

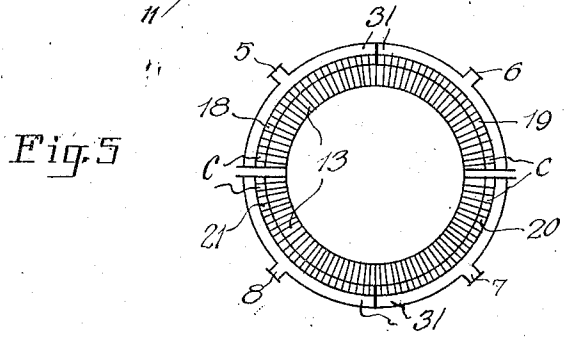
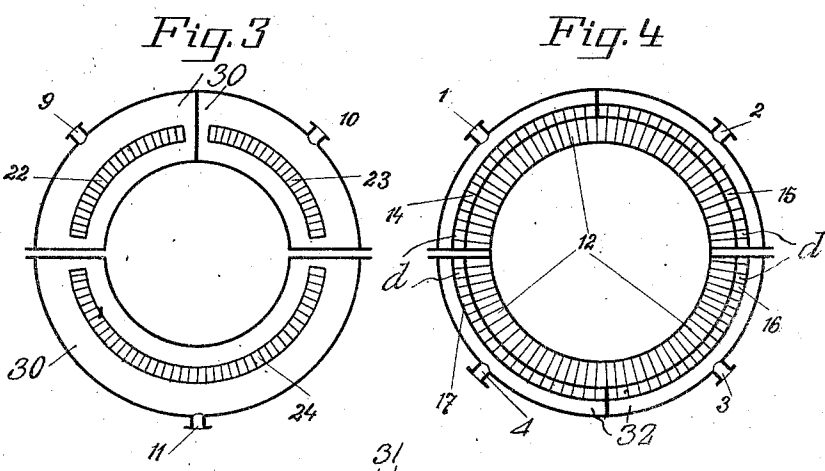
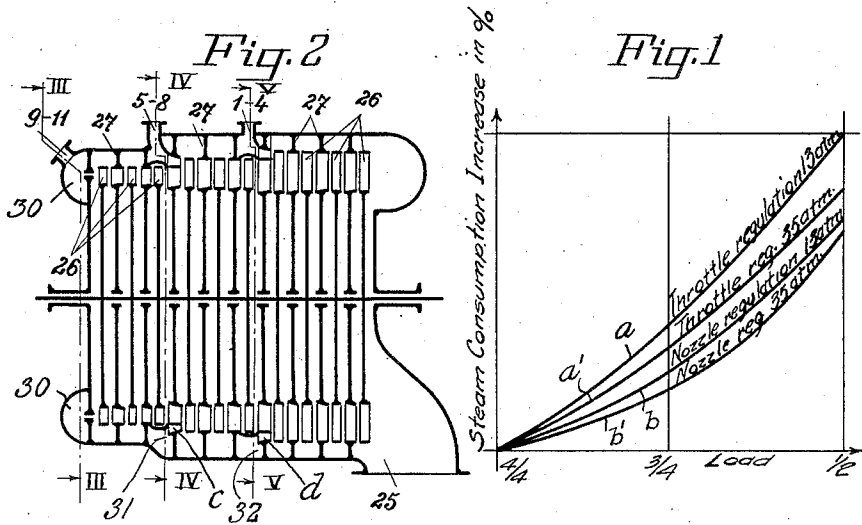
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STEAM TURBINE

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STEAM TURBINE.

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This invention relates to multi-stage elastic fluid turbines, particularly turbines for utilizing high pressures.

The object of the invention generally is a turbine of this character which is capable of more efficient regulation and economical operation than prior turbines.

The efficiency of a steam turbine falls off at partial loads whether throttle or the more efficient nozzle regulation is used, and the object of my invention is a turbine whose regulation may be satisfactorily effected with substantial reduction in the losses usually incident to regulation for small or below normal loads. My invention resides generally in constructing a turbine for full admission or full steam supply at one or more definite partial load values as well as at full load, and with a minimum of control by pressure reduction,—thereby avoiding or substantially reducing the losses incident to partial admission and throttling control such as ventilation, scavenging and eddy losses, and those due to varying back pressures at the intermediate wheels and to the unfavorable variation in steam velocities, and the losses in available heat drop which reach substantial proportions in pressure reduction control. The invention is of particular importance in very high pressure turbines wherein these losses assume undue proportions, and may be advantageously applied to high pressure turbines of large capacity, and also to turbines of the low fluid velocity type. More specifically the high pressure end of the turbine is constructed to operate with full steam supply full steam pressure at all times, but the nozzles in the high pressure end are only capable of admitting and receiving a sufficient quantity of steam to operate the turbine at a definite partial load value, while for full load or larger loads the turbine is constructed and adapted to receive live steam at full steam supply at one or more intermediate stage groups, each successive group of the latter being adapted to admit only the additional steam required for a particular load value. By the successive full admissions to the groups of nozzles the main variations in regulation may be effected, such for example as one-half load for the first group of nozzles, three-quarter load for the second group of nozzles, and full load for a third group of nozzles where there are three groups,—all of which groups of nozzles are disposed at different stages of

the turbine. Each successive group of regulation nozzles admits the steam required for the increased load and such additional steam joins the main flow of steam in the next following rotating wheel to work in the remaining part of the turbine, and preferably each successive group of load regulation nozzles is carried by a stationary disc radially outside of and in juxtaposition to the main guide canals thereof whereby the full admission added steam is introduced in a direction substantially parallel to the main flow and in a manner to join the same in the next rotating wheel without any substantial disturbance of the flow and working thereof. Throttling may take place in certain cases and under certain conditions at the intermediate regulating groups of nozzles, but such throttling only applies to a part of the total quantity of steam consumed, with the resultant diminution of the throttling losses. The regulation, therefore, of the turbine is mainly effected through the successive full admission controls of the main regulating nozzle groups disposed at different stages of the turbine, but if desired a finer and more exact regulation may be effected by dividing the full admission nozzles into sub-groups which may be successively controlled to secure the finer adjustments. Similarly the first group of full admission nozzles may be divided into sub-groups for still smaller loads, but ordinarily it is contemplated that the first group of nozzles as well as the subsequent groups will operate at full admission whenever possible to avoid the losses due to partial admission regulation, particularly when the admission pressure is a relatively high one.

For a better understanding of the invention, reference may be had to the accompanying drawings more or less diagrammatically illustrating the essentials of the invention, wherein:

Fig. 1 contains graphs indicating the large control losses at high pressures;

Fig. 2 is a diagrammatic longitudinal sectional view through a turbine embodying the invention;

Fig. 3 is a diagrammatic sectional view through the front end of the turbine along the line III—III in Fig. 1, and

Figs. 4 and 5 are diagrammatic sectional views adjacent subsequent groups of full admission nozzles along the lines V—V and IV—IV in Fig. 1.

Referring to Fig. 1 the curves *a* and *a'* illustrate steam consumption alteration curves per unit of output for a turbine operating at partial loads with throttle regulation and the curves *b* and *b'* are similar curves for nozzle regulation at thirteen and thirty-five atmospheres pressure respectively. These curves show that nozzle regulation is more efficient than throttle control, but both kinds of regulation become very inefficient with decreasing loads below full load (4/4), each of these curves showing increasing steam consumptions which are more pronounced as the load decreases,—the ordinates representing increasing steam consumption with load reduction and the abscissæ representing percentages of full load.

Referring to Figs. 2-5 I have indicated a multistage turbine having the stationary discs 27 which carry the rings of guide nozzles and the alternating rotor discs which carry the rings of rotating buckets 26. The turbine is provided with a full admission chamber 30 at the first stage which is divided into three sections with intakes 9-10-11 leading thereto. Working throughout the turbine is accomplished through the admission of steam by these intakes 9, 10 and 11, the steam thus admitted performing work on all the wheels 26 of the turbine. The turbine is so constructed and proportioned that with the intakes 9-10-11 fully open with no additional supply of steam at any other stage in the turbine, it is capable of only working at partial load. For assuming larger loads, the turbine is adapted to receive with full admission additional steam at intermediate or lower pressure stages, as for example at the full admission chambers 31 and 32 each of which is divided into four sections with intakes leading thereto and indicated respectively at 5-6-7-8 and 1-2-3-4. The chambers 31 and 32 lead respectively to the auxiliary radially and outwardly disposed rings of guide canals or nozzles *c* and *d*. The construction is such that the additional steam thus capable of being admitted through the intakes 5-8 inclusive to the full admissioned nozzles *c* is just sufficient to take care of a definite part of the load, this additional steam being introduced in a direction substantially parallel to the main flow and combining with the steam admitted at the intakes 9-10-11 and working co-jointly therewith throughout the remainder of the turbine. Similarly, for taking care of another definite part of the load, a set or group of intakes 1-2-3-4 is disposed about the turbine casing at a lower pressure stage and leads into auxiliary stationary full admission guide nozzles *d* radially outwardly disposed with reference to the main stationary guide nozzles (12) of that particular stage.

The nozzle group *d* is adapted to receive and admit a sufficient quantity of steam to assume its definite proportion of the increased load. The turbine exhaust is indicated at 25. For full or maximum load live steam is admitted through all of the steam admissions 1-11 inclusive or to the three separate groups of intakes admitting steam all the way around the turbine periphery. If the output or load should decrease to, say, approximately three-quarter load, the steam admissions 1-4 inclusive are shut off so that the turbine only receives fluid through the openings 5-11 inclusive, but all the way around its periphery at both points of admission. Similarly at, say, one-half load the connections 5-8 are shut off or closed and the turbine works as a full admission turbine with the working fluid passing only through the entrance openings 9-11 inclusive to the first stage. It is obvious, therefore, that with this arrangement the turbine works with full admission at the three definite percentage load values, as for example at one-half load, three-quarter and full load. Only three such full admission groups of nozzles are shown in the drawings, but additional full admission groups may be provided if desired. The preferred order of closing and opening the three full admission groups of intakes is that described above, but it may be expedient in certain cases to vary this order, as for example by opening the intakes 5-8 before opening the intakes 9-11, etc. The main partial load values selected for any turbine unit depend upon the conditions of the particular plant. For example, main partial loads other than one-half and three-quarter loads may be required to meet plant conditions, the main purpose being to operate the turbine at all of such main partial loads at full admission in all stages, and with a minimum of pressure reduction control.

By my invention I secure the advantage that for loads below full load such as half-load or three-quarter load or other degrees of load which may be found desirable in a given case, a full admissioned live steam supply is utilized as in the case of full load, and the throttling of the steam, which may take place at the intermediate regulating stages, would apply only to a part of the total steam supply, thereby reducing the losses incident to total throttle control and partial admission such as ventilation, windage, scavenging and eddy losses and those due to the varying back pressures at the intermediate wheels and to unfavorable variations in steam velocities in size and direction, and the losses due to the decreased available heat drops occasioned by pressure reduction control. With this construction therefore the best thermo-dynamic efficiency practically obtainable is approximated at

all the main partial load values, for example, at one-half, three-quarter and 4/4 load. Theoretically, the best thermal efficiency is obtained when there are always substantially uniform or the same steam velocities through the high pressure stages of the turbine of this type. In the present turbine at certain stages thereof there are under certain conditions of load, departures from these velocities, sometimes in one direction, and sometimes in the other, as for example at the stages of intakes 1-4 and 5-8 and to certain degrees in the preceding and succeeding stages, but these departures are relatively small and in most cases apply only to a fractional part of the steam supply so that the losses in efficiency caused by such variations in velocity are very small as compared with the increased efficiency obtained over other known turbine constructions for changing the steam supply with load conditions, such as the straight throttle or nozzle control constructions. A further advantage obtained by my invention consists in that the power of the turbine may be more finely regulated between the various main percentage load values such as one-half load, three-quarter load and full load by employing partial admission for regulation between these main load values, but the losses due to such partial admission occur only at the intermediate stage and apply only to a small part of the total steam supply.

The adjustments between these definite percentage load values might be effected by throttling the steam, but since the nozzle regulation, as shown in Fig. 1, is more efficient than the throttle regulation, the latter control is preferred, as by sub-dividing the main nozzle groups *c* and *d* of the additional guide blades so that if necessary only a portion of each main group may be opened or closed, as is desired. For example the nozzle group represented by *d* may be sub-divided into sub-groups 14-17 inclusive while the main nozzle group *c* inclusive may be sub-divided into sub-groups 18-21 inclusive. It is thereby possible to successively open or close the sub-groups 14-17 or 18-21 for intermediate loads between the main load regulation values. Such regulation for loads intermediate the main regulation values is thereby effected by the more efficient nozzle regulation, and may be effected at the lower pressure stages supplied with the additional working steam. For example, the sub-groups 14-17 may be first successively controlled for such regulation before the successive control of the sub-groups 18-21.

In Fig. 3 I have indicated the first nozzle group supplied by intakes 9-10-11 as sub-divided into nozzle groups 22, 23 and 24 which render it possible to effect regulation

for load values below the main percentage values, as for example below one-half load, but ordinarily with turbines in practical installations seldom operating at below one-half loads, these sub-divisions of the nozzle group would not be desired or necessary. Also with this arrangement it would be possible, of course, to regulate for varying load values by cutting in and out the groups 22, 23 and 24 while the other main groups 1-4 and 5-8 are fully open.

12 and 13 signify the rings of main guide nozzles for the main driving fluid flow working in the turbine and situated radially within the nozzles *c* and *d* respectively.

I have omitted from the drawings, for convenience in illustration, the regulating or controlling means for regulating the supply of working fluid to the intakes 1-11 inclusive, but it is understood that any suitable known regulating devices or system may be employed. The intakes 1-4, 5-8 and 9-11 are supplied with live steam of the same pressure and the pressure thereof may be reduced at the inlets 1-4 or at the intake nozzles of the intermediate intake stages or at both to function to greatest advantage with the main fluid flow and expansion.

What I claim is:

1. A turbine of the elastic fluid type including a plurality of alternating stationary discs and rotating wheels having aligned rings of stationary nozzles and rotating canals for continuous uninterrupted flow and expansion of the steam from one ring to the other throughout the turbine, the high pressure end of the turbine including a ring of stationary nozzles and being provided with a steam supply means leading thereto, an intermediate stationary disc carrying also a second and concentric ring of nozzles arranged immediately radially outside of and in close proximity to the main ring of nozzles carried by said intermediate disc and adapted to direct steam into the immediately following ring of rotating canals in substantially parallel relation with the flow of steam working through the preceding nozzles and a separate steam supply means leading to said concentric ring of stationary nozzles.

2. A turbine of the character set forth in claim 1, wherein one of said steam supply means includes two or more separate steam supply chambers with separate inlets thereto.

3. A turbine of the elastic fluid type including a plurality of alternating stationary discs and rotating wheels having aligned rings of stationary nozzles and rotating canals for the continuous uninterrupted flow and expansion of the steam from one ring to the other throughout the turbine, a ring of stationary nozzles leading to the first rotating ring of rotating canals and having a steam supply means leading thereto, con-

centric rings of stationary nozzles disposed at certain intermediate stages of the turbine and also carried by the stationary discs, each of said concentric rings being arranged immediately radially outside of and in close proximity to the ring of nozzles carried by the stationary disc at that stage and adapted to direct steam into the immediately following ring of rotating canals in parallel relation to the flow of steam working through the preceding nozzles and a separate steam supply means for each of said concentric rings of stationary nozzles.

4. A turbine of the elastic fluid type including a plurality of alternating stationary discs and rotating wheels having alined rings of stationary nozzles and rotating canals for continuous and uninterrupted flow and expansion of the steam from one ring to the other throughout the turbines, the high pressure end of the turbine being provided with a steam supply means for the first ring of stationary nozzles and the nozzles of the high pressure end of the turbine being adapted with full supply thereto to receive only a sufficient quantity of steam for partial load on the turbine, an intermediate stationary disc carrying a concentric ring of stationary nozzles arranged immediately radially outside of and in close proximity to the stationary ring of nozzles carried by it, said concentric ring of stationary nozzles being adapted with full supply thereto to receive a quantity of steam corresponding to a further part load value on the turbine and to direct it into the immediately following ring of rotating canals in parallel relation with the flow of steam working in the preceding alined nozzles, and a steam supply means for said concentric ring of stationary nozzles.

5. A high pressure steam turbine having a plurality of rings of stationary nozzles alternating with corresponding rings of rotating canals which are alined therewith for the continuous uninterrupted flow and expansion of steam from one ring to the other throughout the turbine, said rings of nozzles and rotating canals being divided into two or more groups, each of which groups gradually increases in exit area toward the low pressure end thereof, but each succeeding group of nozzles and canals having an abrupt increase in area as compared with that of the immediately preceding group; a steam supply means leading to the first group, and a separate steam supply means for each succeeding group leading to the first rotating ring thereof to supply an additional quantity of steam corresponding to the abrupt increase in area thereof and adapted to direct the additional steam into the rotating ring in a direction parallel to the flow of the main body of steam working in and coming from the preceding group.

6. A high pressure steam turbine having a plurality of alined alternating rings of stationary nozzles and rotating canals with a steam supply means and ring of stationary nozzles at the high pressure end of the turbine to provide for the continuous uninterrupted flow and working of the steam received from the chamber throughout the turbine, said rings of stationary nozzles and rotating canals being divided into groups, each of which groups gradually increases in exit area toward the low pressure end thereof, the first group being of a construction and capable of receiving only a sufficient quantity of steam to operate the turbine at a definite partial load value, and each succeeding group of nozzles and canals having a larger area and adapted to receive an additional quantity of steam corresponding to the increase in area and to a definite percentage load value of the turbine a regulating ring of stationary nozzles leading to each intermediate group and disposed radially outside of and in juxtaposition to the last ring of the adjacent preceding group, and a separate auxiliary steam supply means communicating with each of said regulating rings.

7. A multistage turbine of the elastic fluid type including a plurality of alternating stationary discs and rotating wheels having alined rings of stationary nozzles and rotating canals for continuous and uninterrupted working and expansion of the steam from one ring to the other throughout the turbine, the first stage including a ring of stationary nozzles capable with full supply thereto of operating the turbine at a definite partial load value, each of two intermediate stages of said turbine including two separate concentric rings of stationary nozzles, the outer of said stationary concentric rings of nozzles having separate steam supply means and each of them capable with full supply thereto of operating the turbine at a definite partial load value.

8. A turbine of the character set forth in claim 7 wherein one of the separate steam supply means and corresponding outer concentric ring of stationary nozzles at an intermediate stage is divided into separate sections for regulation for load values between the definite partial load values.

9. A multistage high pressure turbine of the elastic fluid type having an admission ring of stationary nozzles at its high pressure end, but capable of only partial load operation when fully supplied by steam thereby, and having at least one intermediate stage provided with an auxiliary ring of stationary nozzles for the reception of additional working fluid to take care of a larger load; the admission nozzles for said intermediate stage being divided into groups disposed in separate and distinct chambers with separate intakes leading thereinto whereby

regulation for loads intermediate the partial load and the larger load values may be effected.

5 10. A multistage high pressure elastic fluid turbine having a single stationary guide nozzle ring for full supply at the first stage and for supplying full pressure live fluid to the turbine, additional load varying admissions for live fluid separate from and disposed at intermediate stages of different pressures, said additional admissions including two or more separate full supply guide nozzle rings which are radially outwardly disposed with respect to the corresponding main guide nozzle rings and are adapted to be successively controlled for regulation for varying loads and the admission of steam into the main working nozzles in parallel relation to the flow of the main working fluid.

10 11. A multistage high pressure elastic fluid turbine having an admission ring of stationary nozzles at its high pressure end and capable of only partial load operation with high pressure fluid fully admitted thereinto and working throughout the turbine separate load varying admission chambers at intermediate stages with substantially full ad-

mission about the whole circumferences of the intermediate stages for regulating the admission of live fluid thereinto for successively larger loads and rings of admission nozzles in communication with said chambers and leading directly into the buckets of rotating wheels.

15 12. A steam turbine of the multistage type having a plurality of alternating rings of stationary nozzles and rotating canals for the continuous working and expansion of the steam from one ring to the next, the first stationary ring of nozzles at the high pressure end of the turbine being capable of supplying only a sufficient quantity of steam to operate the turbine at partial load value, a steam supply means leading there- to, an auxiliary ring of stationary nozzles disposed at a stage of substantially lower pressure than the first stage and adapted to introduce directly into a rotating ring of nozzles at full supply a quantity of steam corresponding to a further partial load value of the turbine, and a steam supply means communicating with said auxiliary ring of stationary nozzles.

In testimony whereof I affix my signature.

FRANZ LÖSEL.