a drive shaft extending across said water box and connecting the prime mover to the pumping element.

9. The combination with a heat exchanger including a tube nest and a water box disposed at the end of the tube nest, of means including said water box for conveying extraneous cooling water for the tube nest, a pumping element disposed in said conveying means laterally of one side of the tube nest, a prime mover disposed laterally of the tube nest and outside of the water box, a drive shaft extending across said water box and connecting the prime mover to the pumping element, and means for supporting both the pumping element and the prime mover from said water box.

10. The combination with a steam condenser including a horizontally-extending tube nest and a water box disposed at one end of the tube nest for distributing cooling water to the latter, of an intake conduit for cooling water extending upwardly and joining the water box, a propeller disposed near the entrance end of the intake conduit for circulating the cooling water through the tubes of the nest and out of the condenser, a prime mover mounted above the water box, and a drive shaft structure depending from the prime mover, said drive shaft structure projecting across the water box and extending into the intake conduit and connecting with the propeller.

11. The combination with a steam condenser including a tube nest and a water box disposed at one end of the tube nest, of an intake conduit joining the water box, a propeller disposed in the intake conduit for circulating extraneous cooling water toward the tube nest, a guide vane structure disposed in the intake conduit on the discharge side of the propeller for directing the fluid circulated by the propeller, a prime mover disposed outside of and adjacent to the same water box, and a drive shaft extending from the prime mover into the water box and connecting with the propeller.

12. The combination with a steam condenser including a tube nest and a water box disposed at one end of the tube nest, of an intake conduit for circulating extraneous cooling water toward the tube nest, a prime mover disposed outside of and adjacent to the same water box, a drive shaft extending from the prime mover into the water box and connecting with the propeller, and a guide vane structure surrounding the drive shaft on the discharge side of the propeller for directing the fluid circulated by the propeller.

13. The combination with a steam condenser including a tube nest and a water box disposed at one end of the tube nest, of an intake conduit joining the water box, a propeller disposed in the intake conduit for circulating cooling water through the tube nest and out of the condenser, said intake conduit embodying a portion on the discharge side of the propeller which diverges in flow-area so as to effect a velocity-pressure conversion of the water discharged by the propeller, a prime mover disposed outside of and adjacent to the same water box, and a drive shaft extending from the prime mover into the water box and connecting with the propeller.

14. The combination with a condenser including a tube nest, of means for conveying cooling water to the tube nest including a water box and an intake conduit joining the water box, said water box having front and side walls and having openings provided in its front and side walls, detachable covers for the openings, a propeller disposed in the conveying means for circulating cooling water through the tube nest, a drive shaft secured to the propeller and projecting outwardly through the cover in the side wall of the water box, and means for supporting the drive shaft and the propeller from the water box and providing for displacement of the drive shaft outwardly through the opening in the side wall of the water box, whereby removal of the propeller from the cooling water conveying means is facilitated.

15. The combination with a condenser including a tube nest, of means for conveying cooling water to the tube nest including a water box and an intake conduit joining the water box, a propeller disposed in the conveying means for circulating the cooling water through the tube nest, said water box having front and side walls and having openings provided in its front and side walls, detachable covers for the openings, a prime mover mounted over the cover in the side wall, a shaft secured to the prime mover and projecting through the cover and the opening in the side wall of the water box, a propeller secured to the shaft within the conveying means, and means for detachably supporting the prime mover from the water box so as to afford axial displacement of the drive shaft through the opening in the side wall of the water box, whereby removal of the propeller from the cooling water conveying means is facilitated.

16. The combination with a condenser including a tube nest, of means for conveying cooling water to the tube nest including a water box and an intake conduit joining the
water box, a propeller disposed in the conveying means for circulating the cooling water through the tube nest, said water box having front and side walls and having openings provided in its front and side walls, detachable covers for the openings, a prime mover detachably mounted adjacent to the cover in the side wall, a drive shaft secured to the prime mover and projecting through the cover and the opening in the side wall of the water box, a propeller detachably secured to the drive shaft in the conveying means, a guide vane structure assembled upon the drive shaft on the prime mover side of the propeller, said guide vane structure freely engaging the adjacent wall of the conveying means and said guide vane structure embodying a steady bearing engaging the drive shaft, and means for detachably supporting the prime mover from the water box so as to afford axial displacement of the drive shaft through the opening in the side wall of the water box, whereby removal of the propeller and the guide vane structure from the cooling water conveying means is facilitated.

In testimony whereof, I have hereunto subscribed my name this 16th day of June, 1931.

HENRY F. SCHMIDT.