

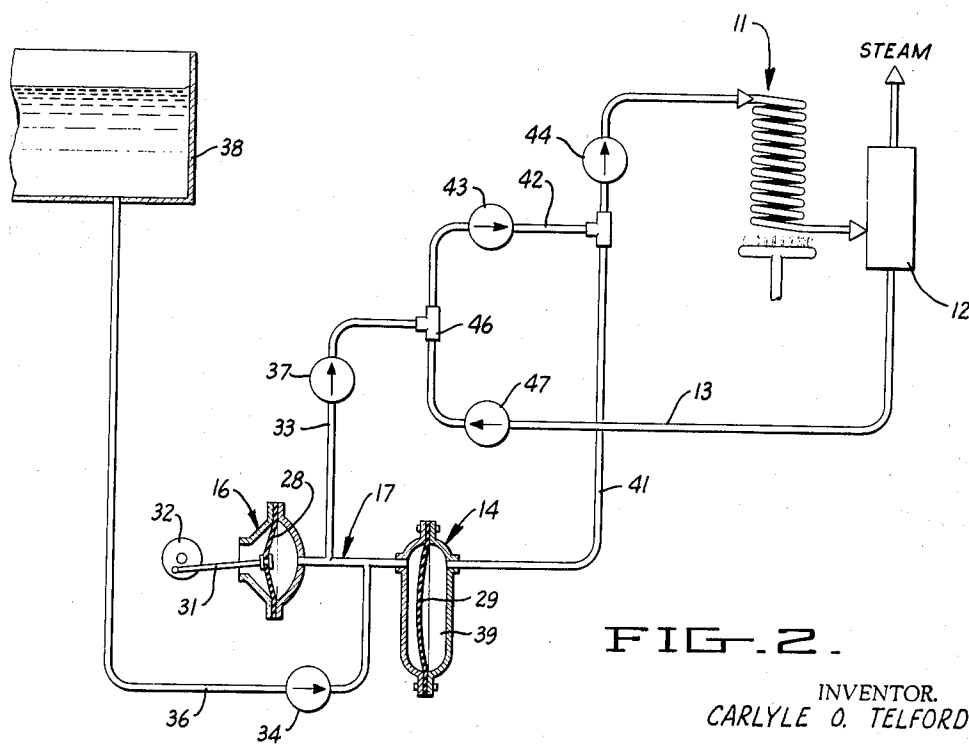
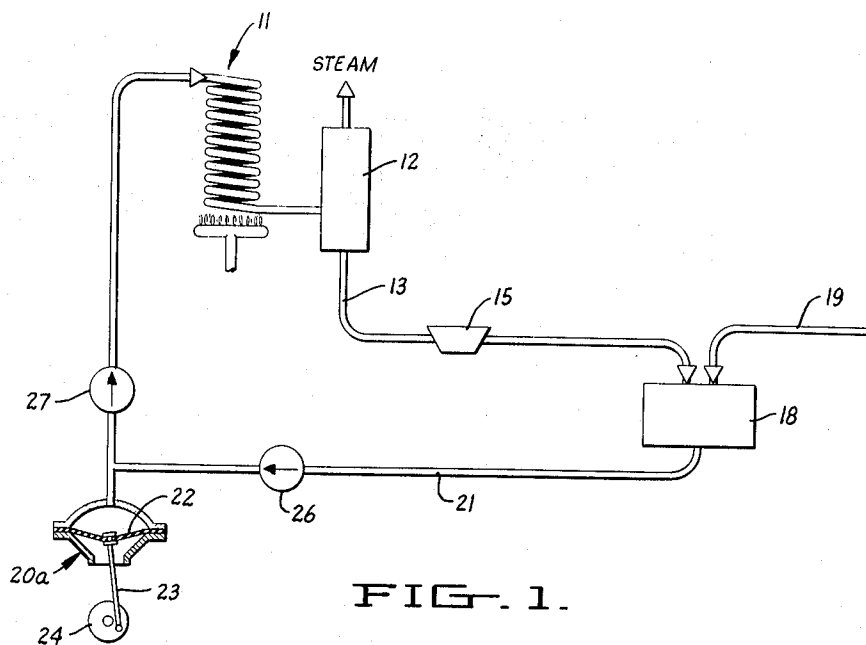
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SELECTIVE FEED WATER SUPPLY SYSTEM

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SELECTIVE FEED WATER SUPPLY SYSTEM

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This invention relates to a selective feed water supply system and is a continuation-in-part of my co-pending application Serial No. 103,542, filed April 17, 1961, entitled Feed Water Supply System, which application is now issued as United States Patent No. 3,131,676, issued May 5, 1964. More particularly, the invention relates to return systems in which surplus water and/or condensate is recirculated to a steam generator or boiler with make-up water being added as required.

It is well-known that considerable amounts of heat energy are contained in the surplus water from steam generators and in the condensate from steam boilers. Significant savings in fuel can be obtained if the surplus water or condensate is returned as feed water to the generator or boiler. Conventionally, the return water is conveyed to a storage tank open to the atmosphere and make-up water is added to the tank as required.

Heat and evaporation losses from systems of this type are high. For example, in a typical system the return water is separated from the pressurized steam by a device known as a trap. When the return water goes through the trap the pressure is reduced down to atmospheric pressure. The return water must then cool down to the boiling point of approximately 212° F. at atmospheric pressure. It does this by flashing part of the water into steam containing considerable amounts of heat energy. It is difficult to salvage this steam and it is usually rejected.

If the return water is very hot and if only small amounts of cold make-up water are required, the water in the tank may attain a temperature high enough to interfere with pumping. This is because of the tendency of the hot water to flash into steam and create a vapor lock on the suction side of the pump.

Attempts have been made to eliminate the problems of pumping very hot return water by utilizing a closed return system in which pressure is maintained at a high enough level to prevent flashing of the water into steam. The simplest of the prior closed system designs consists of a manifold, into which return water flows by gravity, and a pump—usually of the turbine type—which feeds the return water directly to the boiler. Applications of this system are limited by problems of steam erosion of the pump and requirement of a high static inlet head at all times to prevent flashing. More complicated systems have been evolved which combine a centrifugal pump and a jet pump in series in a closed circuit, with the centrifugal pump energizing the jet pump, but such systems become quite expensive and encounter many design and operating difficulties.

Accordingly, it is desirable to provide a simple system which will solve the problems and utilize make-up water. It is also desirable to provide such a system which selectively pumps make-up water to the system when the supply of condensate is low or exhausted and which will preferentially recirculate condensate when available. A satisfactory system for accomplishing such results is the subject of United States Patent 3,131,676 cited above.

In my prior system, a feed water pump is provided to pump condensate when available, and a make-up water pump is provided to pump make-up water when condensate is not available. In order to achieve the proper operation of the pumps, the pumps are specially constructed

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to operate from control means associated with a trap in the return line whereby the action of the make-up water pump is ineffectual whenever hot return water is supplied to the feed pump.

The present invention also utilizes two separate pumps one of which recirculates condensate to the steam generator and the other of which pumps make-up water in accordance with demand. However, the two pumps are operatively connected together in a novel way so that the system operates automatically without the use of a trap and/or associated control means in the return line.

The described function is preferably accomplished by continuously operating positive displacement reciprocating feed water and make-up water pumps simultaneously through a fluid coupling so that the make-up pump will be reciprocating through a conventional power source while the feed water pump operates from the make-up pump as a slave pump. The feed water pump is connected into the condensate return line near the boiler, and the make-up water pump is connected between a source of make-up water and the chamber or head of the first pump.

The system is constructed in such a way that when condensate is available, the feed water pump or first pump uses substantially all of the energy of the make-up pump or second pump, and no make-up water is added to the boiler. Conversely, when vapor is supplied into the return line, the make-up pump acts as a pump on the make-up line as well as means for actuating the feed water pump. In this way, full use of hot water or condensate and improved thermal efficiency is achieved. Since the return water line is continuously retained under pressure, flashing problems are eliminated.

Accordingly, it is a principal object of the present invention to provide a selective feed water supply system for a steam generator or boiler which will pump hot surplus water or condensate back to the generator or boiler whenever available and which will automatically supply make-up water when the supply of hot return water is exhausted.

Another object of the invention is to supply a constant amount of liquid from a variable supply of the liquid under pressure and from a source of the liquid at a lower pressure, the system being adapted to utilize the liquid under higher pressure first and, when such liquid is exhausted, to utilize the liquid at lower pressure.

A further object of the invention is to provide a feed water supply system of the character described which incorporates positive displacement reciprocating pumps mounted in tandem, one of the pumps being adapted to supply feed water to the boiler and the other pump being adapted to supply make-up water to the first pump on demand.

A still further object of the invention is to provide a feed water supply system of the character described in which the energy of the make-up water pump is automatically utilized by a recycling feed water pump whenever condensate is available so that condensate is recycled at full capacity, yet when vapor is drawn into the recycling line, the make-up water pump uses some of this energy to pump make-up water into the return line.

Yet another object of the invention is to provide a feed water supply system of the character described which is simple and sturdy and which is constructed of inexpensive components having a long and trouble-free operating life.

Further objects and advantages of the invention will be apparent as the specification progresses, and the new and useful features of my selective feed water supply system will be fully defined in the claims attached hereto.

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The preferred form of the invention is illustrated in the accompanying drawing forming part of this description, in which:

FIGURE 1 is a flow diagram of a conventional open-well condensate return system; and

FIGURE 2, a flow diagram similar to that of FIGURE 1 but illustrating the feed water supply system of the present invention.

While only the preferred form of the invention is shown, it should be understood that various changes or modifications may be made within the scope of the claims attached hereto without departing from the spirit of the invention.

Referring to the drawings in detail, it will be seen that the feed water supply system of the present invention as illustrated in FIGURE 2 is designed for use with a steam generator 11 having a separator 12 and a hot surplus water return line 13, the feed water system consisting basically of a feed pump 14 for recycling surplus water from the separator to the steam generator, a make-up pump 16 adapted for supplying make-up water to the feed pump 14, and a fluid coupling means 17 between the pumps so that pump 16 operates pump 14 and selectively pumps water in accordance with the condition of the system.

FIGURE 1 illustrates a conventional type of condensate return system in which a steam generator 11 supplies mixed steam and hot water to a separator 12, the surplus water passing out of the separator through the return line 13 and trap 15 to a storage tank 18. Make-up water is added through conduit 19 to the tank 18 in the well known manner to maintain the desired water level in the tank. A feed water pump 20a is connected into a conduit 21 leading from tank 18 to the steam generator 11.

The pump 20a could be a rotary type or, as here shown, may comprise a conventional positive displacement reciprocating type having a flexible diaphragm 22 which is reciprocated by an arm 23 eccentrically connected to a rotary drive member 24. Movement of the diaphragm 22 downwardly, as viewed in FIGURE 1, provides the suction stroke of the pump and movement of the diaphragm upwardly provides the discharge stroke.

In accordance with usual practice, inlet and outlet check valves are provided on opposite sides of the pump. During the suction stroke of the pump a pressure drop is created across inlet check valve 26 and liquid in the line 21 passes into the pump. During the discharge stroke check valve 26 closes and the liquid contents of the pump are forced out through check valve 27 to the steam generator 11.

It will be apparent that, when the water in line 21 is hot enough to flash into steam at the reduced pressures created during the suction stroke of the pump, a vapor lock will be formed and the pump will be ineffective to supply feed water until the vapor pocket condenses. Moreover, very considerable amounts of heat will be lost from the hot return liquid in the form of steam formed when the pressure on the return liquid is reduced to atmospheric at the trap 15.

The system illustrated in FIGURE 2 of the drawing is constructed in accordance with the present invention and is designed to pump the hot return water to the steam generator 11 whenever the return water is available from the separator. The return water in line 13 will be pressurized at approximately the output pressure of the steam generator. Even though some cooling will be unavoidable in the progress of the return water through line 13, the described pressure will be sufficient to prevent flashing and consequent vapor lock. Thus the hot return water will be supplied to the steam generator whenever available.

Preferably and as here shown, the pumps 14 and 16 are of the positive displacement reciprocating diaphragm type and each pump includes a diaphragm such as diaphragms 28 and 29 which are coupled together through

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fluid coupling means 17. Diaphragm 28 of pump means 16 is connected by rod 31 to a rotary drive member 32. Preferably, the volumetric displacement of diaphragm 29 is constructed to be at least as large as that of diaphragm 28 so that all of the energy of diaphragm 28 may be transferred to diaphragm 29 and, in such a case, substantially shut off the pumping action of diaphragm 28.

It will be noted from the coupling that both pumps operate simultaneously, that is, each diaphragm will be undergoing a suction stroke at the same time and each pump will be exerting a discharge stroke at the same time. Thus, when rod 31 retracts diaphragm 28, diaphragm 29 will always be retracted to its full position (the pressure from lines 13 being sufficient to urge the diaphragm 29 rearward). On the forward stroke, the movement of diaphragm 29 to the extreme output position depends upon a comparison of the tendency to push water through its output check valve into the steam generator as opposed to the tendency of diaphragm 28 to push water through its associated output line 33. These tendencies or conditions will vary according to the presence of condensate in the separator 12 as will be more fully explained below.

Thus it is seen that the fluid coupling 17 acts also as part of a pump chamber for diaphragm 28, the pump having as its complete chamber the fluid between the inlet check valve 34 and make up water line 36 and outlet check valve 37 in line 33. Inlet supply 36 obtains make-up water from supply reservoir 38 or any equivalent means which will provide water at a sufficiently low pressure that it does not impede the return movement of diaphragm 29.

Whenever diaphragm 28 of pump 16 forces water through line 33 and check valve 37, the diaphragm 29 does not extend to its full displacement. Accordingly, on the suction stroke of diaphragm 28, and after diaphragm 29 is retracted, check valve 34 opens to allow make-up water to enter the pump chamber of pump 16 to replace the water pumped through valve 37 and maintain the system in operation.

Pump 14 contains a pump chamber 39 having an elongated line 41 associated therewith in communication with section 42 of the recycling return line 13. At each end of section 42 there is placed inlet check valve 43 and outlet check valve 44 to complete the operating chamber of the pump. Thus, in the normal recycling operation, when diaphragm 29 is retracted, condensate is drawn from line 13 through check valve 43 into line 41, and when diaphragm 29 moves forward, the liquid in line 41 is pushed through check valve 44 into steam generator 11.

When make-up water is to be supplied to the steam generator, it passes through outlet check valve 37 to a T section 46 where the make-up stream joins the recycling stream and thence through line 42 toward the steam generator. In order to prevent reverse flow of make-up water to the separator 12, a check valve 47 is provided in line 13 and this check valve defines a boundary of the T section 46.

When an apparatus is constructed in accordance with FIGURE 2 of the drawing, it is found that where liquid or condensate is in line 13 from separator 12 the diaphragm 29 of pump 14 operates to pump condensate and push it into the steam generator 11, and pump 16 does not pump make-up water. However, it is also found that when vapor enters line 13, at least some make-up water is pushed from the chamber of pump 16 through check valve 37 from where it eventually reaches the steam generator. Although the invention is not to be restricted to any theory of operation, it is believed that this desirable result which is automatically achieved by the apparatus described is obtained for the reasons given in the following description of the operation of the system.

As indicated above, when diaphragm 28 is drawn to the rearward position, diaphragm 29 is also drawn to its

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rearmost position. This is positively assured by virtue of the fact that the pressure in separator 12 is in communication to the front of the diaphragm 29 through line 13 and line 41. Preferably, the pressure in the separator will be at least twenty-five p.s.i. although it will be appreciated that the actual pressure limitations will depend on the design of the overall system. Ordinarily, the pressure in the separator will be much higher than 25 p.s.i. As opposed to this, the pressure in line 36 will be comparatively low such as say about one p.s.i. so that no water will pass through check valve 34 unless diaphragm 29 is completely retracted before diaphragm 28 is completely retracted.

If sufficient condensate is present in separator 12 so that water is drawn into line 13, there will be liquid in the entire system from line 13 through check valve 44. Diaphragm 28 is then pushed forward against liquid in the entire system and it will be seen that liquid preferentially moves through line 41 instead of line 33. This preference is due to the fact that the resistance to movement through line 41 through check valve 44 is opposed by the flow through line 41 and check valve 44 only, while the resistance to movement through lines 33 is opposed not only by flow through an equivalent line and the same check valve 44, but also by check valves 37 and 43.

Accordingly, it is seen that where the capacity of pump 14 is as large as that of pump 16, the system may be designed with appropriate check valves to pump condensate while pumping substantially no make-up water. On the other hand, it will be appreciated that some feed water could be pumped at all times, if desired, by making the capacity of pump 14 smaller than the capacity of pump 16 or possibly by the speed of operation of the pump as opposed to the resistance to flow in the check valves. However, in either case, pump 14 will definitely pump condensate in recycling fashion.

When the condensate level in separator 12 is lowered so that the vapor enters line 13, the vapor will be pulled in through line 13 until it reaches the T section 46 bounded by check valves 37, 43 and 47. The dimensions of the system are preferably designed so that liquid remains in line 42 and definitely remains at all times in line 41. Thus on the exhaust stroke, we again have diaphragm 29 tending to push liquid through line 41 and check valve 44 into the steam generator and for whatever movement of diaphragm 29 that takes place, such pumping action does in fact occur. However, the resistance to flow of liquid through line 33 is different from that in the previous case, because now the liquid does not flow through valve 43 toward the steam generator but can instead compress vapor in T zone 46. In addition, since cold water is flowing through lines 33, the entry of cold water into T zone 46 tends to cause condensation therein which favors flow of more water into the T section.

The movement of this water through lines 33 means the diaphragm 28 displaces a larger volume than diaphragm 29 so that on retraction of diaphragm 28 this larger volume is made up by drawing make-up water through line 36. On the next pumping stroke, with liquid being again present in substantially all of the T zone, pump 14 will probably operate to full capacity. However, it will then probably draw in vapor on the next stroke.

This description suggests an alternate entry of batches of make-up water, and it has been found in practice that such alternate operation does in fact take place under certain conditions. However, it will be appreciated that the above operational description has been given for the extreme cases where either 100% condensate or 100% vapor is supplied through lines 13. In actual operation, there will frequently be some of both materials so that the actual operations will be somewhat variable. However, should the 100% positions be reached, the operations explained above will take place. In this way, a considerable range of make-up water varying from zero

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to rather large amounts may be supplied to the system.

It should also be noted that variations in capacity will depend to some extent on the nature of the boiler pressure, the pressure drop through the check valves, and the hydrostatic heads in the various lines. For example, it may be seen that the pressure in T section 46 tends to be an amount slightly less than that in separator 12 due to the pressure drop required to move material through the pressure drop required to move material through check valve 47. By the same token, the selective resistance to movement of liquid through line 33 as opposed to that through line 41 is obtained by the resistance to movement through check valves 37 and 43, as is well-known to those skilled in the art. Thus, it is believed that considerable variations may be obtained not only by changing the capacities of the pump 16 and slave pump 14 coupled thereto, but by other design considerations such as the characteristics of the check valves and that an absolutely fool-proof operation may be positively assured with the minimum of parts herein shown and claimed.

From the foregoing it will be apparent that I have provided a novel feed water supply system for a steam generator or the like which will automatically pump hot condensate to the steam generator when available and which will also automatically furnish make-up water to the feed water pump whenever the hot condensate is not available, the system being designed to utilize more or less standard components in a novel combination providing for much higher efficiency than has previously been obtainable.

What is claimed is:

1. In a pumping system for supplying liquid at a constant rate to an apparatus, a liquid separator providing an intermittent supply of liquid and vapor under pressure, a liquid supply means for providing the liquid at a lower pressure, a first pump having an intake conduit connected to said separator and an output conduit connected to said apparatus, and a second pump having an intake conduit connected to said liquid supply means and an output conduit connected to the intake conduit of the first pump, said first pump containing a first reciprocating plunger means and a first pump chamber associated therewith for drawing liquid into said chamber through the pump intake conduit and expelling liquid from the chamber through the pump output conduit, and said second pump containing second reciprocating plunger means and a second pump chamber in fluid coupled connection with said first pump whereby reciprocating motion on the second pump is operative to actuate the reciprocating plunger means on the first pump.

2. In a pumping system for supplying liquid at a constant rate to an apparatus, a liquid separator providing an intermittent supply of liquid and vapor under pressure, a liquid supply means for providing the liquid at a lower pressure, a first pump having an intake conduit connected to said separator and an output conduit connected to said apparatus, a second pump having an intake conduit connected to said liquid supply means and an output conduit connected to the intake conduit of the first pump, said first pump containing a first reciprocating plunger means and a first pump chamber associated therewith for drawing liquid into said chamber through the pump intake conduit and expelling liquid from the chamber through the pump output conduit, said second pump containing second reciprocating plunger means and a second pump chamber in fluid coupled connection with said first pump whereby reciprocating motion on the second pump is operative to actuate the reciprocating plunger means on the first pump, and check means in the intake conduit of said first pump for preventing reverse flow to said separator by operation of said second pump, said check means being located in between said separator and the connection of the output conduit of the second pump to the intake conduit of the first pump.

3. The pumping system defined in claim 2, in which

the reciprocating plunger means of the first and second pump each consists of a flexible diaphragm and the volumetric movement of the diaphragm of the first pump is constructed to equal the volumetric movement of the diaphragm of the second pump.

4. In a steam generating system having a separator and a hot water return line, a feed water supply system comprising a recirculating conduit for returning hot water from the separator to the steam generating apparatus, a first pump having reciprocating means operating a chamber in fluid communication with a section of the return line, said section being bounded by one-way check valves to prevent reverse movement of fluid through said return lines, a water make-up line connected to a source of make-up water and to the hot water return line upstream of said section of the return line, a second pump in said water make-up line for selectively supplying the water and actuating said first pump, said second pump having reciprocating means and a chamber having a fluid communication to the reciprocating means of said first pump, and means for actuating the reciprocating means of said second pump whereby the fluid in the second pump chamber operates to actuate the reciprocating means on the first pump and supply feed water in accordance with the condition of the fluid in the hot water return line.

5. In a steam generating system having a separator and a hot water return line, a feed water supply system comprising a recirculating conduit for returning hot water from the separator to the steam generating apparatus, a first pump having reciprocating means operating a chamber in fluid communication with a section of the return

line, said section being bounded by one-way check valves to prevent reverse movement of fluid through said return lines, a water make-up line connected to a source of make-up water and to the hot water return line upstream of said section of the return line, a second pump in said water make-up line for selectively supplying the water and actuating said first pump, check means in said hot water return line between the connection of the feed water supply line and the separator to prevent reverse flow there-through, said second pump having reciprocating means and a chamber having a fluid communication to the reciprocating means of said first pump, and means for actuating the reciprocating means of said second pump whereby the fluid in the second pump chamber operates to actuate the reciprocating means on the first pump and supply feed water in accordance with the condition of the fluid in the hot water return line.

6. The steam generating system defined in claim 5, in which the reciprocating means of the first and second pumps are flexible diaphragms.

7. The steam generating system defined in claim 5, in which the first and second pump is a single dual pump unit having a powered diaphragm, a slave diaphragm and a fluid coupling between said diaphragms.

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