

S. Z. DE FERRANTI.
ELASTIC FLUID TURBINE.
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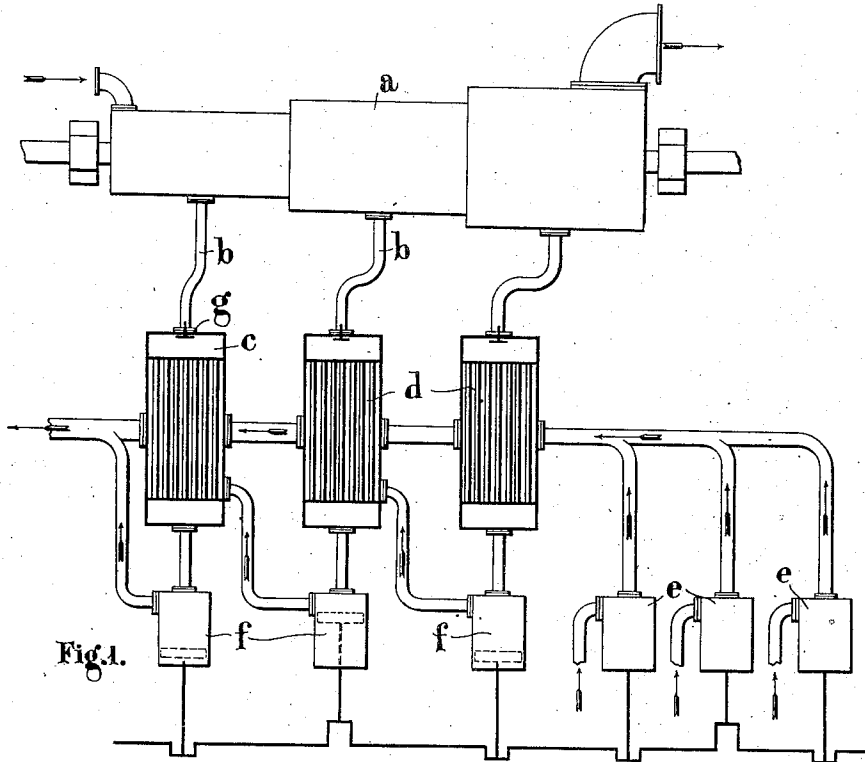


Fig. 1.

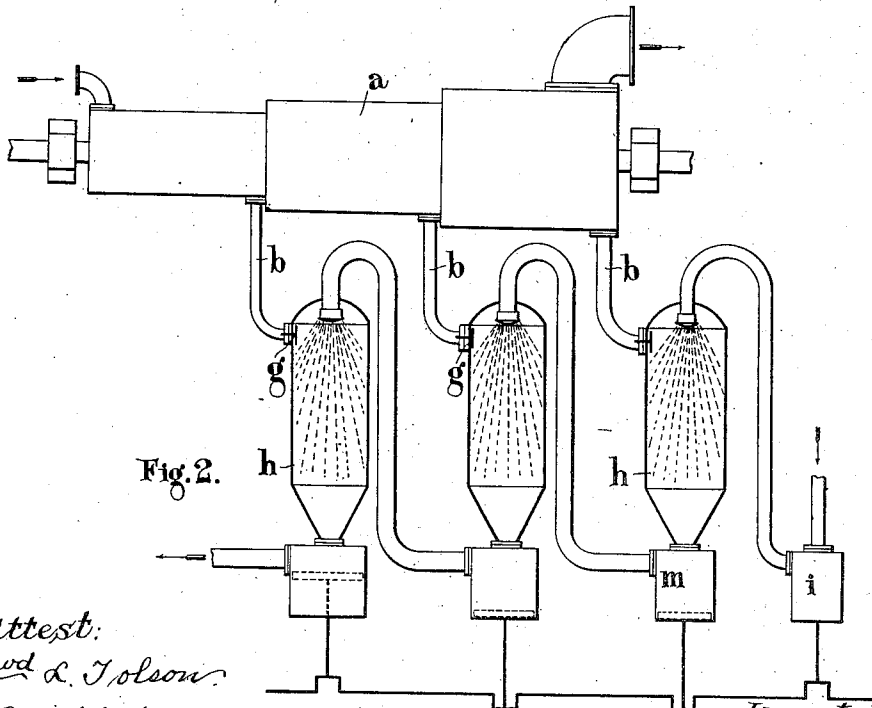


Fig. 2.

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UNITED STATES PATENT OFFICE.

SEBASTIAN ZIANI DE FERRANTI, OF GRINDLEFORD, ENGLAND.

ELASTIC-FLUID TURBINE.

938,309.

Specification of Letters Patent.

Patented Oct. 26, 1909.

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To all whom it may concern:

Be it known that I, SEBASTIAN ZIANI DE FERRANTI, a subject of the King of Great Britain and Ireland, and residing at Grindleford, in the county of Derby, England, have invented certain new and useful Improvements Relating to Elastic-Fluid-Turbine Installations, of which the following is a specification.

10 My invention relates to condensible elastic fluid turbine installations and has for its object to provide improved feed heating arrangements which shall effect a substantial increase in the efficiency of the plant.

15 In such power installations for marine propulsion purposes, for example, it is common practice to pump the feed water direct from the hot-well into the boiler but as the water so introduced is at the same temperature as that of the hot well, it is evident that a considerable increase in the efficiency of the plant could be effected if the temperature of the water before entering the boiler could be raised to a point at or near the
20 temperature of evaporation corresponding to the working pressure of the boiler. According to my present invention I attain this result in an economical manner in turbine installations for either land or marine
30 work.

My invention consists broadly in an elastic fluid turbine power installation in which the feed is heated in a considerable number of stages as it progresses toward the elastic
35 fluid generator by quantities of working fluid of different degrees of expansion abstracted from the turbine so that the more highly expanded fluid imparts heat to the feed at a point in the path thereof more remote from the generator than that at which heat is imparted to the feed by the less
40 highly expanded fluid.

My invention consists more specifically in a turbine installation in which feed water
45 drawn from the hot-well or from a regenerator is heated in a considerable number of progressive stages to substantially the boiler evaporation temperature by abstracting steam from the turbine of different degrees
50 of expansion and utilizing the steam so abstracted to heat the feed water, the more highly expanded steam operating to heat the feed water at a point in the path thereof more remote from the boiler than that at

which the less highly expanded steam operates.

My invention further consists in the improved power and feed heating installations to be hereinafter described.

In the following description I shall take 60 steam as an example of a suitable condensable elastic fluid throughout.

In order to obtain the most economical results according to my improved system of feed heating, the withdrawal of steam at a
65 considerable number of points of different pressure (say 8 or 9) should be provided for, since the feed is then heated at each point by steam only a little hotter than itself and the best conditions for a high ther-
70 modynamic efficiency are secured. A large number of stages, however, means that each stage heater works through only a small temperature difference so that to secure a
75 proper transference of heat it is important with my system to pay particular attention to the provision of ample and efficient heating surfaces.

The combination of a feed heating system such as is herein described with a tur-
80 bine, enables the design of the latter to be greatly improved and thus leads to an increase in the total efficiency of the plant over and above that due to the improved thermal
85 cycle alone. Thus, since steam is abstracted during the course of its expansion in the turbine to heat the feed water the volume of steam entering the high pressure end will be much larger than usual whereas the volume of steam flowing through the low pres-
90 sure end will be less than usual. The effect of this is that on the one hand, the amount of the clearance loss at the high pressure end can be made less in proportion to the volume of steam passed while on the other hand the
95 ratio of the circumferential to the axial velocity can be increased at the low pressure end, a substantial increase in the efficiency of the turbine itself being thus obtained. Further, anything which increases the blade
100 length of the short blades of the turbine, increases economy by reducing the proportionate loss due to eddies and friction at the end boundaries of the flow spaces. Where however, in order to obtain proper surface
105 speed and to reduce the relative clearance losses and without any reference to the present invention, a turbine has been de-

signed, as often occurs, with too large a high pressure end, the mere addition or application of my improved feed heating system will render the proportions adopted as the best compromise under the circumstances more correct than before and give a substantial gain in economy from this cause alone.

Referring now to the accompanying drawings which form part of the specification, Figure 1 shows a form of the invention in which the heat given to the feed water is transmitted to it through metal walls; while Fig. 2 shows a modified form in which jet or spray feed heaters are utilized.

The drawings are to a considerable extent of a diagrammatic nature and should not be taken as working drawings.

When desirable the same reference symbols are used in the different figures to denote corresponding structural features.

I carrying my invention into effect according to one form as applied to a condensing steam turbine installation, I provide a turbine, *a*, (see Fig. 1) of the pressure flow type, for example, and I lead pipes, *b*, from different stages of this turbine to a series of feed heaters, *c*, which may conveniently be constructed after the manner of the ordinary surface condenser, *i. e.*, with tubes, *d*, adapted as shown in Fig. 1 to transmit heat through their walls from the steam passing through them to the feed water.

Pumps, *e*, are provided preferably drawing from the hot-well and forcing the feed water through the heaters, *c*, in series to the boiler. The arrangement is such that the heater which is first encountered by the feed water in its passage toward the boiler is connected to the turbine at a point nearest to its low pressure end while the remaining heaters are individually connected to the turbine in turn at points increasing in distance from the low pressure end so that the feed water is progressively heated on its way to the boiler. I prefer to arrange the tubes of such areas and so forth that the water, and especially the steam pass through the heaters at considerable velocity so as to scour the tubes and insure efficient transference of heat.

The water of condensation from the heaters with any admixture of live steam passing through the tubes is delivered by pumps, *f*, to the main feed water preferably at a point in advance of the heater from which it was drawn. All the pumps, *e* and *f*, may be conveniently driven from one shaft as shown in the figure and suitable non-return valves, *g*, may be provided as indicated.

The transference of heat to the feed water is thus effected in a thermodynamically efficient manner as the steam which has given up most of its energy to the turbine and is therefore of lowest temperature is placed

so as to give up its heat to the water as it passes through the first heater while the following heaters and the water condensed in them and pumped back as described above serve to heat the feed water progressively at increasing temperature.

According to a modified form of the invention, (see Fig. 2) the heaters, *h*, are constructed after the manner of jet spray condensers, being connected as before to different stages of the turbine. A pump, *i*, drawing from the hot-well delivers the feed water through any suitable spraying nozzle, *k*, or the like into the interior of the first heater where it is brought into intimate contact with the steam introduced from the low pressure end of the turbine. A second pump, *m*, of somewhat greater volume than the pump, *i*, delivers the feed water thus formed in the first heater through a similar spray into the second heater and so on, the last pump delivering direct to the boiler. The feed water is thus heated progressively as above in a thermodynamically efficient manner.

As the temperature differences are very small for the heat transferred where a large number of heaters are adopted, it is of special importance in such a case to secure intimate contact of the steam and water over very large surfaces.

In cases where the steam finally leaves the rotor on its way to the condenser with a residual velocity and is consequently at a higher temperature than the hot-well, I prefer to abstract steam from a point of the turbine as near the exhaust end as possible or even from the exhaust pipe itself while on the other hand steam should be abstracted from a point as near the high pressure end as possible so as to insure raising the feed water to the highest temperature available.

Other things being equal it is of more importance to abstract steam from points near the ends of the turbine than from the intermediate points.

When the speed of the turbine is governed by throttling, it is found that even with reduced loads and speeds there is still a substantial gain in efficiency.

In installations of the type employing a regenerator, I arrange for pumping the water from the hot-well through the regenerator and impart the balance of heat necessary to bring the temperature of the feed water equal to that of evaporation in the boiler according to the progressive system of heating hereinbefore described, a corresponding number of heaters being omitted at the low pressure end of the turbine; and in any other case where the feed water is already partially heated from any source of waste heat I may adopt a similar arrangement and add only so much of the herein described

system of feed heating as will bring the feed up to or nearly up to the temperature of the boiler.

I may in some cases use rotary instead of reciprocating pumps and where the pressure difference through which the pump has to work is great, as may occur for instance during the last pumping stage when throttle governing is employed, I may use two or more rotary pumps in series.

In all cases in order to insure the successful working of my system of feed heating it is of the utmost importance to prevent the feed heaters becoming air-logged and when the heater adopted is not self-clearing as regards the air, suitable spaces should be provided in which the air may accumulate together with snifter valves or the like for its escape.

Having thus described my invention what I claim as new and desire to secure by Letters Patent is:—

1. The combination of a condensable elastic fluid turbine; a plurality of feed heaters, said feed heaters being connected to points of different pressure in said turbine so as to progressively heat the feed, as set forth.

2. The combination of a condensable elastic fluid turbine, a plurality of feed heaters,

said feed heaters being connected to points of different pressure in said turbine together with means for passing the feed through the heaters, the feed water being first heated by low pressure fluid and progressively thereafter by higher pressure fluid as set forth.

3. The combination of a condensable elastic fluid turbine; a plurality of condenser feed water heaters, said feed condenser heaters being connected to points of different pressure in said turbine so as to progressively heat the feed water as set forth.

4. The combination of a stage turbine and a plurality of feed heaters connected to points of different pressure in said turbine so as to extract fluid therefrom and progressively to heat the feed, said turbine being proportioned from stage to stage to correspond to the different quantities of fluid passing therethrough.

In testimony whereof, I affix my signature in presence of two witnesses.

SEBASTIAN ZIANI DE FERRANTI.

Witnesses:

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