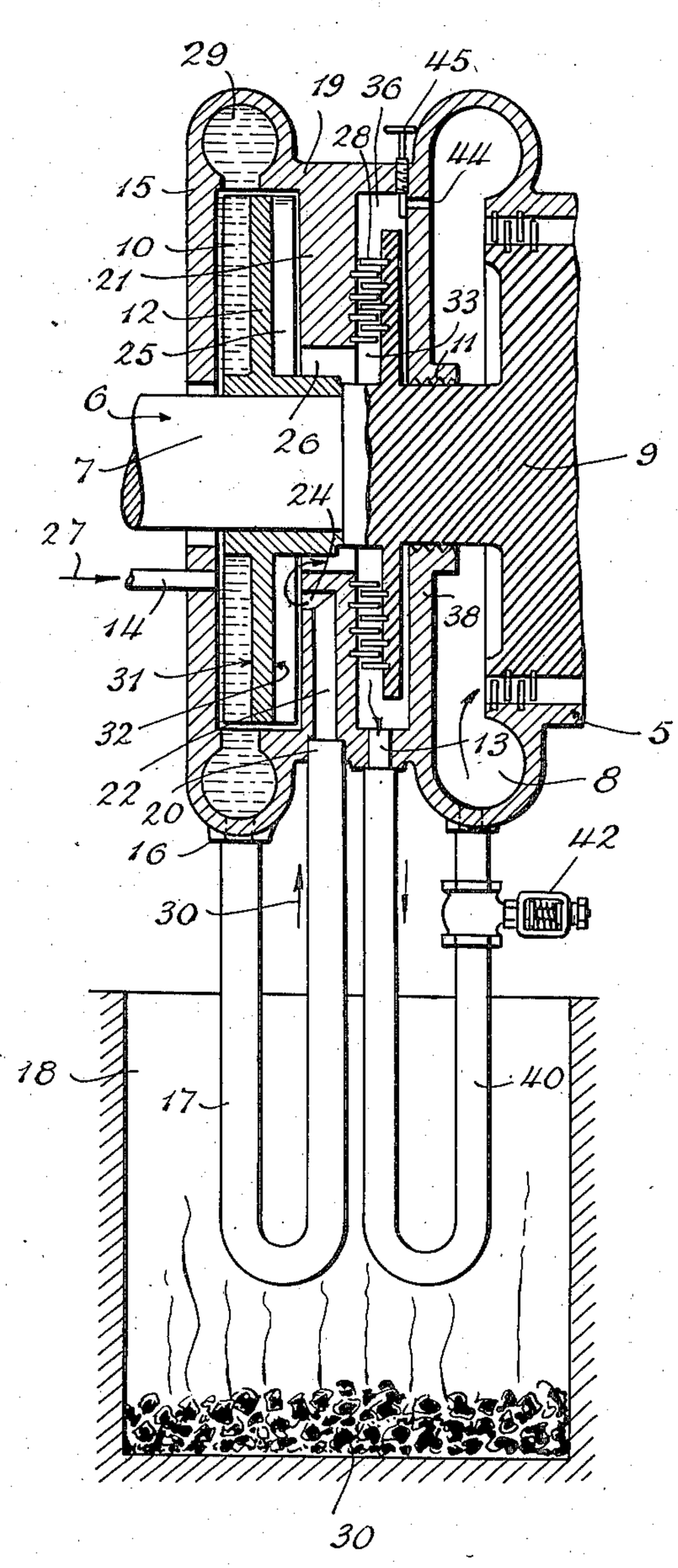
May 4, 1937. R. HINGST 2,079,118

COMBINED TURBINE AND STEAM GENERATOR

Filed Jan. 18, 1936 4 Sheets-Sheet 1

Fig. 1.



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COMBINED TURBINE AND STEAM GENERATOR

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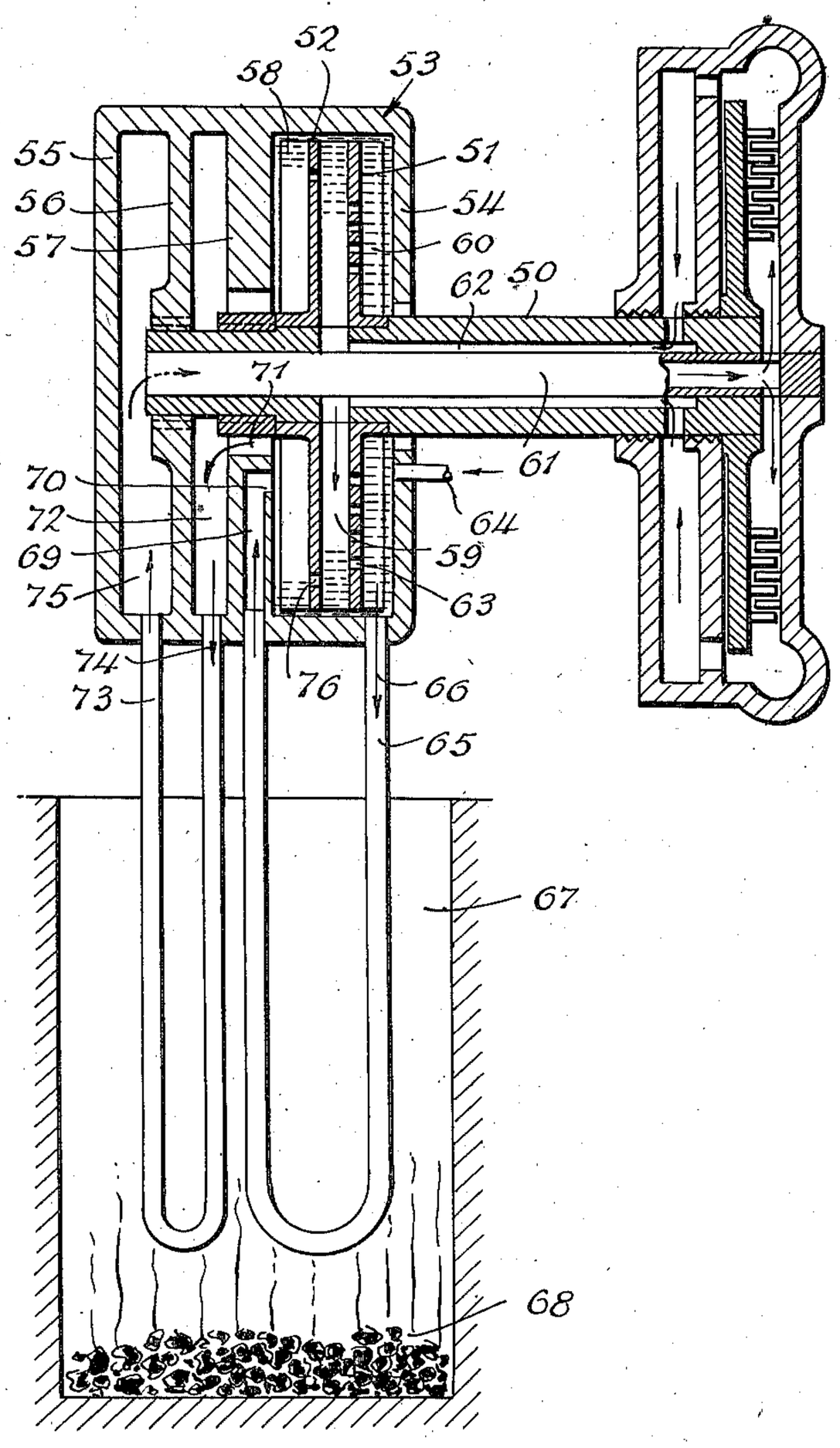
Fig. 2.



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COMBINED TURBINE AND STEAM GENERATOR

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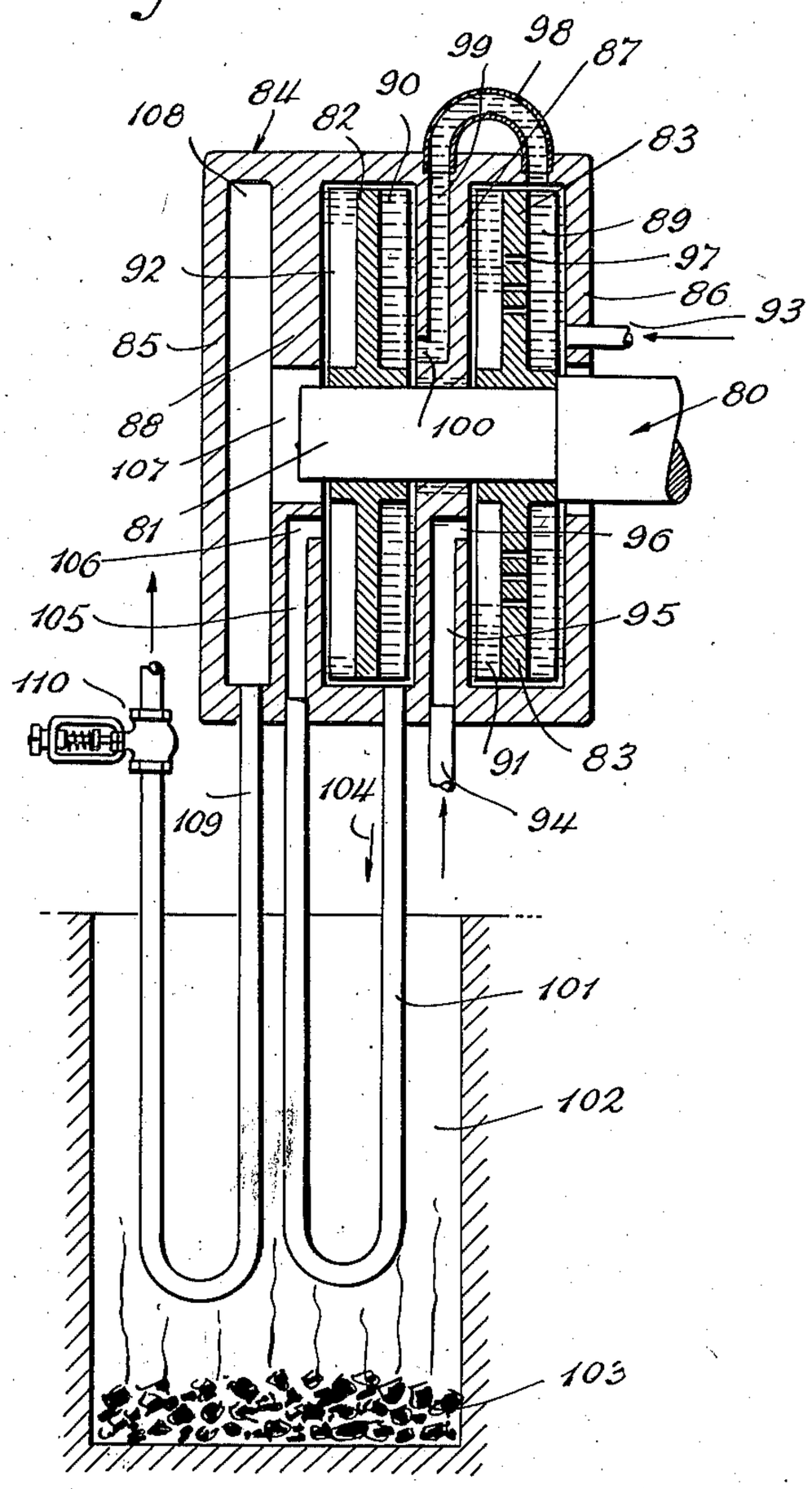
Fig. 3.



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COMBINED TURBINE AND STEAM GENERATOR

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Fig. 4.

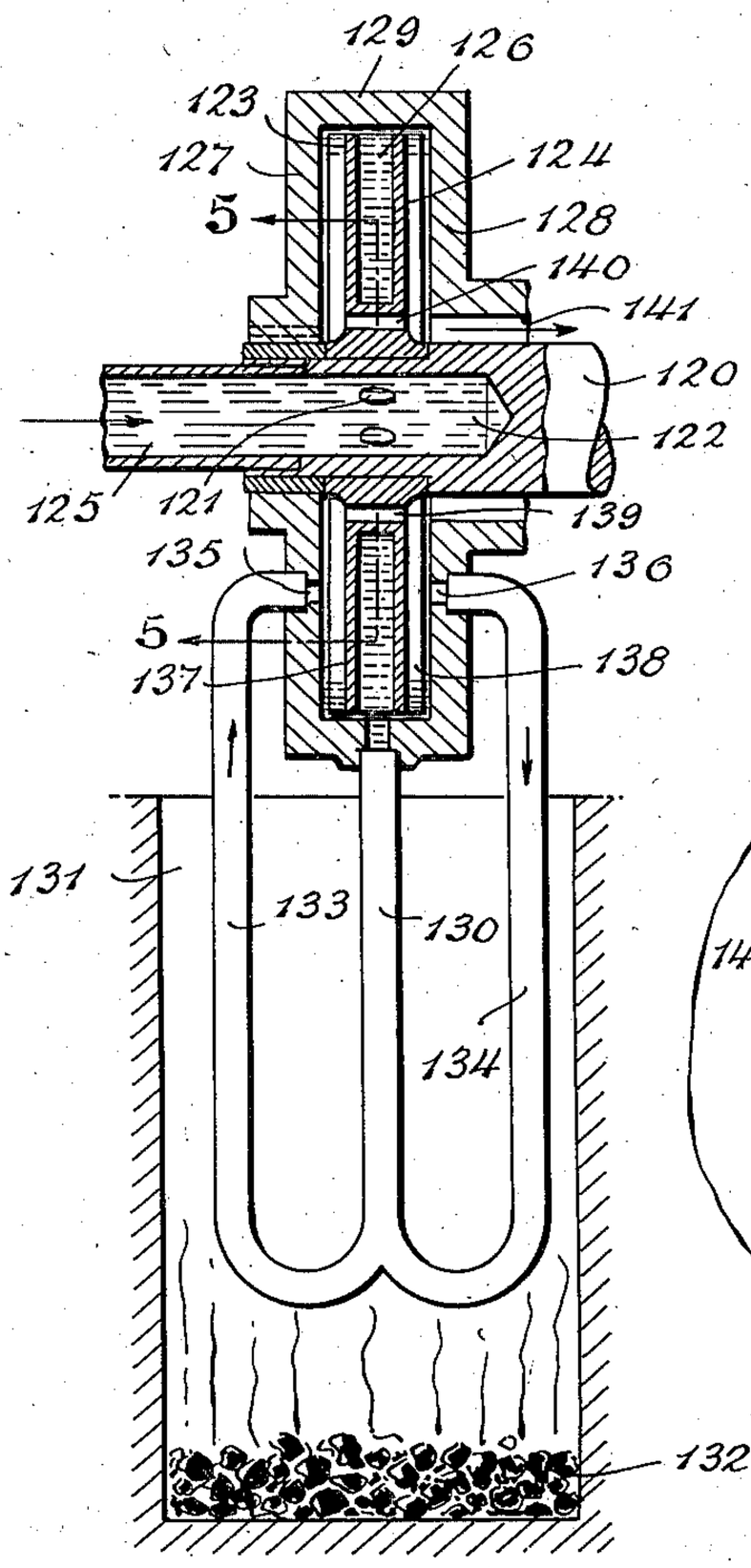
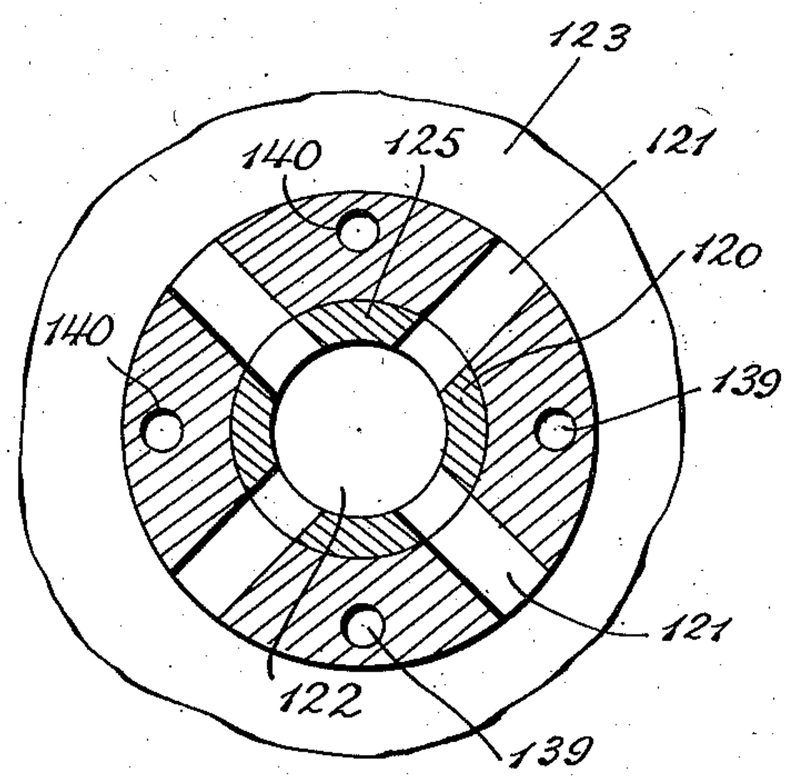


Fig. 5.



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2,079,118

UNITED STATES PATENT OFFICE

2,079,118

COMBINED TURBINE AND STEAM GENERATOR

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Application January 18, 1936, Serial No. 59,745
In Germany January 19, 1935

13 Claims. (Cl. 60—108)

This invention relates to a combined turbine and steam generator, and refers more particularly to steam generators constituting a part of a turbine structure and used for supplying steam to such turbines to operate the same.

An object of the present invention is the provision of a combined turbine and steam generator comprising means for automatically regulating the supply of the feed water.

Another object is to increase the efficiency of a combined turbine and steam generator through the provision of a device for pre-heating the water supplied to the steam generator.

A further object is the provision of a boiler of small dimensions which can be conveniently used in conjunction with a turbine and can be heated by any suitable combustible means.

Still another object is the provision of a steam generator for turbines which is devoid of any regulating means, the feed water being automatically supplied to said steam generator and the generated steam being dried therein in a convenient and simple manner.

The above and other objects of the present invention may be realized through the provision of an aggregate comprising a steam turbine situated closely to a feed pump, a steam generator and a steam drier. For the proper operation of such an aggregate it is necessary that the steam flowing to the turbine be of uniform consistency and that the steam generator be supplied with an amount of water corresponding to the required output. The pump comprises a chamber in which the feed water is placed under pressure, said pump cooperating with the steam drier wherein water particles are separated from a steam-water mixture produced in the generator. The arrangement is such that the separated water particles are returned to the steam generator.

The engine comprises two chambers situated side by side and formed by the turbine casing and by a centrifugal wheel provided on both sides with blades. One of these chambers is used for transmitting under pressure the water flowing to the steam generator. The other chamber is used for the removal of the water from the steam water mixture produced by the generator and for causing a return flow of such water to the steam generator.

The preliminary heating of the feed water can be carried out by a portion of the steam removed at any desired stage of the turbine, the steam being taken out of a chamber which is situated adjacent the intermediate working chamber of the turbine and being introduced into the feed water, whereby the steam is condensed and is caused to give up its heat.

There is the danger that frictional losses will occur due to the pressure applied upon the feed water, if the side wall of the intermediate working chamber is an immovable one. These losses can diminish the out-put of the engine. To avoid these losses, the chamber in which the water is put under pressure is formed on two sides by the rotors or centrifugal wheels provided with blades; furthermore, separate chambers are provided on both sides of the first-mentioned chamber for separating the steam from the water. In such case, the steam is introduced to the rotors through an axial bore hole formed in the main shaft of the turbine.

The device for applying pressure to the water and for removing through the application of centrifugal forces the non-evaporated portions of the water, as well as the preliminary heating of the water can be carried out in two different ways. In accordance with one modification, the rotors of the turbines, such as the auxiliary turbine and the main turbine can be arranged upon one common shaft. In accordance with another modification, the above-mentioned devices and the auxiliary turbine can be arranged upon a shaft which is separated from the main turbine. Due to this arrangement, the form of the engine can be varied in conformity with the local requirements.

The engine is also provided with devices for the superheating of the steam leaving the auxiliary turbine and for regulating the temperature of the superheated steam.

The invention will appear more clearly from the following detailed description when taken in connection with the accompanying drawings, showing preferred embodiments of the inventive idea.

In the drawings:—

Figure 1 is a longitudinal section through a combined turbine and steam generator constructed in accordance with the principles of the present invention;

Figure 2 is a longitudinal section through a device used for the preliminary heating of the feed water in connection with the auxiliary turbine;

Figure 3 is a longitudinal section through a device used for the same purpose as that illustrated in Figure 2;

Figure 4 shows in longitudinal section another modification of the inventive idea, wherein the chamber for supplying pressure to the water is formed by two rotors provided with blades.

Figure 5 is a section along the line 5—5 of Figure 4.

The engine shown in Figure 1 of the drawings comprises a main turbine 5, only one portion of which is illustrated. The main turbine 5 comprises a main shaft 6 which carries a rotor or a centrifugal wheel 12.

The wheel 12 is situated upon the portion 7 of the shaft 6 which is of smaller diameter than the portion 9 of the shaft. The wheel 12 is keyed upon the portion 7 of the shaft 6 and is provided on both sides with blades which are not shown in the drawings.

The casing of the turbine comprises a disk-shaped end portion 15, an outer cylindrical portion 19 and two inner disk-shaped partition walls 21 and 38. The centrifugal wheel 12 is situated within a chamber extending between the outer wall 15 and the inner wall 21. Due to this arrangement, this inner chamber is subdivided into two chambers 10 and 25. The chamber 10 is situated between the wall 15 of the casing and the wheel 12, while the chamber 25 is situated between the wheel 12 and the inner partition wall 21.

The chamber 10 is used for imparting the pressure to the feed water. This water is supplied to the chamber 10 through a pipe 14 carried by the end wall 15 of the casing. One end of the pipe 14 is in communication with the chamber 10. The opposite end of the pipe 14 leads to a water reservoir not shown in the drawings. The water flowing through the pipe 14 in the direction of the arrow 27 is introduced into the chamber 10 and fills this chamber, as well as an annular channel 29 formed in the casing. When the centrifugal wheel 12 is rotated along with the shaft 6 it will place the water situated in the chamber 10 under a certain pressure and will force the water into the channel 29.

A hollow flange 16 is attached to the lower portion of the casing and is in communication with the channel 29. A U-shaped pipe 17 is attached to the flange 16, so that the interior of the pipe 17 is always in communication with the channel 29.

The curved portion of the pipe 17 is situated within a heating chamber 18 which is heated by any suitable source of heat 30*a*.

The opposite end of the pipe 17 is connected with a flange 20 carried by the main casing of the engine. A vertical passage 22 is formed in the partition wall 21 of the casing. One end of the passage 22 is in communication with the pipe 17. The opposite end of the passage 22 is in communication with a horizontal passage 24 which leads into the chamber 25 formed by the partition wall 21, on the one hand, and by a centrifugal wheel 12, on the other hand.

The passage or passages 24 are to be provided in the partition wall 21 as closely as possible to the main shaft 6 of the turbine in order to provide the greatest possible difference in pressure between the centrifugal forces at the circumference of the chamber 25 and at the point of entry of the steam water mixture.

The water flowing through the U-shaped pipe 17 is heated by the source of heat 30 so that a part of the water is evaporated and a mixture of steam and water flows through the passages 22 and 24 in to the chamber 25.

The chamber 25 is used to separate the steam from the water mixed with the steam. Due to the rotation of the centrifugal wheel 12 a ring of water is formed at the circumference of the chamber 25. The inner portions of this ring of water are subjected to the pressure of the steam produced in the pipe 17. The outer surfaces of this ring of water are under the pressure of the feed water supplied to the chamber 10 through the pipe 14 and agitated by the centrifugal wheel 12.

The operation takes place in the following manner:—If too much water is supplied into the steam generator so that more water flows through the pipe 17 than can be changed into steam by the source of heat 30, then the excessive amount of water will join the ring of water formed in the chamber 25 and will increase the dimensions of said ring. This increasing ring of water will increase the pressure within the chamber 25 which will finally overcome the pressure prevailing in the chamber 10 and the pipe 17. Then the water may flow backward through the pipe 17 in a direction opposite to that of the arrow 30.

It is to be noted that the feed water leaves the chamber 10 under a pressure which is substantially constant. Due to the fact that this pressure is constant, the water flowing backward through the pipe 17 will prevent any further supply of the water to the chamber 25 until the dimensions of the ring of water are again diminished. It will be further noted that the entire system is in a balance and that such balance is restored and prevails when the ring of water in the chamber 25 is of such dimensions that its centrifugal effect is equal to the losses in pressure occurring in the course of the passage of the water through the pipe 17 between the flanges 16 and 20.

Feed water ejected out of the chamber 25 passes around the outer periphery of the rotor 12 into the chamber 10 through the space between the outer periphery of the rotor and the adjacent wall of the casing. The result is that the amount of fresh water supplied to the boiler from the chamber 10 is automatically regulated by the water ejected out of the chamber 25 and returning to the chamber 10. This is caused by the fact that the amount of water under pressure in the chamber 10 is made dependent upon the steam pressure in the chamber 25 and the pressure to which the available amount of water to be transformed into steam is subjected.

When the aggregate begins to operate, the steam-water mixture flowing to the chamber 25 contains a large percentage of water. Then a water ring will be formed in the chamber 25 the dimensions of which depend upon the amount of water transformed into steam; the greater is the development of steam, the smaller will be the dimensions of the ring of water.

The following example may be given to explain the operation:—

If the pressure with which fresh feed water is supplied from the pump chamber 10 into the boiler pipe 17 is twenty atmospheres and the drop in pressure in the boiler pipe is three atmospheres (provided the entire water is changed to

steam), then a ring of water will be formed in the separating chamber 25, the dimensions of which will correspond to the pressure of three atmospheres. The dimensions of this ring of water will not change if this output is maintained, i. e., if the total amount of water supplied to the boiler pipe 17 is changed into steam. The pressure of three atmospheres to which the ring of water is subjected and which is imparted to it by the centrifugal force, and the steam pressure of seventeen atmospheres prevailing in the separating chamber 25 will be balanced by the pressure of twenty atmospheres to which the water is subjected in the pump chamber 10. Consequently, there is a balance between the pressures in the two chambers.

If the amount of water transformed into steam in the boiler pipe 17 will diminish, the amount of water separated in the separating chamber 25 will increase, since the steam-water mixture will contain a larger percentage of water. The pressure of this separated water will increase corresponding to the larger amount of the separated water. Let it be assumed that this increased pressure will be equal to five atmospheres. If the steam pressure remains unchanged, the total pressure in the separating chamber 25 will be increased to twenty-two atmospheres. This pressure will not be balanced any more by the pressure of water leaving the pump chamber, since that pressure is still equal to twenty atmospheres. The result is that when the pressure is increased above twenty atmospheres, i. e. above the pressure prevailing at the circumference of the pump chamber 10, that amount of water which is equivalent to this increase in pressure in the separating chamber 25 will flow through the clearance around the outer periphery of the rotor 12 into the pump chamber 10 and, consequently, into the steam generating pipe 17. During that time the supply of fresh feed water out of the pump chamber 10 is considerably diminished or even interrupted, since the pump pressure of twenty atmospheres cannot overcome the higher pressure of twenty-two atmospheres.

The steam generating pipe 17 of the aggregate operates, therefore, not only as a feed boiler but also as a circulation boiler, i. e., a constant predeterminable amount of water is always passed through the pipe 17, that part of the water which has not been transformed into steam being caused to circulate until it is completely evaporated and until there is a balance again between the pressure existing in the pump chamber 10 and the pressure existing in the separating chamber 25.

From the above explanation it is apparent that the ring of water is always subjected to the pressure of the steam generated in the boiler pipe 17.

The return flow of the ejected water depends, therefore, only upon the increase in the dimensions of the ring of water, provided that the steam pressure is a constant one.

There is no danger that an increase in the dimensions of the ring of water will close up the channel 24 since it is clear from the above description that after the pressure in the pump chamber 10 is increased, water will flow back from the chamber 25 through the clearance around the outer periphery of the rotor 12 into the chamber 10.

It is apparent that the two sides of the centrifugal wheel 12 are subjected to unequal pressures. The pressure upon the surface 31 of the wheel 12, which surface constitutes a part of the chamber 10, increases gradually in proportion to the distance from the central axis of the shaft 7 until a certain maximum pressure is reached. The opposite surface 32 of the centrifugal wheel 12 which constitutes a part of the chamber 25 is subjected to a pressure which is equal to the pressure of the ends of a boiler and which is approximately equal to the greatest centrifugal pressure. It will be noted that the difference in pressure in the chambers 10 and 25 tends to shift the centrifugal wheel 12 in a direction parallel to the longitudinal axis of the shaft 7. On the other hand, the turbine as a whole also exerts an axial pressure upon the centrifugal wheel 12 in an opposite direction. Due to the existence of these opposed pressures, the system is substantially balanced so that it is not necessary to provide any special means for eliminating the axial pressure upon the wheel 12.

It should be noted that the pressure in the pump chamber 10 increases along a parabolic curve with an increase of the distance from the axis from zero to the operating value. This pressure operates against the boiler pressure prevailing in that part of the chamber 25 which is devoid of water; this pressure acts uniformly from the axis to the water ring against the pressure prevailing in the pump chamber 10. The difference between the two pressures causes an axial pressure upon the rotor 12 toward the left (looking in the direction of Fig. 1), i. e. against the direction of the turbine pressure.

Another feature of this construction is the elimination of a packing which would prevent the escape of the gas from the turbine through the casing enclosing the wheel 12. Since the wheel 12 causes a circulation of the water which is heated and transformed into steam before it is introduced into the turbine, such water circulated by the wheel 12 will prevent any escape of the steam through the casing enclosing the wheel 12.

As has been mentioned already, the steam is dried in the chamber 25 and is separated therein from the water particles. This pure steam flows into an annular passage 26 and reaches the chamber 33 which encloses the auxiliary turbine, indicated diagrammatically by the numeral 28 in the drawings. The device is constructed as a radial turbine which is of advantage, since it makes possible a compact construction of the engine and also since it diminishes the longitudinal axial pressure.

The steam loses a part of its pressure in the auxiliary turbine 28. This steam is assembled in an annular chamber 36 which is limited by the partition walls 21 and 38.

A passage 13 formed in the casing of the engine connects the annular chamber 36 with a U-shaped pipe 40 which is situated within the heating chamber 18. Steam leaving the chamber 36 is superheated while it passes through the U-shaped pipe 40. The superheated steam reaches the chamber 8 of the main turbine. This chamber 8 is separated from the chamber 36 by means of the usual labyrinth packing 11 formed upon the partition wall 38 adjacent the portion 9 of the shaft 6. The amount of steam flowing through the pipe 40 is regulated by a steam regulator 42.

A variation of the temperature of the superheated steam flowing into the chamber 8 of the main turbine can be carried out by a passage 44 provided in the partition wall 38 and connecting the chamber 8 with the chamber 36. A throttling device 45 which is indicated diagrammatically in the drawings is situated in the passage 44.

Through the use of this throttling device a certain amount of wet steam can flow from the chamber **36** into the chamber **8** and thereby change the temperature of the superheated steam in the chamber **8** in the desired manner.

The steam collected in the chamber **8** will flow into the main turbine **5**, will carry out its work there, and is then led to a condenser which is not shown in the drawings.

Figure 2 shows a device for the preliminary heating of the feed water. This device may be used in lieu of the engine illustrated in Figure 1. The device illustrated in Figure 2 comprises a main turbine shaft **50** which carries two centrifugal wheels **51** and **52**. The wheels. **51** and **52** are enclosed by a casing **53** comprising end walls **54** and **55** and inner partition walls **56** and **57**. The centrifugal wheels **51** and **52** are situated in the interior of the casing between the outer wall **54** and the inner wall **57** and they subdivide this interior into three chambers **58**, **59** and **60**. The chamber **58** is situated between the partition wall **57** and the centrifugal wheel **52**. The chamber **59** is situated between the two centrifugal wheels **52** and **51**, while the chamber **60** is situated between the centrifugal wheel **51** and the outer wall **54**.

The shaft **50** is hollow and an inner shaft **61** is situated within the shaft **50**. An annular space **62** is formed between the outer surfaces of the shaft **61** and the inner surfaces of the shaft **50**. The space **62** is used for supplying a portion of steam taken out of the auxiliary turbine **28** or any stage of the turbine **5** and for introducing said steam into the chamber **59** formed by the two centrifugal wheels **51** and **52**.

The centrifugal wheel **51** is provided with bore holes **63** which constitute passages connecting the chamber **59** with the chamber **60**.

The steam removed from any desired stage of the turbine and introduced into the chamber **59** has a much higher pressure than that of the feed water. The feed water is supplied into the interior of the casing **53** through the inlet pipe **64** and fills the chamber **60** of the casing.

Due to the provision of the holes **63** formed in the centrifugal wheel **51**, the steam introduced into the chamber **59** passes into the chamber **60** and thus is mixed wth the feed water. The steam is condensed and gives up its heat to the feed water situated in the chamber **60**.

Due to the rotation of the wheels **51** and **52** a ring of water will be formed in the chamber **59**. The dimensions of this ring will depend upon the pressure prevailing within the chamber **59**. Obviously, a ring of water of larger dimensions will cover more bore holes in the wheel **51** and thus will cause less steam to flow from the chamber **59** into the chamber **60**, while a ring of water of smaller dimensions will permit a greater amount of steam to flow through the bore holes **63** into the chamber **60**. The bled steam pressure varies approximately proportionally to the load and, therefore, the water ring varies with the steam pressure and load. It should be noted that it is impossible for the water ring formed upon the periphery of the chamber to be pressed back completely into the feed pump chamber against the higher pressure prevailing therein, due to the fact that the preheating steam has lost some pressure in the boiler and the turbine. Therefore, due to the described arrangement, the amount of steam supplied to the feed water is automatically regulated depending upon the load.

The automatic regulation of the steam introduced into the feed water is carried out due to the fact that at the outer circumference of the casing the feed water flows from the chamber **60** into the steam chamber **59** and forms there a rotating ring of water, the thickness of which is increased or diminished, in accordance with the pressure of the steam taken out from the turbine.

If, for instance, the pressure of the steam taken out of the turbine is lowered, then more feed water will flow into the chamber **59** and will cover more and more openings **63** formed in the centrifugal wheel **51**. The more feed water flows into the chamber **59**, the more bore holes **63** will be covered which are situated farthest away from the shaft **50** of the turbine. Consequently, the steam flowing from the chamber **59** into the chamber **60** will flow only through those bore holes which are situated nearest the longitudinal axis of the engine, so that such steam will penetrate regions having a comparatively low pressure. The efficiency of the turbine will drop and less feed water will be transported thereby. Consequently, the relationship between the amount of steam used for pre-heating purposes and the amount of the feed water remains always the same.

If, on the other hand, the pressure of the steam removed from any desired stage of the turbine to preheat the water is increased, then the thickness of the rotating ring of water is diminished and a greater amount of steam is introduced into the feed water. This greater amount of steam corresponds to the increase in the circulation of water.

The pre-heated water with the condensate added to it flows through the U-shaped pipe **65** in the direction of the arrow **66**. The pipe **65** is situated within a heating chamber **67** which is heated by any suitable combustion fuel **68**. The water flowing through the pipe **65** is changed into steam by the heat developed in the chamber **67**. The generated steam flows through a passage **69** formed in the partition wall **57** and penetrates the chamber **58** through the horizontal passage **70**.

The steam situated in the chamber **58** is subjected to the influence of the rotating centrifugal wheel **52** which separates the steam from water particles contained therein.

The dry steam flows through a passage **71** into a chamber **72** formed between the two inner partition walls **57** and **56**.

The chamber **72** is in communication with a U-shaped pipe **73** which is situated within the heating chamber **67**. The dry steam flows through the pipe **73** in the direction of the arrow **74** and is superheated therein.

The superheated steam passes from the U-shaped pipe **73** into a chamber **75** formed between the outer partition wall **55** of the casing and the inner partition wall **56**. The steam will leave the chamber **75** through the interior of the hollow shaft **61** of the auxiliary turbine and is conducted to the turbine itself.

The centrifugal wheel **52** is provided with slots or bore holes **76** which are situated adjacent the outer circumference of the wheel. The object of the bore holes **76** is to prevent an interruption of the supply of the steam to the turbine. If the wheel **52** were not provided with bore holes **76**, then in case of an overload, the steam would press against the water ring which separates the chambers **58** and **59** from the chamber **60**, and

would flow into the chamber 60, thereby interrupting the supply of steam.

If the pressure in the chambers 58 and 59 is increased and the water ring liberates the bore holes 76, the steam flows from the chamber 58 into the pre-heating chamber 59 and thus diminishes the load. This steam is supplied to the auxiliary turbine from which the steam was originally removed.

Figure 3 shows a device wherein the increase in pressure and the simultaneous pre-heating of the water is carried out in two stages.

The device comprises a turbine shaft 80 having a narrower end portion 81. The portion 81 of the main turbine shaft carries two centrifugal wheels 82 and 83. A casing 84 surrounds the centrifugal wheels 82 and 83 and comprises two outer walls 85 and 86 and inner partition walls 87 and 88. An inner chamber 89 is formed between the wheel 83 and the adjacent outer wall 86. Another chamber 90 is formed between the centrifugal wheel 82 and the inner partition wall 87. The two chambers 89 and 90 are used for applying pressure to the water.

A pre-heating chamber 91 is provided between the partition wall 87 and the centrifugal wheel 83. Furthermore, a chamber 92 which serves for separating the water particles from the steam is provided between the centrifugal wheel 82 and the partition wall 88.

The feed water is supplied into the interior of the casing 84 through a pipe 93 which leads into the chamber 89. The centrifugal wheel 83 revolving in the chambers 91 and 89 imparts pressure to the feed water penetrating the chamber 89 through the pipe 93.

Steam taken out of any desired stage of the turbine is introduced into the interior of the casing through a pipe 94 which is in communication with the passages 95 and 96 formed in the partition wall 87. This steam flows into the chamber 91 and passes through openings 97 formed in the centrifugal wheel 83. The steam thus reaching the chamber 89 is mixed with the water contained therein and gives up its heat to the water, thereby preheating the same.

A pipe 98 connects the chamber 89 with a vertical passage 99 formed in the partition wall 87. The passage 99 is in communication with a horizontal passage 100 leading to the chamber 90.

Due to the centrifugal forces developed by the rotation of the wheel 83 the preheated water situated in the chamber 89 is forced to flow into the U-shaped pipe 98 and thence through the passages 99 and 100 into the chamber 90.

A U-shaped pipe 101 is situated within a heating chamber 102 which is heated by any suitable combustion fuel 103. The water forced into the chamber 90 flows through the pipe 101 in the direction of the arrow 104. The pipe 101 is in communication with a vertical passage 105 and a horizontal passage 106 leading into the chamber 92. The steam formed in the pipe 101 by the heat of the heating chamber 102 flows through the passages 105 and 106 to the chamber 92 which is situated adjacent the chamber 90 and which is used for separating water particles from the steam produced in the pipe 101. The chamber 92 is in communication, by means of a central passage 107 formed in the partition wall 88, with the steam chamber 108 situated between the outer wall 85 of the casing 84 and the inner partition wall 88.

The steam collected in the chamber 108 flows through a U-shaped pipe 109 which is situated within the heating chamber 102. The steam passing through the pipe 109 is superheated by the heat prevailing in the chamber 102.

A suitable quantity governor or flow regulator 110 (similar to the one shown in Fig. 1) is carried by the U-shaped pipe 109. The steam leaving the pipe 109 is introduced into the turbine by any suitable means not shown in the drawings.

It is sometimes desirable or necessary to preheat the steam in the second stage as well. Then this second stage is constructed in exactly the same manner as the first stage and the first stage is then connected with a stage comprising a chamber 90 for the operating medium and a chamber 92. The device constituting the preheating stage and comprising chambers 89 and 91 would be placed then next to the intermediate wall comprising the channels 99 for the feed water, and the device constituting the final stage would be placed next to it.

In all the described constructions the centrifugal wheel of the feeding aggregate and the casing therefor form a chamber in which the operative fluid is subjected to pressure. In order to prevent frictional losses caused by the immovable side wall of the chamber for the operative fluid, the chamber in which pressure is applied to the operative fluid can be formed by centrifugal wheels provided with blades on both sides. Another chamber for the removal of the operative fluid may be provided on both sides of the last-mentioned chamber. Such construction is shown in Figure 4 of the drawings.

The device comprises a main turbine shaft 120 provided with several radial bore holes 121 and a horizontal bore hole 122. Two centrifugal wheels 123 and 124 are mounted side by side upon the main turbine shaft 120 over the bore hole 121, which is in communication with the horizontal bore hole 122. Each of the centrifugal wheels 123 and 124 is provided with blades on both sides of the wheel.

A pipe 125 is fitted into the interior of the bore hole 122. The opposite end of the pipe 125 is connected with any suitable container for the feed water which is not shown in the drawings.

The water introduced into the interior of the shaft 120 through the pipe 125 flows through the radial bore holes 121 into a chamber 126 formed by the centrifugal wheels 123 and 124.

The wheels 123 and 124 are surrounded by a casing 129 provided with partition walls 127 and 128.

The water penetrating the interior of the chamber 126 through the radial bore holes 121 is placed under pressure due to the rotation of the centrifugal wheels 123 and 124.

Due to this arrangement, the chamber 126 is limited on both sides by rotating side walls so that the frictional losses are reduced to a minimum.

The water situated in the chamber 126 leaves the casing 129 through a vertical pipe 130 situated within a heating chamber 131 which is heated by any suitable combustion fuel 132. Two pipes 133 and 134 are connected with the pipe 130 and lead to passages 135 and 136 formed in the side walls 127 and 128 respectively. The water passing through the pipes 130, 133 and 134, is transformed into steam which penetrates a chamber 137 formed between the wall 127 and the wheel 123 and the chamber 138 formed between the wall 128 and the centrifugal wheel 124. Due to centrifugal forces developed by the

wheels 123 and 124 the steam filling the chambers 137 and 138 is freed from water particles contained therein. The two chambers 137 and 138 are in communication with each other through the passages 139 and 140 formed in the centrifugal wheels 123 and 124. The dried steam is supplied to the turbine through the passage 141, while the water particles are caused to circulate again in the pipes 130, 133 and 134 until they are changed into steam.

An important advantage of the described constructions is the possibility of providing a boiler of comparatively small capacity which is not rotated, and which may be heated by any type of combustion fuel. The steam generated by this boiler is automatically supplied to the turbine and the steam is dried in a very simple manner. By the centrifugal projection of water particles, the heating surface causing the formation of steam is definitely separated from the heating surface providing a superheated steam, so that the latter always remains constant irrespective of the load upon the turbine.

In the described constructions the axial shifting load of the turbine is either totally or partially eliminated by the different pressures acting upon the centrifugal wheel. The feed water to which pressure has been imparted by the centrifugal wheel provides a positive sealing of the steam chambers, so that it is not necessary to construct a separate sealing device for the steam which would unquestionably increase the losses of the turbine. The arrangement of the steam chambers in the turbine casing makes it possible to arrange the superheaters in a very simple manner. Since all the chambers lie close to one another, the entire construction occupies but little space.

A further advantage is achieved by arranging the chamber for imparting pressure to the feed water adjacent the chamber for introducing steam taken out of the turbine into the feed water, since by such arrangement the feed water is preheated very uniformly irrespective of the load. The arrangement of the pressure chamber between two centrifugal wheels has the further advantage of eliminating or diminishing frictional losses.

What is claimed is:—

1. A combined steam turbine and steam generator, comprising a centrifugal wheel, a turbine casing enclosing said centrifugal wheel, said centrifugal wheel and said casing forming a pump chamber and a separating chamber, means for introducing the feed water into the first-mentioned chamber, a steam generator connected with said two chambers, the centrifugal forces developed by said centrifugal wheel causing a flow of the water from the first-mentioned chamber into said steam generator, the steam produced by said steam generator flowing into the second-mentioned chamber and being separated therein from water particles contained in said steam, means in communication with the second-mentioned chamber for superheating said steam, an auxiliary turbine wheel, and means for supplying the superheated steam to said auxiliary turbine wheel.

2. A device in accordance with claim 1, comprising in combination with a main turbine wheel; a main shaft, said centrifugal wheel, said auxiliary turbine wheel, and said main turbine wheel being mounted upon said shaft and being rotatable therewith.

3. A device in accordance with claim 1, comprising in combination with a main turbine wheel a shaft carrying said centrifugal wheel and said auxiliary turbine wheel, and another shaft which is separate from the first-mentioned shaft and which carries said main turbine wheel.

4. In a combined turbine and steam generator, a main turbine shaft, a turbine wheel mounted upon said shaft, a centrifugal wheel mounted upon said turbine shaft, a casing surrounding said centrifugal wheel, said centrifugal wheel and said casing forming two chambers, means for introducing water into one of said chambers, a passage formed in said casing and communicating with the second-mentioned chamber adjacent said shaft, a pipe having one end communicating with the first-mentioned chamber and another end communicating with said passage, a heating chamber, said pipe being at least partly situated within said heating chamber, and means for transmitting the steam from the second-mentioned chamber to said turbine wheel.

5. In a combined turbine and steam generator, a turbine shaft, an auxiliary turbine wheel, a centrifugal wheel carried by said turbine shaft, a single casing for said centrifugal wheel and said turbine shaft, a steam chamber being formed in said casing adjacent said turbine wheel, said casing and said centrifugal wheel forming one chamber for supplying pressure to the feed water and another chamber for separating steam from water particles, means for introducing feed water to the second-mentioned chamber, and a steam generator, said steam generator being connected with the second-mentioned chamber and the third-mentioned chamber, an open passage being formed in said casing for inter-connecting the third-mentioned chamber with the first-mentioned chamber.

6. A device in accordance with claim 5, wherein the first-mentioned chamber is situated behind the auxiliary turbine wheel, said device comprising a main turbine wheel, a pipe supplying steam from the first-mentioned chamber to the main turbine wheel, and means for heating the last-mentioned pipe to superheat the steam passing therethrough.

7. In a combined turbine and steam generator, a main turbine shaft, an auxiliary turbine wheel, a main turbine, a casing having walls enclosing said turbine wheels, a steam chamber being formed in said casing adjacent the outlet of the auxiliary turbine wheel, another chamber being formed in said casing adjacent the first-mentioned chamber and the main turbine wheel, a partition wall between the first-mentioned chamber and the second-mentioned chamber, a passage being formed in said partition wall connecting the first-mentioned chamber with the second-mentioned chamber, throttling means situated in said passage for changing the cross-sectional area thereof, a rotary centrifugal wheel situated within said casing, said casing and said centrifugal wheel constituting a pump chamber and a separating chamber, means for introducing water into the pump chamber, and a steam generator interconnecting the pump chamber and the separating chamber, a passage being formed in said casing connecting the separating chamber with the first-mentioned chamber.

8. In a combined turbine and steam generator in combination with a turbine wheel, a centrifugal wheel, a casing having inner walls and constituting a preheating chamber for the feed water, the walls of said chamber being formed by a surface of said centrifugal wheel and some of the

inner walls of said casing, and means constituting a part of said casing and forming a pressure chamber, said centrifugal wheel separating said preheating chamber from said pressure chamber, means for introducing water into said pressure chamber, openings being formed in said centrifugal wheel which interconnect said two chambers, means for introducing steam into said preheating chamber to preheat the feed water, a steam generator connected with said pressure chamber, and means connected with said steam generator for supplying the steam generated therein to the turbine wheel.

9. In a combined turbine and steam generator in combination with a rotor of a turbine, a centrifugal wheel, another centrifugal wheel situated at a distance from the first-mentioned centrifugal wheel, means for driving the two centrifugal wheels, a casing enclosing the two centrifugal wheels, the space between two adjacent surfaces of the two centrifugal wheels constituting a preheating chamber, means for introducing steam into said preheating chamber, the space between the first-mentioned centrifugal wheel and a wall of said casing constituting a pressure chamber, openings being formed in the first-mentioned centrifugal wheel, said openings interconnecting said two chambers, means for introducing water into said pressure chamber, a steam generator connected with said pressure chamber, and means connected with said steam generator for supplying the steam generated therein to the rotor of the turbine.

10. In a combined turbine and steam generator in combination with the rotor of a turbine, a pair of centrifugal wheels situated at a distance from each other, means for rotating said centrifugal wheels, a casing enclosing said centrifugal wheels, the space between the adjacent surfaces of said centrifugal wheels constituting a preheating chamber, the space between one of said centrifugal wheels and a wall of the casing constituting a pressure chamber, the space between the other one of said centrifugal wheels and another wall of said casing constituting a steam purifying chamber, wherein steam is separated from water particles contained therein, the first-mentioned centrifugal wheel having a plurality of openings interconnecting the preheating chamber with the pressure chamber, the second-mentioned centrifugal wheel having at least one opening situated at a predetermined distance from the circumference thereof and interconnecting the preheating chamber and the steam purifying chamber, means for introducing water into the pressure chamber, a steam generator, means connecting said steam generator with the pressure chamber and the steam purifying chamber, means for introducing steam into the preheating chamber, and means for conducting steam from the steam-purifying chamber to the rotor of the turbine.

11. In a combined turbine and steam generator in combination with the rotor of a turbine, two centrifugal wheels, each of said centrifugal wheels having blades situated upon both sides thereof; a casing enclosing said centrifugal wheels, means for rotating said centrifugal wheels, the space between adjacent surfaces of the two centrifugal wheels constituting a pressure chamber, means for introducing water into said pressure chamber, the spaces between said centrifugal wheels and the adjacent walls of said casing constituting two chambers, a steam generator, means connecting said steam generator with said pressure chamber and the last-mentioned two chambers, the steam in the last-mentioned chambers being separated from the water particles by the rotation of said centrifugal wheels, and means connected with one of the last-mentioned chambers for transmitting steam from the last-mentioned chambers to a rotor of the turbine.

12. In a combined turbine and steam generator in combination with the rotor of a turbine, a pair of centrifugal wheels, a shaft carrying said centrifugal wheels and firmly connected therewith, said shaft having a longitudinal central bore hole and radial bore holes in communication with said longitudinal bore hole, said radial bore holes leading to the space between the two centrifugal wheels, the space between the two centrifugal wheels constituting a pressure chamber, a casing enclosing said centrifugal wheels, means for introducing water into said central longitudinal bore hole of said shaft, the walls of said casing and said centrifugal wheels constituting two interconnected chambers, a steam generator, means connecting said steam generator with said pressure chamber and the two last-mentioned chambers, and means for transmitting steam from one of the two last-mentioned chambers to the rotor of the turbine.

13. A device for purifying steam, comprising steam generating means, means constituting a pump chamber and a separating chamber, the first-mentioned means comprising a passage interconnecting the two chambers, the second-mentioned means comprising rotary means for causing a flow of water from said pump chamber and through the steam generating means and for separating in said separating chamber a steam-water mixture produced in said steam generating means into steam and water particles, and means connected with said separating chamber for removing steam separated from water particles from said separating chamber to the second-mentioned means having a passage formed therein interconnecting the two chambers, whereby water separated from steam in the separating chamber may be returned to the pump chamber through the last-mentioned passage when the pressure of the steam-water mixture in the steam generating means reaches a predeterminable value.

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