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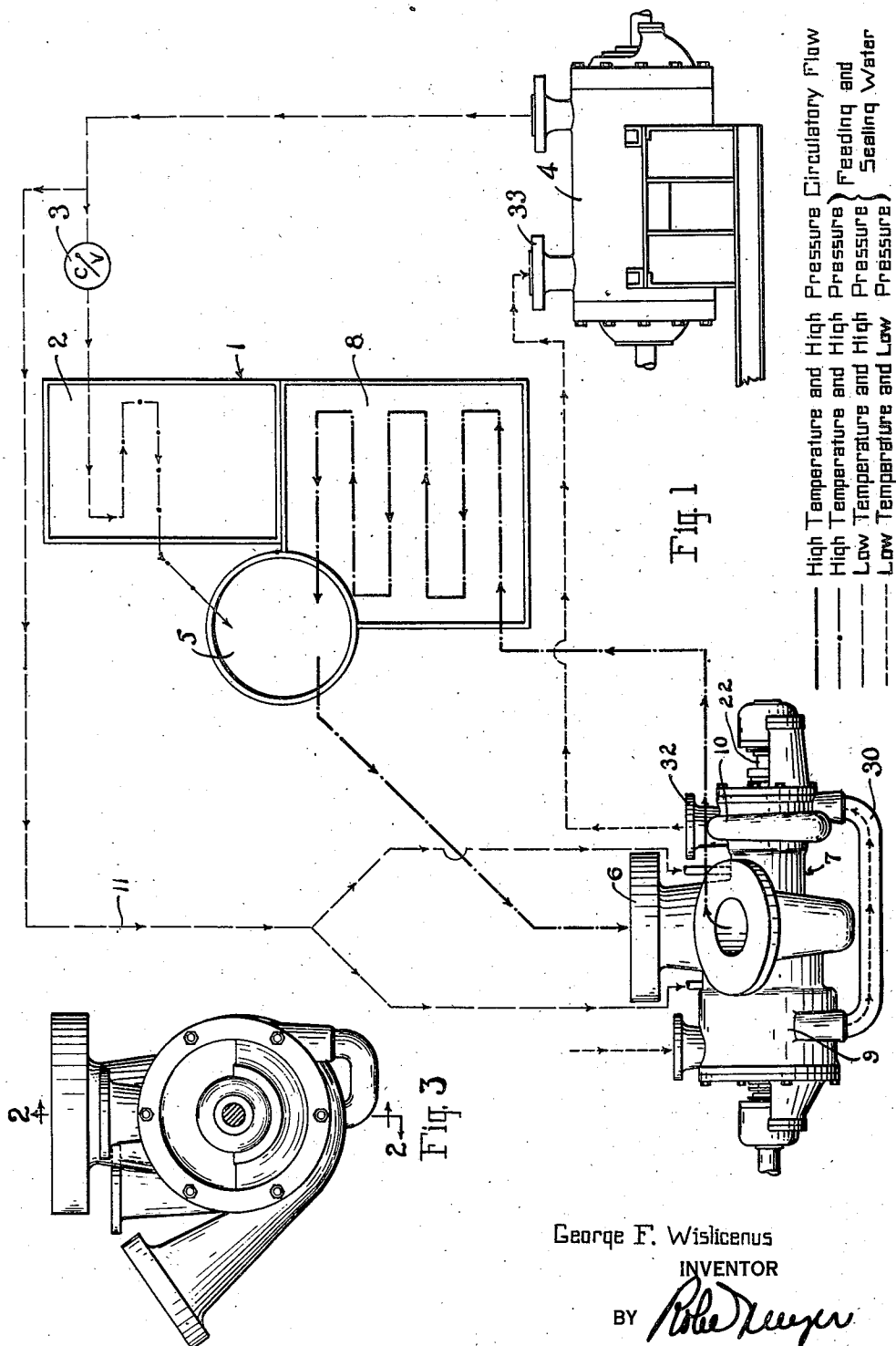
G. F. WISLICENUS

2,281,650

CIRCULATING PUMP FOR STEAM GENERATORS

Filed Jan. 27, 1940.

3 Sheets-Sheet 1



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3 Sheets-Sheet 2

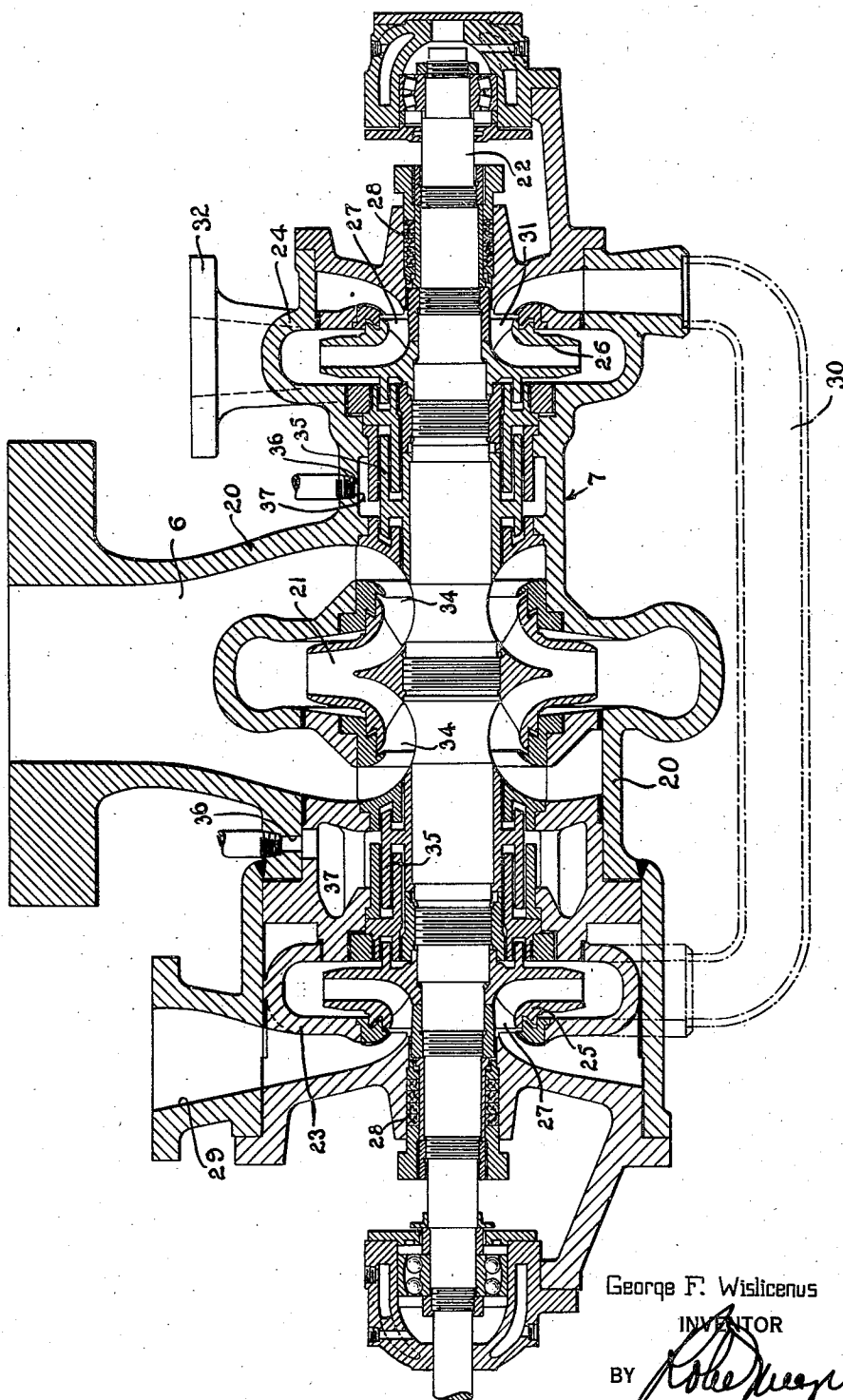


Fig. 2

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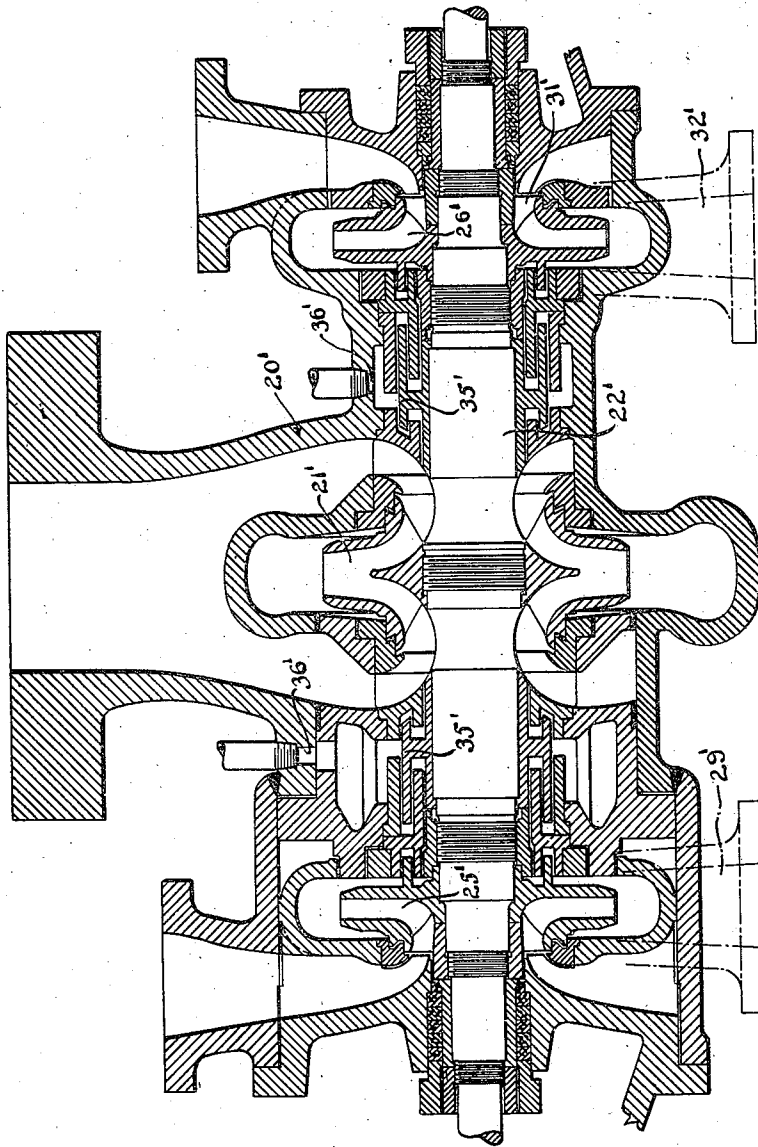


Fig. 4

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CIRCULATING PUMP FOR STEAM GENERATORS

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16 Claims. (Cl. 103—105)

This invention relates to boiler or steam generator feed systems and more particularly to a circulating pump for circulating the water through the boiler or steam generator of a forced feed circulation type of steam generator.

In forced circulation boiler feed systems such as the "La Mont," etc., the water is circulated through the economizer or part of the tubes of the boiler, passing from this economizer in most instances to the boiler drum, from which the water is picked up by a circulating pump and forced under slightly increased pressure through the evaporator section or remaining tubes of the boiler. Thus the circulating pump must handle water or liquid at a high pressure and high temperature. The tubes in the boiler of such a system are arranged together with the circulation arrangement of the water in such manner that each tube receives the correct amount of water according to its steam generating capacity, as determined by its position in the system.

Such forced circulation system steam generators or boilers have many advantages over natural circulation types, especially in installations where maximum steam generation per unit of space and weight is required. These facts have been recognized in the field, but considerable difficulty has been experienced in providing an efficient, practical circulating pump for handling the water at the temperatures and pressures necessary to provide the proper operation of such a forced circulation of water through the boiler or steam generator.

The primary object of the present invention is to provide a pump which will meet all of the requirements of such a boiler feed system and which is particularly designed to overcome the packing and leakage difficulties which have been prevalent in circulating pumps heretofore employed in such systems.

With these and other objects in view, as may appear from the accompanying specification, the invention consists of various features of construction and combination of parts, which will be first described in connection with the accompanying drawings, showing a circulating pump for steam generators of the preferred form embodying the invention, and the features forming the invention will be specifically pointed out in the claims.

In the drawings:

Figure 1 is a diagrammatic view of a steam generating system showing the improved pump incorporated therein.

Figure 2 is a longitudinal section through the pump.

Figure 3 is an end view of the pump.

Figure 4 is a longitudinal section through a modified form of the pump.

In the present invention the forced circulation steam generating system is of the type which embodies a boiler feed water booster pump which receives the boiler feed water from a suitable source and discharges it to the inlet of the main boiler feed pump in the system. In systems of this type the booster pump and the circulating pump which takes the water from the boiler drum and delivers it to the evaporator section of the boiler usually work under a relatively low inlet head over the vapor pressure of the liquid pumped and the speed of these pumps is restricted by their expected cavitation limits. The optimum speed for these pumps is approximately equal so that the combination of these pumps on one shaft permits the best possible hydraulic design and more compact construction for both units.

Since forced circulation boilers or steam generators operate usually at pressures of approximately one thousand to three thousand pounds or the critical pressure per square inch (1000 to 3000 lbs. p. s. i.), it is difficult, if not impossible, to reliably pack the shaft of the circulating pump against such pressure and corresponding high temperature without unduly reducing the operating speed of the circulating pump. The use of pressure breakdown devices between the impeller and packing is well known, but has the disadvantage that it requires separate return pipes for the leakage, and that it is often difficult to return such leakage into the system in a satisfactory manner. For this reason, the present invention includes the arrangement of the booster pumps on the two ends of the double suction circulating pump.

The pressure differences between the boiler circulating pump and the booster pump is such that it must be broken down by suitable pressure breakdown structures, such as a labyrinth between the circulating pump and the booster pump impellers. However, if the high temperature water in the circulating pump leakage were throttled down in the pressure breakdown structure to the booster pump pressure an appreciable portion of the leakage water would be converted into vapor or steam during the pressure reduction action because the water in the circulating pump has practically boiler temperature and is therefore close to the point of vaporization. This

would cause the leakage stream from the breakdown structures to be a mixture of steam and water. If such a stream, passing into the booster pump, were mixed with the colder water in the booster pump or booster stages, the sudden condensation of the steam would cause serious vibrations, noise and possibly erosion of the surrounding walls. Therefore, to avoid the danger and undesirability of breaking down the pressure of the leakage from the circulating pump and still derive the several advantages of combining the circulating and booster pump, the present invention embodies means for and the introduction into the pressure breakdown structure, preferably near its high pressure end, of high pressure sealing liquid at a temperature below the vaporization temperature corresponding to the pressure in the booster stages or pump, so that the sealing water will not turn into steam when its pressure is broken down to the pressure of the booster pump. In this way the breaking down of the high pressure, high temperature leakage water from the circulating pump is avoided, with its consequent vaporization.

Referring more particularly to the drawings, and particular to the diagrammatic Figure 1, at 1 is indicated the boiler or steam generator embodying the economizer section 2 into which the boiler feed water is pumped through any approved type of boiler check valve 3 by the main boiler feed pump 4. From the economizer section 2 of the boiler the water passes into the boiler drum 5 from which it is taken by the circulating pump 6 of the pump structure 7. The circulating pump 6 takes the high pressure, high temperature water from the boiler drum 5 and discharges it into the forced circulation boiler or vaporizing section 8 of the steam generator, from which the steam and such water as is not vaporized returns to the boiler drum. The steam is taken from the boiler drum to the point of use, while such water as is not vaporized is again circulated through the forced circulation boiler 8 by the circulating pump 6.

In the system shown the boiler feed water is taken from the feed water heaters (not shown) or from the suitable source of supply of boiler feed water by the booster pump structure which is shown in Figure 1 of the drawings as comprising the two booster pumps 9 and 10, connected in series, with the booster pump 10 discharging into the main boiler feed pump 4.

The system above generally described is old in the art of steam generation, and the present invention relates specifically to the arrangement and construction of the circulating pump 6 and the booster pump, together with the arrangement of breaking down the pressure of the leakage water from the circulating pump and introducing into such water during the pressure break down operation a sealing water at a relatively low temperature and high pressure. This sealing water may be a bleed-off from the discharge of the main boiler feed pump, such bleed-off being shown at 11 in Figure 1 of the drawings.

As pointed out hereinabove, the speeds of rotation of the booster pumps and the boiler circulating pump are the same and conditions of operation are such that they can practically operate at the same speeds. Therefore, for the purpose of economy, both in the cost of manufacture and installation, and for the purpose of economy in occupied space of the pumps they are combined in a single unit driven by a single shaft, as

shown clearly in the longitudinal section comprising Figure 2 of the drawings.

The combined circulating and booster pump unit generically referred to by the numeral 7 comprises a casing 20 which is constructed to provide centrally of its ends the casing 6 for the circulating pump. The circulating pump 6 includes a double suction impeller 21 which is mounted on and is rotated by rotation of the shaft 22. The casing 20 has formed therein at each end, upon opposite sides of the circulating pump structure 6, casing sections forming the casings 23 and 24 of the booster pump structure, and these casing sections 23 and 24 have a booster pump impeller 25 and 26 respectively, mounted in each. The impellers 25 and 26 are mounted upon and rotate with the shaft 22, and they each have their suctions or inlet eyes 27 facing towards the outer ends of the casing so that the packing structures 28 between the casing 20 and the shaft 22 will be subjected only to the suction pressure of the booster pump impellers 25 and 26.

In Figure 2 of the drawings the impellers 25 and 26 are shown connected in series. That is, the initial inlet of the feed water is through the inlet 29 of the casing 23, to the impeller 25, while the impeller 25 discharges into a connecting pipe or passage 30, which opens into the suction eye 31 of the impeller 26. The impeller 26 discharges through the booster pump outlet 32 to the suction 33 of the main boiler feed pump, as shown in Figure 1 of the drawings.

The backs or sides of the impellers 24 and 25 which are subjected to their discharge pressures face towards the suction eyes 34 of the circulating pump structure 6. Leakage from the circulating pump 6 will be along the shaft 22 in both directions under the pressure and temperature of the water or liquid at the suction of the circulating pump 6. However, the circulating pump 6 receives the water at a pressure slightly below the discharge pressure of the main boiler feed pump 4, and at a temperature slightly below the vaporization point of the water at its pressure. In modern type steam generating systems the pressure of the water entering the suction of the circulating pump 6 will be approximately one thousand to three thousand pounds per square inch (1000 to 3000 lbs. p. s. i.) with the corresponding temperature, while the discharge pressures of the boosted pump impellers 25 and 26 will be considerably below one thousand pounds per square inch. Therefore pressure breakdown structures of any suitable type, such as the labyrinth pressure breakdown structures 35 are positioned between the circulating pump 6 and the two stages of the booster pump for breaking down the pressure of the leakage liquid from the circulating pump 6. However, if the pressure of the leakage from the circulating pump 6 were broken down, at its corresponding temperature, to the pressure of the booster pump discharges, this leakage would vaporize or flash into steam with resultant undesirable action and impairment of the efficiency of the booster pump. To prevent such vaporization of the leakage the casing 20 has two inlets 36 therein which open through chambers 37 into the pressure breakdown structures 35, preferably near the points of the leakage from the circulating pump or at a point of high pressure in the pressure breakdown structures. These inlets 36 are connected by the bleed-off connection 11 with the discharge of the main boiler feed pump 4 so that sealing water under high pressure and relatively low temperature will

be fed into the pressure breakdown structures 35 and mingle with the leakage from the circulating pump 5, lowering the temperature of the leakage water so that its pressure may be broken down in the remaining portions of the pressure breakdown structure to approximately the discharge pressures of the stages of the booster pump without vaporizing.

While in Figures 1 to 3 inclusive of the drawings, and in the foregoing description, the two impellers of the booster pump structure are shown connected in series, it is to be understood that the present invention equally comprehends provision of a pump of this type wherein the two stages of the booster pump operate in parallel. That is, each has independent suction inlets and discharges which may be merged some place between the booster pump and the source of supply of the feed water and between the booster pump and the main boiler feed pump.

A pump showing the impellers operating in parallel is illustrated in Figure 4 of the drawings. This modified form of the pump construction is the same in all other respects to the construction of pumps shown in Figures 1 to 3 of the drawings. That is, it has a casing 20' in which is positioned the double suction impeller 21' of the circulating pump. The impeller 21' is mounted upon and rotated by the shaft 22', which also carries the impellers 25' and 26' of the two stages of the booster pump structure. The volutes, inlet passages, and discharge passages for the circulating pump impeller and the impellers of the booster pump stages are all formed in the casing 20'. Pressure breakdown structures 35' are positioned between the circulating pump and each stage of the booster pump, and these pressure breakdown structures 35' may receive a high pressure low temperature liquid through the inlets 36' for preventing vaporization of the leakage from the circulating pump. This modified form differs from the form shown in Figure 2 in that the discharge 29' of the impeller 25' of the booster pump is connected directly to the line which leads to the main boiler feed pump, rather than leading to the suction eye 31' of the impeller 26'. The discharge of the impeller 26' is through the discharge connection 32' directly to the main boiler feed pump 4.

These two stages of the modified form of booster pump may receive water from any suitable source.

It will be understood that the invention is not to be limited to the specific construction or arrangement of parts shown, but that they may be widely modified within the invention defined by the claims.

What is claimed is:

1. The method of preventing leakage from the circulating pump which consists in passing the leakage from the circulating pump into a pressure breakdown structure and introducing into the pressure breakdown structure near its high pressure end a sealing liquid of a pressure approximately equal to the pressure of the leakage fluid and at a temperature below the point corresponding to the vaporization temperature of the pressure at the point of the leakage outlet to prevent vaporization of the leakage fluid without appreciably lowering its temperature.

2. The method of preventing leakage from a centrifugal pump which consists in passing leakage from the pump into a pressure breakdown structure and introducing into the pressure breakdown structure near its high pressure end

a sealing liquid at a pressure slightly greater than the pressure of the leakage fluid and at a temperature below the point corresponding to the vaporization temperature of the pressure of the leakage to prevent vaporization of the leakage fluid without appreciably lowering its temperature.

3. The method of preventing leakage from a centrifugal pump receiving liquid at its suction at a pressure of approximately one thousand to three thousand pounds per square inch and at a temperature slightly below its vaporization temperature at its pressure, which consists in passing the leakage from the pump into a pressure breakdown structure and introducing into the pressure breakdown structure near its high pressure end a sealing liquid of a pressure slightly greater than the pressure of the leakage fluid and at a temperature below the point corresponding to the vaporization temperature of the leakage.

4. The method of preventing leakage from a centrifugal pump receiving liquid at its suction at a pressure of approximately one thousand to three thousand pounds per square inch and at a temperature slightly below its vaporization temperature at its pressure, which consists in passing the leakage from the pump into a pressure breakdown structure and introducing into the pressure breakdown structure near its high pressure end a sealing liquid of a pressure slightly greater than the pressure of the leakage fluid and at a temperature below the point corresponding to the vaporization temperature of the leakage, and finally passing the leakage fluid after its pressure and temperature has been lowered into a pump operating under pressure and temperature of liquid below the temperature and pressure of liquid acted upon by the centrifugal pump.

5. In a centrifugal pump, a casing, a double suction impeller in said casing, impellers in said casing on each side of said double suction impeller for receiving therein and discharging with their discharge leakage from said double suction impeller, labyrinthian pressure breakdown means between the double suction impeller and each of said second-named impellers for breaking down the pressure of leakage from the double suction impeller before it reaches the second-named impellers, and means for introducing a high pressure sealing liquid into said pressure breakdown structures.

6. In a centrifugal pump, a casing, a high pressure high temperature liquid circulating impeller in said casing, an impeller in said casing for pumping liquid at a lower pressure than the liquid pumped by the circulating impeller and for receiving leakage from said circulating impeller and discharging it with its discharge, and a pressure breakdown structure between said impellers, said casing provided with an inlet opening into said pressure breakdown structure for admitting high pressure sealing liquid into the high pressure breakdown structure.

7. In a centrifugal pump, a casing, a circulating impeller in said casing for pumping high pressure high temperature liquid, an impeller in said casing for pumping liquid at a pressure and temperature lower than the temperature and pressure of liquid pumped by the circulating impeller, said impellers constructed and arranged whereby leakage from the high pressure circulating impeller will flow into the lower pressure impeller, and a pressure breakdown structure in said casing between said impellers for breaking down the pressure of leakage from the circulating impeller.

8. In a centrifugal pump, a casing, a circulating impeller in said casing for pumping high pressure high temperature liquid, an impeller in said casing for pumping liquid at a pressure and temperature lower than the temperature and pressure of liquid pumped by the circulating impeller, said impellers constructed and arranged whereby leakage from the high pressure circulating impeller will flow into the lower pressure impeller, a pressure breakdown structure in said casing between said impellers for breaking down the pressure of leakage from the circulating impeller, and means for preventing the leakage from flashing into vapor upon the breaking down of its pressure.

9. In a centrifugal pump, a casing, a circulating impeller in said casing for pumping high pressure high temperature liquid, an impeller in said casing for pumping liquid at a pressure and temperature lower than the temperature and pressure of liquid pumped by the circulating impeller, said impellers constructed and arranged whereby leakage from the high pressure circulating impeller will flow into the lower pressure impeller, a pressure breakdown structure in said casing between said impellers for breaking down the pressure of leakage from the circulating impeller, said casing provided with an inlet opening into said pressure breakdown structure for admitting high pressure low temperature sealing liquid into the pressure breakdown structure.

10. In a centrifugal pump unit, a high pressure high temperature liquid double suction circulating pump, pumps at each end of said circulating pump for circulating liquid at lower pressure and lower temperature than the circulating pump, said pumps constructed and arranged whereby leakage from the circulating pump will flow to the lower pressure pumps, and pressure breakdown structure between said circulating pump and each of said lower pressure pumps for breaking down the pressure of the leakage, and means for preventing the leakage from flashing into vapor upon the breaking down of its pressure.

11. In a pumping system, a source of high pressure relatively low temperature liquid, a double suction centrifugal circulating pump for pumping high pressure high temperature liquid, a pair of booster pumps for pumping relatively low pressure low temperature liquid and positioned one at each end of said circulating pump, said circulating pump and low pressure pumps arranged and constructed whereby leakage from the circulating pump will flow to the low pressure pumps, pressure breakdown structures for breaking down the pressure of leakage between said pumps, said pressure breakdown structures connected to said source of high pressure relatively low temperature liquid whereby a high pressure relatively low temperature sealing liquid will be introduced into the pressure breakdown structures to prevent the leakage from flashing into vapor upon the breaking down of its pressure.

12. In a pumping system, a source of high pressure relatively low temperature liquid, a double suction centrifugal circulating pump for pumping high pressure high temperature liquid, said circulating pump including a double suction impeller, a pair of booster pumps for pumping relatively low pressure low temperature liquid and positioned one at each end of said circulating pump, said booster pumps including impellers, a driving shaft, all of said impellers mounted upon said driving shaft, said circulating pump and low pressure pumps arranged and constructed whereby leakage from the circulating pump will

flow to the low pressure pumps, pressure breakdown structures for breaking down the pressure of leakage between said pumps, said pressure breakdown structures connected to said source of high pressure relatively low temperature liquid whereby a high pressure relatively low temperature sealing liquid will be introduced into the pressure breakdown structures to prevent the leakage from flashing into vapor upon the breaking down of its pressure.

13. A combined feed water circulating and booster pump for steam generating systems including a driving shaft, a circulating pump including an impeller, said impeller mounted upon said shaft intermediate its ends, a booster pump including a plurality of stages placed equally upon opposite sides of said circulating pump impeller, each of said booster pump stages including an impeller mounted upon said driving shaft and driven thereby, the impellers of said booster pump stages having their backs or sides subject to discharge pressure facing the suction eyes of the circulating pump impeller, pressure breakdown means between the circulating pump and said booster pump stages for breaking down the pressure of leakage between the circulating pump and the booster pump stages, and means for maintaining the relative pressure and temperature of the leakage in said pressure breakdown means so as to prevent vaporization of the leakage fluid.

14. A combined feed water circulating and booster pump for steam generating systems including a driving shaft, a circulating pump including an impeller, said impeller mounted upon said shaft intermediate its ends, a booster pump including a plurality of stages placed equally upon opposite sides of said circulating pump impeller, each of said booster pump stages including an impeller mounted upon said driving shaft and driven thereby, the impellers of said booster pump stages having their backs or sides subject to discharge pressure facing the suction eyes of the circulating pump impeller, and pressure breakdown means between the circulating pump and said booster pump stages for breaking down the pressure of leakage between the circulating pump and the booster pump stages, said pressure breakdown structures provided with inlets intermediate their ends to permit the introduction of sealing liquid into the pressure breakdown structures, said sealing liquid being at such temperature and pressure as to maintain relative pressure and temperature of the leakage in said pressure breakdown means as to prevent vaporization of the leakage fluid.

15. In a centrifugal pump, a casing, a circulating impeller in said casing for pumping high pressure high temperature liquid, an impeller in said casing for pumping liquid at a pressure and temperature lower than the temperature and pressure of liquid pumped by the circulating impeller, said impellers constructed and arranged whereby leakage from the high pressure circulating impeller will flow into the low pressure impeller, a pressure breakdown structure in said casing between said impellers for breaking down the pressure of leakage from the circulating impeller, and means for introducing a liquid at predetermined temperature and pressure into said pressure breakdown means for mixture with and cooperation with said leakage to permit lowering of the pressure of the leakage below its vaporization pressure without change in the physical organism of the leakage.

16. The method of preventing leakage from a centrifugal pump pumping liquid at high temperature and high pressure and having a high suction inlet pressure which consists in passing leakage from the pump into a pressure breakdown structure and introducing into the pressure breakdown structure a liquid at predetermined

temperature and pressure for mixture and cooperation with the leakage to permit lowering of the pressure of the leakage below its vaporization pressure without change in the physical organism of the leakage.

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