

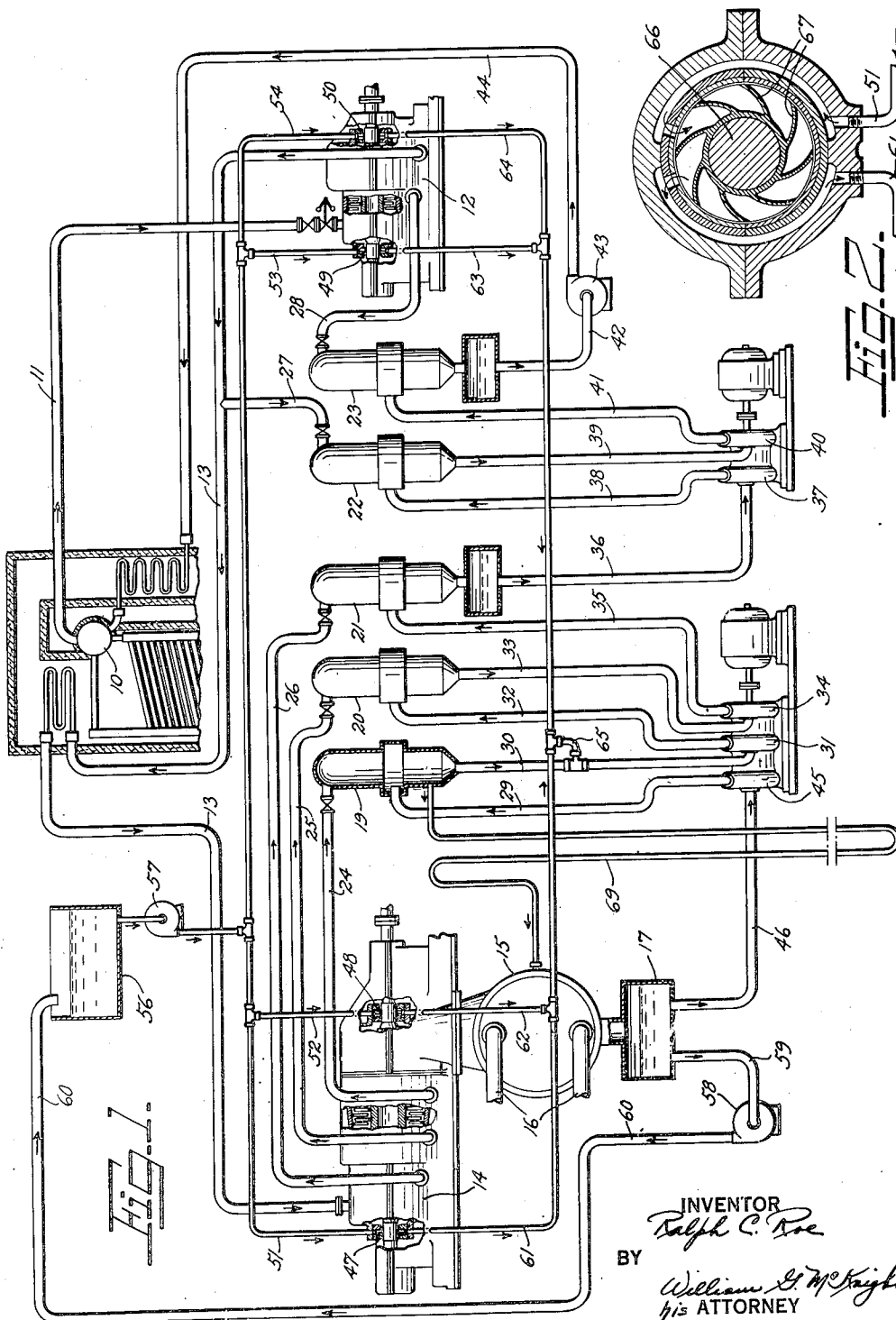
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R. C. ROE

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STEAM PLANT

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INVENTOR
Ralph C. Roe
BY
William S. McKnight
ATTORNEY

UNITED STATES PATENT OFFICE

RALPH C. ROE, OF ENGLEWOOD, NEW JERSEY, ASSIGNOR OF ONE-HALF TO STEPHEN W. BORDEN, OF SUMMIT, NEW JERSEY

STEAM PLANT

Application filed February 25, 1930. Serial No. 431,086.

My invention relates to power plants and more particularly to power plants having turbines or like prime movers having shafts which must be packed to prevent leakage of steam. Various types of packing devices are known, and amongst these are what I term a water gland seal, a device through which water flows and prevents travel of steam along a shaft. The present invention relates particularly to the utilization of heat developed in water gland seals.

Water passing through seals is necessarily heated, and in the case of large installations, operating at high pressure, the amount of heat transferred to the seal water is quite appreciable and well worth saving. It has been the custom heretofore to discharge this seal water directly into the turbine condenser. This has a disadvantage in many, if not in most cases, in that condensers are operated at a vacuum, and the seal water, being highly heated at higher absolute pressure, after passing through the seal or seals, is so hot that when introduced into the condenser, an appreciable portion of it flashes into steam. This steam must be condensed by the cooling water in the condenser tubes and not only puts an additional burden on the condenser, requiring a larger condenser, but constitutes a loss of heat, since the latent heat of vaporization of this steam condensed by the cooling water passes into the cooling water and therefore goes to waste.

In a steam power plant of relatively large size wherein the steam generation at full load is, for example, 250,000 pounds per hour, the rate of flow of gland water may be, for example, 15,000 pounds per hour. It will be readily seen that this amount of water is an appreciable quantity and is not a factor to be lightly regarded. Especially is this evident when it is considered that the flow of gland water is constant during operation, so that when the same plant is, for example, generating 50,000 pounds of steam per hour, the flow of gland water will be still at a rate of 15,000 pounds per hour.

In working on this problem, I have had particular regard to the type of steam plant disclosed in my copending application, Serial

No. 399,152, filed October 12th, 1929, in which steam is bled from various points of a turbine to open direct contact heaters wherein the steam is condensed by feed water which is pumped successively through the heaters, and I believe that the present invention has particular advantages in connection with such a plant, though it may be applicable to other types of plants. In order to overcome the disadvantage above pointed out, as regards the discharge of the gland water into the condenser, I propose to introduce the gland water into the feed water system at a point of higher pressure than the pressure of the condenser. Specifically, in a plant such as above referred to, I introduce the gland water either into one of the heaters of the feed water system or between two of the heaters of the feed water system. This avoids, at least to a major extent, the pressure drop referred to and consequently the flashing of steam from the gland water and its loss. Even with my arrangement, some steam may be flashed, but it is conserved in that it becomes recondensed within the system and the heat remains in the system, being ultimately conveyed to the boiler in the feed water.

With this introduction of a substantially constant quantity of hot water into the feed water system, which quantity bears no proportionate relation to the flow of feed water under varying loads, the problem arises as to how to adjust the system to take care of this. The water flow through the pump between the condenser and the feed water system should not be stopped or even substantially stopped, despite the fact that sufficient water is available for the feed water system ahead of this pump, due to the gland supply, because this pump takes hot water from the hot well and the slight addition of heat would cause formation of steam. This factor must be taken care of, particularly in a plant of the type above referred to where the pump between the hot well and the feed water system is connected to run with one or more pumps of the feed water system. The churning of water in the pump would generate heat, which would cause steaming. I therefore

designed this pump so that it will always pump an appreciable amount or will pump a proportionately greater amount at low load than at high load on the plant. I then provide a return connection from the feed water system to the condenser to take care of the spillage of this pump and the excess supply of the gland system, which return connection is arranged, for example, with a loop, to provide means, such as a hydrostatic column, for balancing the difference of pressure between the feed water system and the condenser as caused by the pressure differential of the lowest pressure pump.

The nature of the invention will become apparent from a consideration of the following specification taken in conjunction with the accompanying drawings showing, more or less diagrammatically, a steam plant embodying the invention.

On the drawings:

Fig. 1 represents the steam plant as a whole; and

Fig. 2 is a cross-sectional view of a water gland seal.

Steam is generated in the boiler unit 10 and passes through conduit 11 into the high pressure turbine unit 12, including the usual blade elements. From turbine unit 12 the steam passes through conduit 13 and into low pressure turbine unit 14. Connected to turbine unit 14 is a condenser 15, through which cooling water flows, the cooling water being introduced into and discharged from the condenser through the pipes 16. The steam passing through the turbines is condensed in the condenser 15 and passes into a reservoir or hot well 17.

The feed water system comprises a plurality of open heaters 19, 20, 21, 22 and 23. The number of these heaters is optional. These heaters receive steam from different pressure points of the turbine units through conduits 24, 25, 26, 27 and 28, respectively. In each of the feed heaters the steam bled from the turbine is brought into direct contact with the feed water. The feed water is supplied to the feed water system by means of conduit 29, which is connected to heater 19. In heater 19 the feed water supplied by conduit 29 is heated by the bleed steam passing through conduit 24 and the water passes from heater 19 through conduit 30, through pump unit 31 and conduit 32 into heater 20. Pump unit 31 maintains a higher pressure in heater 20 than in heater 19, and serves to pump the water from the lower pressure of heater 19 to the higher pressure of heater 20. In heater 20, there is again a heating of feed water and a condensation of bleed steam and the water then passes through conduit 33, pump unit 34 and conduit 35 into heater 21. From heater 21 the water passes through conduit 36, pump unit 37 and conduit 38 into heater 22. From heater 22 the water flows through

conduit 39, pump unit 40 and conduit 41 into heater 23. From heater 23 the water flows through conduit 42 and boiler feed pump 43 and conduit 44 into the boiler. The control of the system may be in accordance with my copending application above referred to, Serial No. 399,152.

The pump unit 45 draws water from hot well 17 through conduit 46 and pumps this water through conduit 29 and into the feed water system. The pump 45 may be on the same shaft as pump units 31 and 34, or it may be separate. I do not consider pump unit 45 as a part of the feed water system, but treat it as the means for pumping water from the condenser to the feed water system. The feed water system is therefore at a higher pressure than the condenser and, so far as the present application is concerned, may be considered as beginning at the inlet to heater 19 and ending at the boiler feed pump 43. The disposition of the pump units on one or more shafts is a matter of selection and I have illustrated the same arrangement as shown in my aforesaid copending application.

Each turbine unit includes water gland seals 47, 48, 49 and 50. Water is supplied to these seals by means of pipes 51, 52, 53 and 54, which are interconnected to be supplied from a common source 56, for example, a storage tank. A pump 57 may be used for supplying the gland water to the gland seals. Water is drawn from hot well 17 by pump 58 through conduit 59 and is forced through conduit 60 into tank 56. The discharge from the water gland seals is through conduits 61, 62, 63 and 64. For purposes of description and defining the invention, I consider the gland water system as comprising conduit 59, pump 58, conduit 60, conduits 51, 52, 53, 54, and conduits 61, 62, 63 and 64. The gland water system is connected in accordance with the present invention to discharge through conduit 65 into conduit 30, which is an intermediate conduit between heaters of the feed water system. It will be seen that the gland water system receives water from the hot well 17, conducts it through the water gland seals where it is heated appreciably, and then conducts it into the feed water system where a higher pressure prevails than in hot well 17. It will also be seen that if this water returned to its original pressure in hot well 17, with the additional heat imparted to it, there would be a flashing of steam and heat would be thrown away.

In Fig. 2 I have shown a cross-sectional view of a known water gland seal merely for illustrative purposes. The turbine shaft 66 carries a wheel 67, which is in effect a centrifugal pump. Water is supplied to the seal through conduit 51 and is discharged through conduit 61. The action of the wheel

67 causes a water seal to be formed which prevents leakage of steam along the shaft. Heat will be imparted to this water due to the temperature of the turbine and of the steam adjacent the water, and due to friction.

The point at which the gland water is introduced into the feed water system is also one of selection. The gland water may be introduced directly into heater 19. It might be introduced into any one of the heaters. This would depend on plant conditions. While the point selected must lie within certain pressure limits, the predominating factor in the selection is the average plant load factor, the most desirable point for the introduction of the gland water being that point where the temperature of the gland water matches the temperature of the feed water averaged over an operating cycle.

With full load on the turbine, since the gland water is introduced between heaters 19 and 20, pump units 31, 34, 37 and 40 will be pumping the full feed water flow of the feed water system while pump 45 will be pumping a lesser amount by the gland water supply which may be, for example, 15,000 pounds per hour, as above stated. Now, if the pump units were all designed to pump proportionately, when the load decreased materially, the point would be reached where pump 45 should pump little or no water. This, however, must not take place, particularly when pump 45 is operating always, as by being connected to the same shaft with other pump units. Consequently, my system involves the special designing of the pump 45 so that it will pump proportionately more water at low load. Pumps can be designed, as is well known, to given pumping characteristics of variable selected character, and it is sufficient to state that this condition must obtain for a pump designer to design a pump which will suit the requirements. It will now be seen that at low loads more water is supplied to the feed water system than is required, and therefore I provide a return connection 69 connecting heater 19 with condenser 15. This connection is bent downwardly to form a loop and this loop is adapted to maintain the difference in pressure between heater 19 and the condenser incident to the operation of pump unit 45. The level of water in the legs of loop 69 will adjust itself to balance the difference in pressure. The adjustment of water quantity in the feed water system may be taken care of as in my aforesaid application, Serial No. 399,152, and in event there is too much water, the water will simply overflow through conduit 69 into condenser 15. When the plant is in operation; the left-hand leg of loop 69 will contain more water than the right-hand leg, to balance the pressure. The height of the loop must be such that the column of liquid therein

can be as great as the maximum pressure difference.

It will be seen that the water gland seals are in effect additional feed water heaters and that the water from these gland seals passes into the feed water system and thence into the boiler without passing through the condenser.

While I have described one plant layout embodying the invention, it will be evident that the arrangement may be varied within the scope of the invention and that various devices may be used in connection with the invention.

What I claim is:

1. A power plant comprising a steam generator, a steam turbine including blade elements and gland water sealing means, means for conducting steam from the steam generator to the turbine, a condenser, means to conduct steam from the turbine to the condenser, a feed water system comprising a plurality of open direct contact steam and water heaters, a gland water system for producing flow of water through the sealing means, means comprising a pump for conducting water from the condenser to the feed water system, means to conduct water from the feed water system to the generator, means to conduct steam from the turbine to the feed water system, means to conduct water from the condenser to the gland water system, means to conduct water from the gland water system to the feed water system and a connection between said feed water system and said condenser.

2. A power plant comprising a steam generator, a steam turbine including blade elements and gland water sealing means, means for conducting steam from the steam generator to the turbine, a condenser, means to conduct steam from the turbine to the condenser, a feed water system, a gland water system for producing flow of water through the sealing means, means comprising a pump for conducting water from the condenser to the feed water system, means to conduct water from the feed water system to the generator, means to conduct steam from the turbine to the feed water system, means to conduct water from the condenser to the gland water system, means to conduct water from the gland water system to the feed water system and a connection between said feed water system and said condenser comprising a loop.

3. A power plant comprising a steam generator, a steam turbine including blade elements and gland water sealing means, means for conducting steam from the steam generator to the turbine, a condenser, means to conduct steam from the turbine to the condenser, a feed water system, a gland water system for producing flow of water through the sealing means, means comprising a pump for conducting water from the condenser to the feed

water system, means to conduct water from the feed water system to the generator, means to conduct steam from the turbine to the feed water system, means to conduct water from the condenser to the gland water system, means to conduct water from the gland water system to the feed water system and a connection between said feed water system and said condenser for conducting water from the feed water system to the condenser and forming a liquid column for balancing the pressure differential of said pump.

4. A power plant comprising a steam generator, a steam turbine including blade elements and gland water sealing means, means for conducting steam from the steam generator to the turbine, a condenser, means to conduct steam from the turbine to the condenser, a feed water system, a gland water system for producing flow of water through the sealing means, means comprising a pump for conducting water from the condenser to the feed water system, means to conduct water from the feed water system to the generator, said feed water system comprising a plurality of direct steam and water contact heaters and pumping means between the heaters, means to connect said heaters with points of different pressure in the turbine, means to conduct water from the condenser to the gland water system, means to conduct water from the gland water system to a point in said feed water system between heaters of said system and a connection between said feed water system and said condenser.

5. A power plant comprising a steam generator, a steam turbine including blade elements and gland water sealing means, means for conducting steam from the steam generator to the turbine, a condenser, means to conduct steam from the turbine to the condenser, a feed water system, a gland water system for producing flow of water through the sealing means, means comprising a pump for conducting water from the condenser to the feed water system, means to conduct water from the feed water system to the generator, said feed water system comprising a plurality of direct steam and water contact heaters and pumping means between the heaters, means to connect said heaters with points of different pressure in the turbine, means to conduct water from the condenser to the gland water system, means to conduct water from the gland water system to a point in said feed water system between heaters of said system and a connection between said feed water system and said condenser comprising a loop.

6. A power plant comprising a steam generator, a steam turbine including blade elements and gland water sealing means, means for conducting steam from the steam generator to the turbine, a condenser, means to conduct steam from the turbine to the condenser,

a feed water system, a gland water system for producing flow of water through the sealing means, means comprising a pump for conducting water from the condenser to the feed water system, means to conduct water from the feed water system to the generator, said feed water system comprising a plurality of direct steam and water contact heaters and pumping means between the heaters, means to connect said heaters with points of different pressure in the turbine, means to conduct water from the condenser to the gland water system, means to conduct water from the gland water system to a point in said feed water system between heaters of said system and a connection between said feed water system for conducting water from the feed water system to the condenser and forming a liquid column for balancing the pressure differential of the pump between the condenser and the feed water system.

7. A power plant comprising a steam generator, a steam turbine including blade elements and gland water sealing means, means for conducting steam from the steam generator to the turbine, a condenser, means to conduct steam from the turbine to the condenser, a feed water system, a gland water system for producing flow of water through the sealing means, means comprising a pump for conducting water from the condenser to the feed water system, means to conduct water from the feed water system to the generator, said feed water system comprising a plurality of direct steam and water contact heaters and centrifugal pumping means between the heaters, means to connect said heaters with points of different pressure in the turbine, means to conduct water from the condenser to the gland water system, and means to conduct water from the gland water system to a point in said feed water system having a pressure at least as high as the pressure existing in the heater of lowest pressure.

8. A power plant comprising a steam generator, a steam turbine including blade elements and gland water sealing means, means for conducting steam from the steam generator to the turbine, a condenser, means to conduct steam from the turbine to the condenser, a feed water system, a gland water system for producing flow of water through the sealing means, means comprising a pump for conducting water from the condenser to the feed water system, means to conduct water from the feed water system to the generator, said feed water system comprising a plurality of direct steam and water contact heaters and pumping means between the heaters, means to connect said heaters with points of different pressure in the turbine, means to conduct water from the condenser to the gland water system, means to conduct water from the gland water system to a point in said feed water system having a pressure at least

as high as the pressure existing in the heater of lowest pressure, and a connection between said feed water system and said condenser.

9. A power plant comprising a steam generator, a steam turbine including blade elements and gland water sealing means, means for conducting steam from the steam generator to the turbine, a condenser, means to conduct steam from the turbine to the condenser, a feed water system, a gland water system for producing flow of water through the sealing means, means comprising a pump for conducting water from the condenser to the feed water system, means to conduct water from the feed water system to the generator, said feed water system comprising a plurality of direct steam and water contact heaters and pumping means between the heaters, means to connect said heaters with points of different pressure in the turbine, means to conduct water from the condenser to the gland water system, means to conduct water from the gland water system to a point in said feed water system having a pressure at least as high as the pressure existing in the heater of lowest pressure, and a connection between said feed water system and said condenser forming a liquid column for balancing pressure differential.

10. A power plant comprising a steam generator, a steam turbine including blade elements and gland water sealing means, means for conducting steam from the steam generator to the turbine, a feed water system, means providing a path of flow from said turbine to said feed water system having a condenser and a pump therein, a gland water system for producing flow of water through the sealing means, means to conduct water from the feed water system to the generator, said feed water system comprising a plurality of direct steam and water contact heaters and centrifugal pumping means between the heaters, means to connect said heaters with points of different pressure in the turbine, means to supply water to the gland water system, means to conduct water from the gland water system to said feed water system, and means to conduct surplus water from said feed water system to said path of flow.

11. A power plant comprising a steam generator, a steam turbine including blade elements and gland water sealing means, means for conducting steam from the steam generator to the turbine, a feed water system, means providing a path of flow from said turbine to said feed water system having a condenser and a pump therein, a gland water system for producing flow of water through the sealing means, means to conduct water from the feed water system to the generator, said feed water system comprising a plurality of direct steam and water contact heaters and centrifugal pumping means between the heaters, means to connect said heaters with

points of different pressure in the turbine, means to supply water to the gland water system, means to conduct water from the gland water system to said feed water system, and means to conduct surplus water from the feed water system to a point in the plant of lower pressure than the feed water system.

12. A power plant comprising a steam generator, a steam turbine including blade elements and gland water sealing means, means for conducting steam from the steam generator to the turbine, a feed water system, means providing a path of flow from said turbine to said feed water system having a condenser and a pump therein, a gland water system for producing flow of water through the sealing means, means to conduct water from the feed water system to the generator, said feed water system comprising a plurality of direct steam and water contact heaters and centrifugal pumping means between the heaters, means to connect said heaters with points of different pressure in the turbine, means to supply water to the gland water system, means to conduct water from the gland water system to said feed water system, and means for recirculating water through the pump in said path of flow without passing through the feed water system.

In testimony whereof I hereunto affix my signature.

RALPH C. ROE.