Jan. 26, 1932. F. H. C. COPPUS 1,842,961

LOCOMOTIVE FEED WATER HEATER

Original Filed Nov. 16, 1925 2 Sheets-Sheet 1

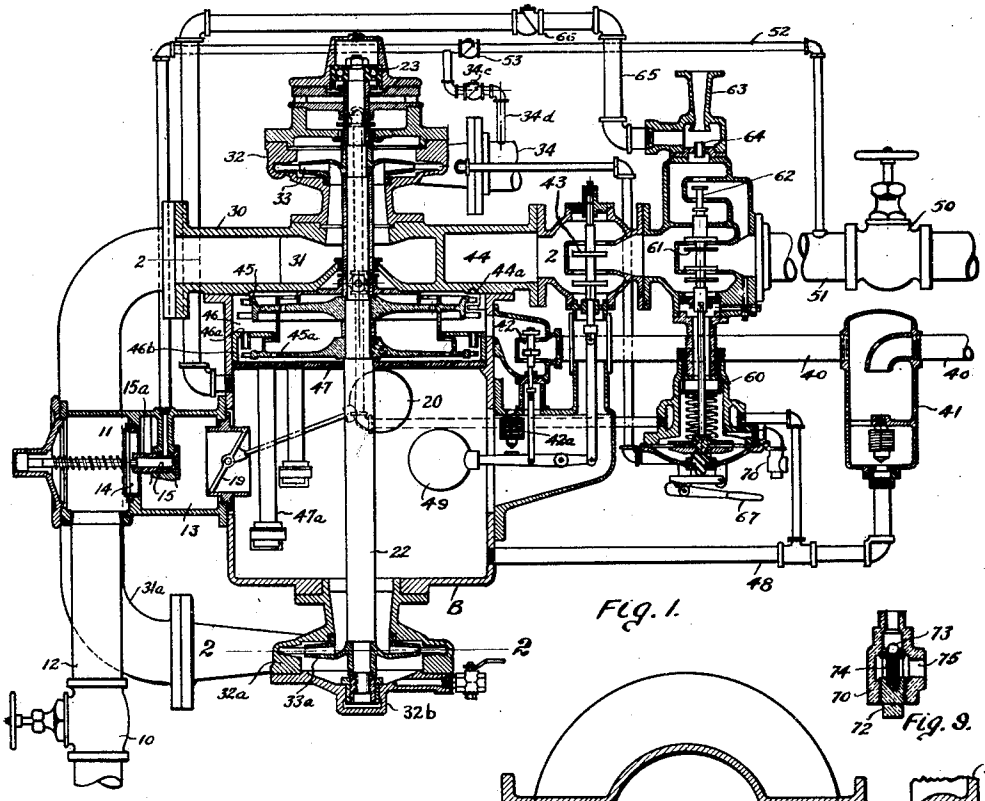


Fig. 1.



Fig. 9.

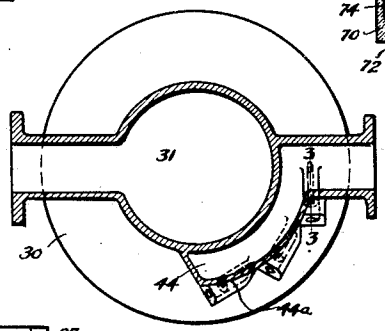


Fig. 2.

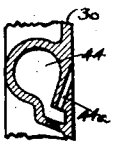


Fig. 3.

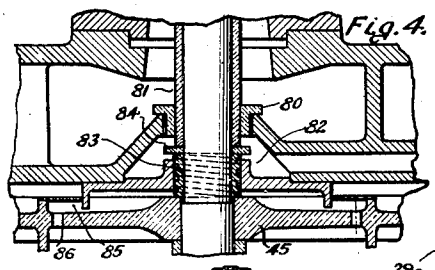


Fig. 4.

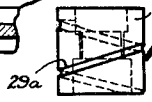


Fig. 7.

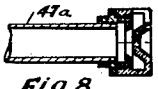


Fig. 8.

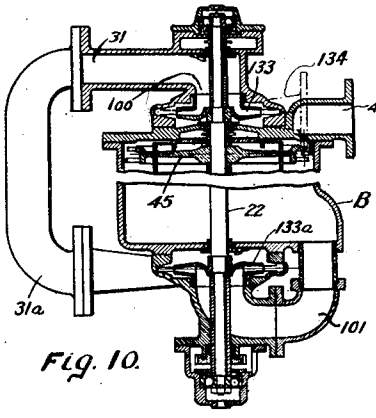


Fig. 10.

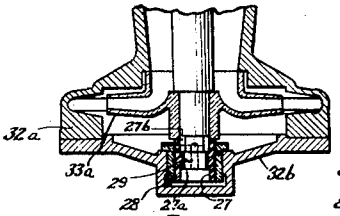


Fig. 6.

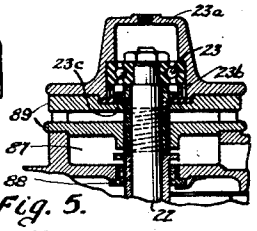


Fig. 5.

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LOCOMOTIVE FEED WATER HEATER

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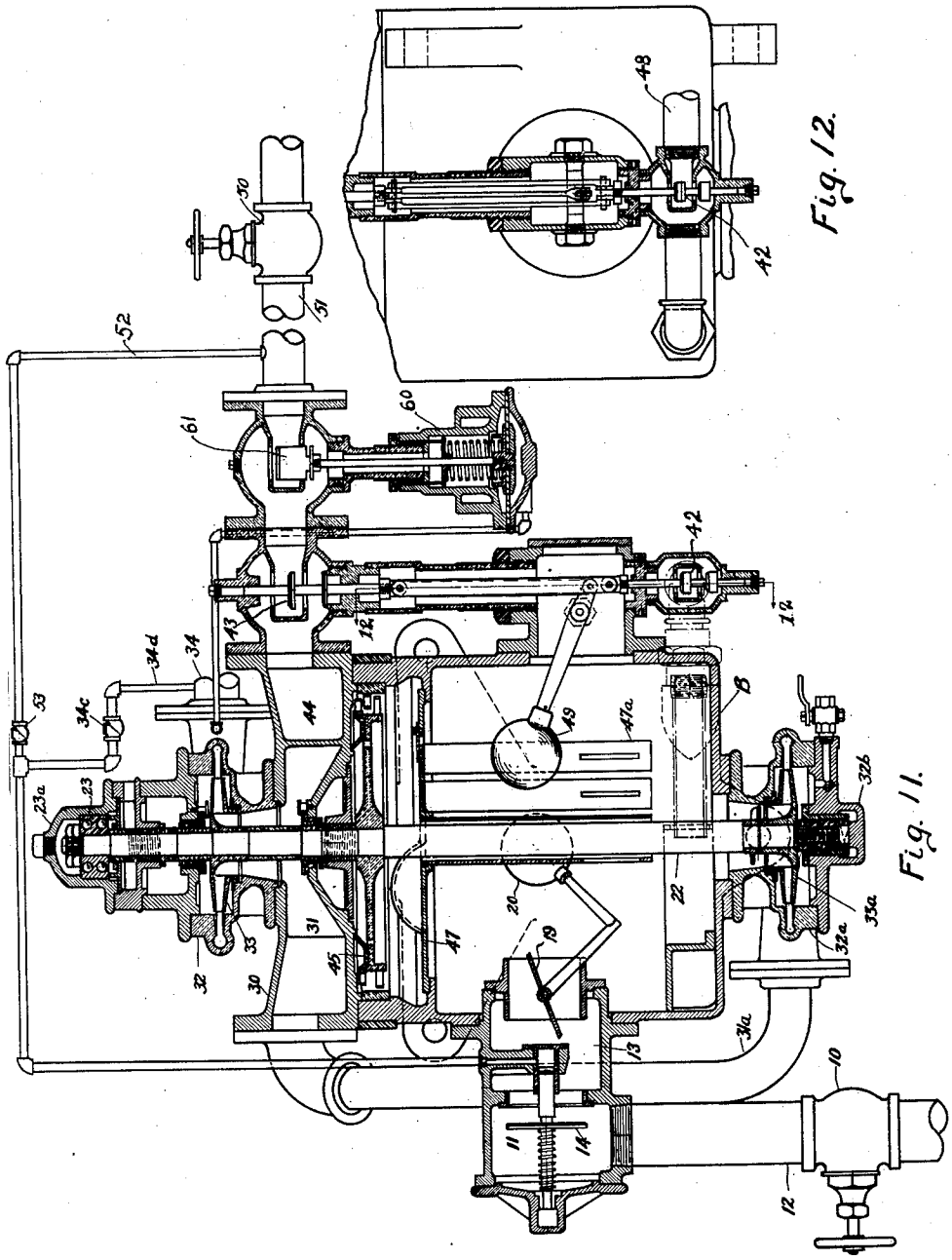



Fig. 12.

Fig. 11.

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# UNITED STATES PATENT OFFICE

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## LOCOMOTIVE FEED WATER HEATER

Application filed November 16, 1925, Serial No. 69,276. Renewed April 20, 1931.

This invention relates to a pump, particularly designed for boiler feeding for locomotives but capable of general use as well.

The principal objects of the invention are to provide a centrifugal pump automatic in action after once started and requiring the least possible attention of the engineer; to provide a centrifugal pump having its different compartments so connected that they all automatically drain by gravity to a single point, necessitating only one drain cock to drain off all the water to prevent freezing; to provide a centrifugal pump with impellers having inlets facing each other so as to do away with the end thrust and eliminate the usual balancing piston; to provide a centrifugal pump without the usual stuffing boxes; to provide a centrifugal pump driven by a low pressure condensing turbine using exhaust steam for its motive power to be automatically augmented by live steam whenever necessary; to provide means for condensing the exhaust of the turbine within the pump, the condensate being discharged with the feed water by the pump, so that the water delivered by the pump is always preheated; to provide a bearing for the pump submerged in water yet lubricated by grease; to provide means for receiving the condensate of a closed heater and to have this condensate mix with the feed water and to have the exhaust steam after it passes through the closed heater heat the feed water, all within the pump; to provide means for starting the pump by holding open manually, until the pump is delivering water, the steam admission valve of a combination excess pressure governor and safety stop, in conjunction with means to stop this admission of steam to the pump if there should be no water in the pump, thereby preventing the pump from running away while the admission valve is being held open; to provide means for priming the pump automatically by causing steam to flow into the steam line leading to the combination excess pressure governor and safety stop of the pump and prior to the opening thereof; to provide means for keeping the water supply line to the pump open, as long as the pump remains operative, and to shut off the water supply to the pump the moment the pump becomes inoperative; to provide a centrifugal pump which remains primed when the pump stops without the use of a foot valve.

Other objects and advantages of the invention will appear hereinafter.

Reference is to be had to the drawings in which

Fig. 1 is a central sectional view of the feed water heater constructed in accordance with this invention, some parts being in side elevation and showing the turbine operated by both exhaust and live steam;

Fig. 2 is a horizontal sectional top view on the line 2—2 of Fig. 1;

Fig. 3 is a vertical sectional view on the line 3—3 of Fig. 2;

Fig. 4 is an enlarged vertical sectional view showing the central part of the operating turbines;

Fig. 5 is an enlarged vertical sectional view showing the top part of the receiver;

Fig. 6 is an enlarged vertical sectional view showing the bottom impeller;

Fig. 7 is an enlarged elevation of one of the parts of the turbine;

Fig. 8 is an enlarged sectional view of an exhaust pipe of the turbines;

Fig. 9 is an enlarged sectional view of an automatic relief valve;

Fig. 10 is a modification of the pump shown in Fig. 1;

Fig. 11 is a central sectional view of another modification and Fig. 12 is a vertical sectional view on the line 12—12 of Fig. 11.

The complete feed water heating plant comprises a storage tank, not shown, for cold water, a combination receiver and pump B (Fig. 1) for receiving water therefrom and a closed heater, not shown, through which an impeller forces the water into the boiler.

Cold water is fed through a valve 10, which, under ordinary conditions, is always open, and through a pipe 12 into a chamber 11. This chamber may be located anywhere in the line and is provided with a port having a valve seat in one wall thereof which wall separates it from a second chamber 13 into which the chamber 11 discharges and which discharges into the chamber of the receiver B.

A spring loaded stop valve 14 closes this port but it is provided with a plunger 15 in a cylinder 15ª adapted to receive steam behind the plunger to open the valve.

The stop valve 14 is only opened by steam through pipe 52 and steam main 51, supplying live steam to the pump through a valve 50, the moment valve 50 is opened, but as soon as the pump has developed a discharge pressure in excess of the pressure in the steam line 51 check valve 53 is closed by the pressure of the water from the discharge line 34 through pipe 34ᵈ and check valve 34ᵉ thus displacing steam pressure by water pressure back of the piston 15. Therefore, normally when the pump is in operation, water pressure is maintained back of piston 15 thus eliminating the use of live steam for this purpose. A butterfly valve 19 is provided at the outlet of the chamber 13 to control the passage of water from the chamber 13 into the receiver B. This butterfly valve is provided with a float 20 so that when the water in the receiver B raises above a certain point, the valve 19 will be closed and no more water will flow in until the level is decreased.

The receiver is provided through the center with a vertical shaft 22 hanging on a ball bearing 23 from the top and having a high pressure turbine wheel 45 and a low pressure turbine wheel 45ª for rotating it. Live steam enters the turbine wheel 45 from the pipe 51 and steam chamber 44 above, through the usual nozzles 44ª (Fig. 2) and exhausts on its lower side into an annular chamber 46, hence, through nozzles 46ª in an angular partition 46ᵇ to the low pressure turbine wheel 45ª, exhausting in a compartment the top of which is formed by partition 46ᵇ and the bottom of which is formed by a partition 47. This partition 47 is provided with exhaust pipes 47ª extending down into the receiving tank B and below the water level in the same, the exhaust steam thus being condensed. The pipes 47ª may be open at the bottom, perforated or preferably provided with conical outlets as shown in Fig. 8. From the standpoint of turbine efficiency it is preferable to use two turbine wheels as shown, with turbine blading designed respectively for high and low pressure steam. From the standpoint of simplicity it is preferable to have both the live and the exhaust steam act on a single turbine wheel. Either arrangement comes within the scope of this invention.

In addition to the exhaust steam from the high pressure steam turbine, exhaust steam from the closed heater is admitted into the annular chamber 46, through a pipe 40, a combination steam separator and steam trap 41 and balanced valve 42. The water of condensation which accompanies the exhaust steam from closed heater is discharged into the bottom of the receiver B through a pipe 48. I prefer to have this water pass through a trap as shown to prevent exhaust steam from being discharged directly into the receiver with the water of condensation, in order to save the exhaust steam for driving the turbine. The steam trap shown is of the expansion type, but any other kind may be used. The temperature to which the water in the receiver may be heated is limited and, if the water is heated directly by exhaust steam, less exhaust can be passed through the low pressure turbine and more live steam must be used for supplying the high pressure turbine in order that it may carry the required load.

The arrangement as shown is preferred because with it, a larger amount of exhaust steam having to pass through the closed heater, its velocity will be higher, the scrubbing effect of the steam on the outside of the water tubes greater, therefore, the heat transfer greater. As the exhaust steam from a locomotive engine has usually considerable superheat, the benefits of this superheat can be had only when the exhaust steam is rushed at a very high velocity through the heater, not allowing time enough to partly condense before the exhaust steam leaves the closed heater, as superheat cannot exist in the presence of moisture. The economy derived from the superheat in the exhaust steam is greater if the superheat is used to heat the feed water to a higher degree than if left in the exhaust steam and thereby the water rate of the low pressure steam turbine is reduced. Furthermore, the condensate is partly or wholly re-evaporated and the exhaust steam again slightly superheated by passing the exhaust and condensate from the closed heater through a coil in the smoke box.

Live steam is admitted to chamber 44 through a balanced valve 43. The balanced valves 42 and 43 are operated by a float 49 if the water ever gets below a predetermined water level. They are normally held wide open throughout the whole operation. These valves are safety valves to prevent the steam turbines from operating when there is no water in the receiver B, or when the water in it has fallen to a predetermined level, in which case float 49 will drop, thereby shutting the valves.

The quantity of steam used by the turbine in proportion to the amount of water delivered will be much larger, and consequently the water in the receiver will be heated to a higher degree, when the turbine is driven by exhaust steam than by live steam. To prevent the water from getting too hot and flashing into steam, thus causing the pump to become steam bound, a thermostat 42ª will, at a predetermined temperature of the water, throttle or close entirely exhaust steam valve 42. The relation between the valves 42 and 43 is therefore made such, that valve 42 will close prior to valve 43. These valves are

both operated by the lever of float 49 and when thermostat 42ª expands the float is lowered, thereby lowering valve 42 and raising valve 43, but when valve 42 is closed valve 43 is still fully open and will remain open unless the float 49 drops considerably lower on account of lack of water in the pump.

Live steam is admitted from the main 51 to the valve 43 through a quadruple seated balanced valve 61 and live steam is also admitted through a double seated balanced valve 62, which is cast integrally with the valve 61, to an air ejector 63 through a nozzle 64 whereby the air is removed through a pipe 65 from the tank B thereby creating a vacuum in the tank.

The receiver B is closed by a cover 30 (Fig. 2) containing the high pressure steam chamber 44 and a water chamber 31. Bolted to this cover is a pump volute 32 in which rotates a pump impeller 33 on the vertical shaft 22. To the bottom of the receiving tank is bolted a pump volute 32ª in which rotates an impeller 33ª on the same shaft 22. Water flows by gravity from the receiver B into impeller 33ª and is forced thereby through the volute 32ª, a pipe 31ª and the chamber 31 into the impeller 33 which forces it through the volute 32 and pipe 34 to the closed heater C and into the boiler.

The impellers are of the single inlet type and the inlet of the impeller 33ª faces the inlet of the impeller 33. The two impellers are of the same size and of identical construction with the exception of the vanes which are curved in the opposite direction, the necessity of which will be apparent. Anyone familiar with centrifugal pumps understands why the use of a single inlet impeller creates an end thrust on the shaft in the opposite direction to the flow of the water to the impeller. In a multistage pump each impeller creates the same end thrust so that if in a two stage pump, as in this invention, the total end thrust created is 500 lbs. each impeller is responsible for 250 lbs. It will therefore be readily understood that in my invention, on account of the inlets of the impellers facing each other, the end thrust created by one impeller offsets the end thrust created by the other.

The bottom journal of the shaft 22 is in the form of a nut bushing 27 (Figs. 6 and 7) located in a composition bearing 28. Grease is provided for its lubrication in the chamber 27ª formed by the nut bushing and the hub of the cover 32ᵇ which closes the chamber of the volute 32ª. The shaft has a passage 29 consisting of a concentric hole with one or more radial holes leading from the center hole to a small chamber 27ᵇ formed by the undercutting of the thread on the shaft and also of the thread in the bushing 27. A hole is drilled through the bushing connecting this chamber with a helical groove 29ª on the outside of the bushing.

The grease is under water pressure existing in the volute chamber and cannot escape. The centrifugal force of the shaft, however, causes a circulation of the grease through the helical groove on the outside of the nut bushing into the grease chamber and up through the central hole in the shaft.

The ball bearing 23 at the top is also lubricated by grease. The bearing is located in a cover 23ª (Fig. 5) by the removal of which the whole bearing is exposed. The outer face of the bearing rests on a T-ring 23ᵇ the outside diameter of the vertical flange of which is smaller than the outside diameter of the ball bearing and the flange is cut away in two places so that the ball bearing can be pried up and easily removed. The upper face of the inner part of the horizontal flange of the T-ring forms with the lower face of the flange of a bushing 23ᶜ an enclosure of the grease chamber to prevent the grease from running out of the chamber.

When the pump is not in operation the two faces will close the chamber tightly and when the pump is in operation the flange of the bushing 23ᶜ prevents, through centrifugal action, the grease from flowing out even if there should be a small upward thrust thereby separating the two faces slightly.

The pressure in the water chamber 31 is approximately one-half the ultimate discharge pressure of the pump, and as the shaft extends through this water chamber a packing box of some sort must be provided to prevent the water from escaping. It would be very difficult and impractical to provide a stuffing box of usual construction as it is out of reach from the outside of the machine.

Such a stuffing box would have to be absolutely tight and remain tight, which no stuffing box ever does, therefore means must be provided to minimize the escaping of the water and to collect this water and return it to the suction of the pump, because a pump would not be efficient, which would waste hot water. On a locomotive no water, either hot or cold, should be wasted because it would necessitate extra stops for taking on water. A stuffing box of usual construction could be used in combination with means for collecting the water and returning it to the suction of the pump, but I prefer to provide a wearing ring 80 which fits closely to the distance bushing 81 on the shaft (Fig. 4) but has considerable clearance through the casing so that the wearing ring centers around the distance bushing. The water pressure holds it stationary. The water leaking by this wearing ring is collected in a chamber 82 from which it is drained back to the receiving tank. A screw thread on another distance bushing 83, with a throw ring 84 thereon, will prevent any great amount of water from escaping downward.

If the chamber 82 should ever be filled then this screw thread will put the chamber under a slight pressure discharging the water out of the chamber so much faster, but any water which should leak out downward is caught on top of the turbine wheel which is provided with an annular chamber 85, closed on top but open on the inner side. Any water collecting in this chamber is forced downward by centrifugal force through holes 86 in the turbine, then downward on top of the low pressure turbine wheel, which has a similar chamber to that of the high pressure turbine wheel and similar discharge holes. Thus ultimately any water coming from the water chamber 31 is collected in the low pressure turbine chamber and discharged with the exhaust into the receiver B.

The pressure in the volute chamber 32 above the impeller 33 is equal to the full discharge pressure of the pump, or approximately double that of the pressure in the water chamber 31. This chamber 32 is closed by a housing, having a chamber 87 (Fig. 5) closed by a double cover 89 interposed between this housing and the bearing housing $23^a$. The shaft passes through the horizontal wall of the chamber and the double cover, the upper part of which forms the bottom of the bearing housing. The space between the two parts of the double cover is open to the atmosphere. I have already explained how the grease is prevented from leaking out of the grease chamber. To prevent the water from leaking by the shaft where it passes through the horizontal wall of the chamber 87, or rather to reduce the leakage to a minimum, I again provide, instead of a stuffing box, a wearing ring 88 similar to the wearing ring 80 where the shaft passes through the water chamber 31, and bushing $23^c$ is provided with a screw thread similarly and for the same purpose as in bushing 83. If any water should pass by bushing $23^c$ it will be discharged to the atmosphere between the lower and upper part of double cover 89. The water in the chamber 87 is drained back to the receiving tank like the water in the chamber 82.

To start the pump the valve 50 is opened fully. This allows the steam to flow into pipes 51 and 52 opening stop valve 14 and into air ejector 63 and water will flow immediately into the receiver B. Now, by pulling down on lever 67 (Fig. 1) of the combination excess pressure governor and safety stop 60, valve 61 will be opened and the moment the tank is filled with a pre-determined amount of water, the float 49 will rise opening the valves 42 and 43 and live steam and also exhaust steam, if available, will flow into the respective turbines. As soon as there is sufficient excess pressure in the discharge line, the excess pressure governor will remain open and the lever 67 may be released. The valves 61 and 62 will close gradually if the excess pressure increases above a predetermined amount, but the relation between these two valves is such that the valve 61 closes ahead of valve 62, therefore, full steam pressure to the air ejector is maintained until and well after valve 61 is fully closed when the pump will be operating with exhaust steam only.

If the demand upon the pump is not larger than the exhaust steam supply can take care of, the valve 61 will remain closed, and if, under these conditions the excess pressure should still increase, then valve 62 will gradually close, thereby reducing the vacuum in the receiver. When the demand increases or the vacuum goes too low, valve 62 will open again thereby increasing the vacuum in the tank, and if the demand still increases so that the exhaust steam alone cannot take care of it, then the valve 61 will open and live steam will be supplied. This is possible because the valves 61 and 62 close by passing into an opening of the same size as the valve in each case.

It will be noted that by pulling down lever 67 of the excess pressure governor, steam is allowed to flow through valve 61, and if the pump was not primed and no safety valve 43 had been provided, the pump would start up and run away. Therefore, an excess pressure governor, which is mannally opened and held open, is very dangerous to use without the float controlled safety valve. The manual control, however, is necessary if the excess pressure governor is to function also as a safety stop in case the suction breaks or the pump gets steam bound, in which case the discharge pressure would decrease and the valve 61 close, all of which is fully explained in patent granted to Otto Wechsberg No. 1,536,697. The combination excess pressure governor and safety valve shown here, however, is different from the Wechsberg patent in that it not only controls and regulates the steam supply to the receiver but also the steam supply to the air ejector. It might therefore be called a double excess pressure governor and safety stop.

Another feature which is not shown in the Wechsberg patent is an automatic drain for the chamber above the diaphragm where water collects. This drain (Fig. 9) consists of a valve body 70 which is screwed into a pipe connection to this chamber. In the valve body is screwed a hollow plug 72 supporting a ball 73 on a spring 74. When there is no pressure in the chamber the ball is lifted off its seat by the spring and any water in the chamber would automatically drain through the outlet 75 of the valve body, but where there is pressure in the chamber the ball will be forced to its seat.

In Fig. 10 I have shown a modification of the arrangement of the impellers so that while their inlets do not face each other,

nevertheless they are in the opposite direction balancing each other. In this case certain numerals have been used to indicate practically the same parts as indicated in Fig. 1 by the same numerals. But in this case the impellers 133 at the top and 133ª at the bottom are arranged to receive the water in a different way. The lower impeller 133ª receives its water from below through a pipe 101. The impeller 133 receives its water from above through a chamber 100 connected with the pipe 31 and discharges into the pipe 134 indicated in dotted lines.

The invention as shown in Fig. 1 is my preferred form because the highest efficiency is obtained for the following reasons:—exhaust steam otherwise wasted is used to drive the pump; the superheat in the exhaust steam is made the most efficient use of; the location of the pump may be anywhere because it is always primed.

By sacrificing economy in operation, however, the plant can be considerably simplified. Figs. 11 and 12 show an application of my invention using live steam only to drive the pump and running non-condensing. The pump, when used in connection with a locomotive is placed preferably under the cab so that the water will flow in by gravity from the tender. This avoids the use of an ejector and simplifies the governor. It avoids the use of a steam separator and steam trap. The valve 42 is connected to the lower part of the receiver but operated nevertheless by float 49. The purpose of this valve, when using live steam only to drive the pump and it being controlled by the float 49, is to control the amount of exhaust steam admitted to the water in the receiver B with the condensate from the closed heater. If too much steam should be admitted then pressure would be created in the receiver and would keep back the water from the supply pipe 12. In such a case the float 49 will drop and shut off valve 42 stopping the admission of exhaust steam, thereby reducing the pressure in the receiver, and immediately water would flow again into the receiver. Instead of using a float controlled valve 42 for this purpose, a valve controlled by the pressure in the receiver, or a thermostatic valve controlled by the temperature of the water in the receiver, may be used which would accomplish the same purpose because with a certain temperature goes a certain pressure and vice versa.

The receiver B is placed preferably under the cab so that the water will flow in by gravity.

Instead of using a combination excess pressure governor as shown in Fig. 1, merely an excess pressure governor as shown in Fig. 11 may be used, that is, a governor without manual means for opening the valve and with a double seated valve instead of a quadruple seated valve 61, in which case valve 61 will be normally open and will remain open until the excess pressure increases above a predetermined amount.

It will be seen that by this invention I have provided a pump with two impellers which eliminates the end thrust and the usual necessity of balancing the piston. I provide on the same shaft two turbines, high pressure and low pressure, using respectively live and exhaust steam. I so arrange them that automatically the turbine using the exhaust steam will receive its supply first and, if that supply is sufficient to run the pump at a high enough rate of speed, no live steam will be admitted to the high pressure turbine, but if more power is called for, the degree of vacuum over the water in the receiver will first be increased to produce a higher operating pressure for the low pressure turbine and if that is not sufficient live steam will be admitted to the high pressure turbine. On the other hand, when the pump is operating as last described, the fact that it is doing more work than necessary will immediately be compensated for by throttling the steam from the high pressure turbine and, if still less power is required, then the vacuum within the receiver will be reduced on the discharge side of the low pressure turbine, all these actions taking place automatically without any attention on the part of the operator. Furthermore, as has been indicated above, the air is exhausted from the air space in the receiver so as to reduce the pressure on the exhaust side of the exhaust steam turbine by means of an ejector operated by the live steam from the line 51. Steam is delivered through the ejector for this purpose whenever necessary, the connection to the ejector being closed by a valve working automatically. This valve arrangement for controlling the action of the ejector and the admission of live steam into the high pressure turbine are so arranged that the pump can be started by holding open the valve until the pump is delivering water, by the use of the combination excess pressure governor and safety stop, in conjunction with means for stopping the admission of steam to the receiver if there is no water therein so as to prevent racing. Furthermore, the pump is automatically primed by causing the steam to flow into the steam pipe leading to the excess pressure governor and safety stop prior to the opening thereof. I have also provided means for keeping the water supply line to the receiver open while the pump is operated and to shut off the water supply automatically the moment it becomes inoperative. I have also provided means for draining the several compartments of the centrifugal pump automatically to a single point, thus necessitating only one drain cock for draining off all the water for the purpose of preventing freezing. I have also

provided a construction of centrifugal pump entirely without stuffing boxes and have provided means for condensing the exhaust of the turbine within the receiver, the condensate being discharged from the receiver with the feed water so as to help preheat the water in the receiver. I have provided a bearing for the pump submerged in water but lubricated by grease and operated so as to insure circulation of the grease. I have provided a centrifugal pump which remains primed when the pump is stopped without the use of any foot valve, and the entire combination feed water heater and centrifugal pump is arranged for automatic action after once being started and requiring very little attention on the part of the engineer.

The subject matter shown in original Figs. 11 to 20 inclusive is not claimed herein as it constitutes the subject matter of a divisional application. Certain elements and combinations are shown, but not claimed herein because they are claimed in one of my co-pending applications, Serial No. 51,677, filed August 21, 1925 and Serial No. 76,828, filed December 21, 1925.

Although I have illustrated and described only a few forms of the invention I am aware of the fact that other modifications can be made therein by any person skilled in the art without departing from the scope of the invention as expressed in the claims. Therefore I do not wish to be limited to the details herein disclosed, but what I do claim is:

1. A pump comprising a receptacle having an air chamber above the water, a shaft in the receptacle, a turbine for turning the shaft by live and exhaust steam, means operated by the shaft for forcing the water out of the receptacle, and an extension from the chamber of the turbine opening below the water level, whereby the steam after turning the shaft is forced through the water.

2. In a pump, the combination of a receptacle for the water, a turbine, a shaft extending through the receptacle to which said turbine is fixed, means on the shaft for forcing the water out of the receptacle, means for introducing exhaust steam into said turbine to operate it, a valve for controlling the admission of exhaust steam into the turbine, a float in the receptacle arranged to close the valve when the water in the receptacle gets below a certain level, means for introducing live steam into the turbine to operate it, and a second valve operated by said float for shutting off the live steam when the water gets low.

3. In a pump, the combination with a receptacle for the water having an air chamber above the water and a partition across it to provide a chamber at the top, and a shaft extending through the receptacle and chambers, of means on the shaft for forcing the water out of the receptacle, two turbines fixed to said shaft in the chamber above the partition, means for directing exhaust steam into one of said turbines for operating it, means for supplying live steam to the other turbine for operating it, and means for directing the exhaust steam from the latter turbine into the first named turbine for assisting in its operation, a float device in the receptacle, and two valves connected with the float device, one for controlling the admission of exhaust steam to the first turbine and the other for controlling the admission of live steam to the second turbine so arranged that the former will close first when the water in the receptacle gets below a certain level.

4. In a pump, the combination with a receptacle for the water, of a shaft in the receptacle, means on the shaft for forcing the water out of the receptacle, two turbines fixed to said shaft, means for directing exhaust steam into one of said turbines for operating it, means for supplying live steam to the other turbine for operating it, and means for directing the exhaust steam from the latter turbine into the first named turbine for assisting in its operation.

5. In a pump, the combination with a receptacle for the water having an air chamber above the water and a shaft extending through the receptacle, of means on the shaft for forcing the water out of the receptacle, two turbines fixed to said shaft, means for directing exhaust steam into one of said turbines for operating it, means for supplying live steam to the other turbine for operating it, means for directing the exhaust steam from the latter turbine into the first named turbine for assisting in its operation, and means connected with the live steam supply for ejecting the air from the air chamber in the receptacle to reduce the air pressure on the exhaust side of the first mentioned turbine.

6. In a pump, the combination with a receptacle for the water having an air chamber above the water, a shaft extending through the receptacle, of means on the shaft for forcing the water out of the receptacle, two turbines fixed to said shaft, means for directing exhaust steam into one of said turbines for operating it, means for supplying live steam to the other turbine for operating it, means for directing the exhaust steam from the latter turbine into the first named turbine for assisting in its operation, means connected with the live steam supply for ejecting the air from the air chamber in the receptacle, a valve for controlling said means, a valve for controlling the admission of live steam connected with said valve and arranged to close before the first named valve closes, and means whereby when the two turbines are in operation the reduction of the load will result in the closing of the supply of steam to the second valve first and later in the closing of the first named valve to operate the ejector by

the steam and reduce the air pressure on the exhaust side of the first-mentioned turbine.

7. The combination in a pump of a receptacle, of a shaft in the receptacle, means on the shaft for forcing the water out of the receptacle, a turbine on the shaft in the receptacle for operating the shaft, a steam supply arrangement for the turbine, an ejector connected with said steam supply, a valve for controlling the admission of steam to said turbine, a valve for controlling the admission of steam to the ejector, said valves being connected to operate together, and a pipe leading from the air space over the water in the receptacle to the ejector, whereby when the ejector is supplied with steam it will exhaust air from said space and reduce the pressure on the exhaust side of the turbine.

8. The combination in a pump of a receptacle, of a shaft in the receptacle, means on the shaft for forcing the water out of the receptacle, a turbine on the shaft in the receptacle for operating the shaft, a live steam supply arrangement for the turbine, an ejector connected with said steam supply, a valve for controlling the admission of said steam supply to the turbine, a valve for controlling the admission of steam to the ejector, said valves being connected to operate together, and a pipe leading from the air space over the water in the receptacle to the ejector, an exhaust steam supply arrangement for the turbine, and means whereby, when the load on the turbine is too great for the exhaust steam supply to carry, the valves will move to admit steam to the ejector and reduce the pressure on the exhaust side of the turbine and thereafter, if the load continues too great, will open the valve for the admission of live steam to the turbine.

9. The combination in a pump of a receptacle, a shaft in the receptacle, means on the shaft for forcing the water out of the receptacle, a turbine on the shaft in the receptacle for operating the shaft, of a live steam supply arrangement for the turbine, an ejector connected with said steam supply, a valve for controlling the admission of said live steam to the turbine, a valve for controlling the admission of steam to the ejector, said valves being connected together, a connection from the air space in the receptacle to the ejector, means whereby both of said valves are closed when the water level is below a predetermined height, an exhaust steam supply arrangement for the turbine, and means whereby when the load on the turbine is too great for the exhaust steam supply to carry, the valves will open to admit steam first to the ejector and reduce the pressure on the exhaust side of the turbine and thereafter, if the load continues too great, admit live steam to the turbine and whereby when the live steam supply is no longer required it will be shut off automatically and thereafter, if the load is still too small, the ejector will be shut off automatically.

10. The combination of a pump, means for operating said pump by a live and exhaust steam turbine, and a steam admitting valve adapted to be held open manually until the pump is delivering water, with a combination live and exhaust pressure governor and safety stop, and means for automatically stopping the admission of steam to the pump when there is little or no water in the pump, whereby the pump will be prevented from speeding up materially even though the admission valve is held open.

11. In a pump, the combination with a receptacle for the water, a water inlet, a spring controlled valve for closing the inlet, means for opening the valve by steam pressure, of means for putting water out of said receptacle under pressure, and means whereby after the valve has been opened by steam pressure it will be held open by the water pressure as long as the pump is operating.

12. In a pump, the combination with a pump receptacle, of means operated by steam for admitting water to the receptacle, means for discharging water from the receptacle and means controlled by the water discharged from the pump receptacle to hold said means open as long as the pump is discharging and for stopping the admission of water to the receptacle when the pump stops.

13. The combination with a pump including a vertical shaft, of a floating wearing ring around the shaft, a chamber beyond the wearing ring for collecting any water that may pass between the shaft and the wearing ring, and a throw ring on the shaft for the purpose described.

14. The combination with a pump including a vertical shaft, of a bushing on the shaft having a wearing ring, a chamber below the wearing ring for collecting any water that may drain through it, a distance bushing having a screw thread, and a throw ring on the shaft, for the purpose described.

15. In a centrifugal pump, a shaft, a chamber around the shaft, an impeller on the shaft, discharging water into said chamber, a means around the shaft where it passes through one of the walls of the chamber for minimizing the escape of water around the shaft, a leakage chamber adjacent to the first chamber for receiving water leaking between said means and the shaft, and means for draining the water out of the second chamber.

16. In a centrifugal pump the combination of a receiving tank, a shaft, a chamber around the shaft, an impeller on the shaft, discharging water into said chamber, means around the shaft where it passes through one of the walls of the chamber for minimizing the escape of water around the shaft, a leakage chamber adjacent to the first chamber for receiving water leaking around the shaft, and

means for draining the water out of the second chamber to the receiving tank.

17. In a centrifugal pump the combination of a receiving tank, a shaft, a chamber around the shaft, an impeller on the shaft, discharging water into said chamber, means around the shaft where it passes through one of the walls of the chamber for minimizing the escape of water around the shaft, a leakage chamber adjacent to the first chamber for receiving water leaking between said means and the shaft, means for preventing water from passing through the wall of the leakage chamber, and means for discharging the water from the leakage chamber to the receiving tank.

18. The combination with a centrifugal pump comprising a shaft, an impeller on the shaft, a suction chamber on the inlet side of the impeller, and a pressure chamber on the opposite side of the impeller, of means fitting around the shaft where the shaft passes through the walls of the suction chamber and of the pressure chamber for minimizing the escape of water around the shaft, a chamber adjacent to the suction chamber, another chamber adjacent to the pressure chamber for collecting any water that may pass by the shaft, and means for draining said adjacent chambers.

19. In a centrifugal pump, a shaft, a chamber around the shaft, an impeller on the shaft putting water under pressure in said chamber, means around the shaft where it passes through the wall of said chamber to minimize the discharge of water from said chamber, a leakage chamber adjacent to the first chamber for receiving the water leaking between the shaft and said means, and means for draining the leaking chamber into the suction of the pump.

20. In a feed water heating system, the combination of a pump, a turbine in said pump for operating it, means for conducting live and exhaust steam to the turbine, valves for closing said steam conducting means, a thermostat in the pump, and means for connecting the thermostat with said valves, whereby the exhaust steam conductor will be closed when the water gets too hot in the pump and if it continues to grow hotter the live steam supply valve will be closed.

21. In combination a receptacle, of a shaft in the receptacle, a turbine on the shaft for operating it, means on the shaft for discharging the water from said receptacle when the shaft rotates, a steam supply arrangement for the turbine, an ejector connected with said steam supply, a valve for controlling the admission of steam to said turbine, a valve for controlling the admission of steam to the ejector, said valves being connected to operate together, and a pipe leading from the air space over the water in the receptacle to the ejector, whereby when the ejector is supplied with steam it will exhaust air from said space.

22. In a feed water heating system, the combination of a pump, means for operating said pump by steam, and a steam admitting valve adapted to be held open manually until the pump is delivering water, with a combination excess pressure governor and safety stop, and means for automatically stopping the admission of steam to the pump when there is little or no water in the pump whereby the pump will be prevented from speeding up materially though the steam admitting valve is held open.

23. In a turbine pump, the combintion of a receptacle for the water having a chamber in its upper part, means for introducing water above said chamber, a turbine in the receptacle above said chamber, means for discharging its exhaust steam into said chamber and into the incoming water, a pump shaft extending through the receptacle and its chambers to which said turbine is fixed, a pump driven by said shaft, means for introducing steam into said turbine to operate it. and a valve for controlling the admission of steam into the turbine.

24. In a turbine operated pump, the combination with a pump receptacle and means for introducing water into it, of a pump shaft in the receptacle, a pump driven by said shaft, a steam turbine on the shaft for operating it, a steam supply pipe, an ejector connected with the top of the receptacle and with the steam supply for reducing the pressure on the exhaust side of said turbine, a valve for controlling the supply of steam to said turbine, means for introducing steam into the turbine independent of said valve, and means for mixing the exhaust steam from the turbine with the water.

25. In a turbine driven pump, the combination of a receptacle for the water having a space or chamber in its upper part, means for introducing water, a turbine in the receptacle, a shaft in the receptacle and its chambers to which said turbine is fixed, a pump driven by said shaft, means for introducing exhaust steam into said turbine to operate it, a steam separator located in the path of the exhaust steam to said turbine, means for draining the separator into said receptacle, means for mixing the exhaust steam from the turbine with the water, and a valve for controlling the admission of exhaust steam into the turbine.

26. The combination with a turbine driven pump comprising a receptacle having an air space therein, a shaft in the receptacle, a pair of turbines on the shaft in the receptacle for operating the shaft, means on the shaft for discharging the water when the shaft rotates, of a steam supply arrangement for one turbine, means for mixing the exhaust steam from the turbine with the water, an ejector

connected with said steam supply, a valve for controlling the admission of steam to the ejector, said turbines exhausting into the air space in the receptacle, a connection from the air space in the receptacle to the ejector, whereby when the ejector is supplied with steam it will exhaust air from said space and reduce the pressure on the exhaust side of the turbines, means whereby said valve is normally closed, and means whereby when the load one one turbine is too great, the valve will open to admit steam first to the ejector and to one turbine.

27. In a turbine driven pump, the combination with a pump receptacle, a turbine in said pump receptacle for operating it, means for feeding steam to the turbine, means for mixing the exhaust steam from the turbine with the water, a valve for controlling the admission of steam to the turbine, a thermostat in the pump receptacle, and means for connecting the valve with the thermostat, whereby when the water in the pump receptacle gets above a certain temperature the valve will be closed.

28. In a turbine driven pump, the combination of a pump receptacle, two turbines in said pump receptacle for operating it, means for conducting live steam to one turbine, means for conducting exhaust to the other turbine, automatic valves for closing said steam conducting means, means for mixing the exhaust steam from the turbine with the water, a thermostat in the pump receptacle, and means for connecting the thermostat with the valve for controlling the exhaust steam supply, whereby the exhaust steam conductor will be closed when the water gets too hot in the pump receptacle.

29. The combination with a pump receptacle, of a turbine therein for operating it, and means for introducing steam into the turbine, of an ejector, means for connecting the ejector with the space in the pump receptacle on the exhaust side of the turbine for reducing the back pressure, a steam supply pipe, a valve for closing it, a valve fixed with respect to said valve for controlling the supply of steam to the ejector, and means connected with said valves for closing the first valve when the pump exhaust pressure gets too high.

30. The combination with a pump receptacle, of a turbine therein for operating the pump, and means for introducing steam into the turbine, of an ejector, means for connecting the ejector with the space in the pump receptacle on the exhaust side of the turbine for reducing the back pressure, a steam supply pipe, a valve for closing it, a valve fixed with respect to said valve for controlling the supply of steam to the ejector, means connected with said valves for closing the first valve when the pump exhaust pressure gets too high, two steam chambers, one of which is constantly connected with said pipe on the low pressure side of the first named valve, nozzles in both of said steam chambers for directing steam into the turbine, whereby the turbine will be operated by a larger number of nozzles if both chambers are supplied with steam, means for mixing the exhaust steam from the turbine with the water, a valve for controlling the connection of the second chamber with a steam supply, and automatic means for opening and closing said valve.

31. In a pump, the combination with a receptacle for the water, of a shaft in the receptacle, means for forcing the water out of the receptacle, a turbine on said shaft and means for supplying exhaust and live steam to said turbine for operating it.

In testimony whereof I have hereunto affixed my signature.

FRANS H. C. COPPUS.