R. SCHULZ.

REGULATION OF TURBINES.

APPLICATION FILED JUNE 24, 1907.

919,253.

Patented Apr. 20, 1909.

2 SHEETS—SHEET 1.

Fig. 1.

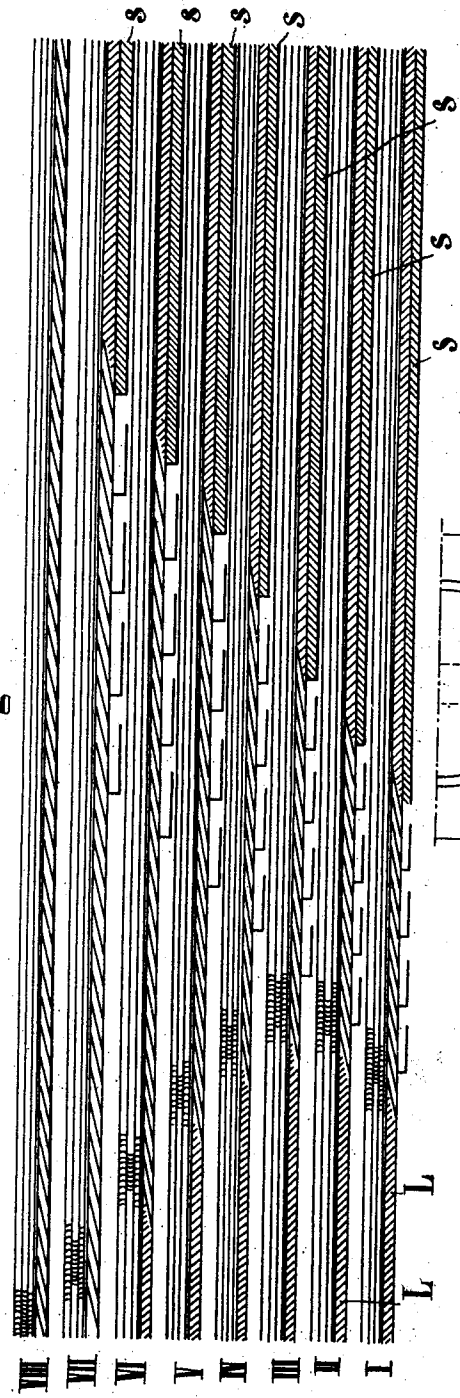
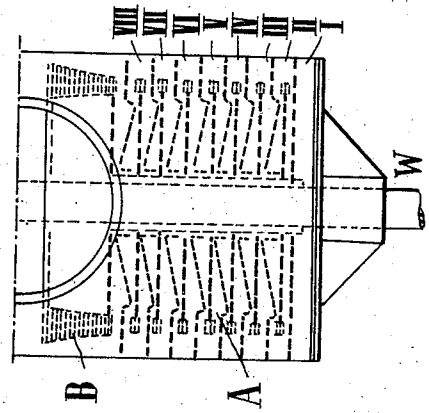


Fig. 2.



Witnesses

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2 SHEETS—SHEET 2.

Fig. 3.

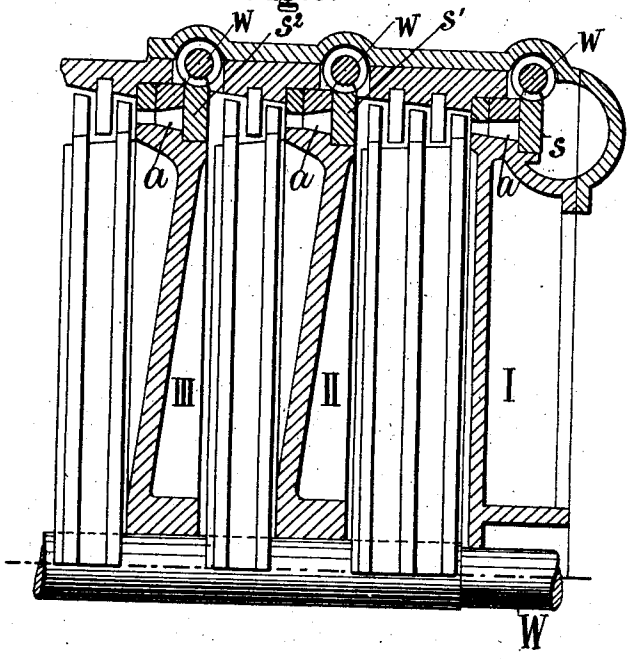
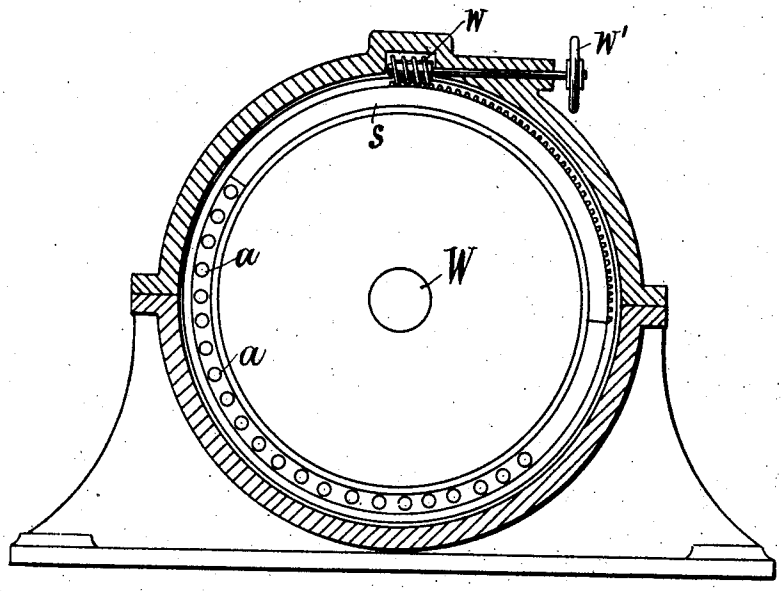


Fig. 4.



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RICHARD SCHULZ, OF BERLIN, GERMANY.

REGULATION OF TURBINES.

No. 919,253. Specification of Letters Patent. Patented April 20, 1909.

Application filed June 24, 1907. Serial No. 380,556.

To all whom it may concern:

Be it known that I, RICHARD SCHULZ, a subject of the German Emperor, residing at Berlin, N. W., Germany, have invented certain new and useful Improvements in Regulation of Turbines; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same, reference being had to the accompanying drawings, and to letters or figures of reference marked thereon, which form a part of this specification.

My invention relates to a method of regulating multistage steam and gas turbines and has for its object to achieve a more economical motive fluid consumption especially when low powers are developed.

Referring to the drawings in which like parts are similarly designated, Figure 1, is a developed diagrammatic view of an eight stage turbine of the impact type. Fig. 2 is a plan view of the turbine showing the eight stages discharging into a parallel flow expansion turbine wheel. Fig. 3 is a vertical longitudinal section through the upper half of three stages showing means for regulating the valves and Fig. 4 a vertical cross section through the turbine showing a series of nozzles on part of the circumference and the annular segmental valve for controlling the steam admission therethrough.

It is very desirable especially in war vessels to use the steam in steam turbines in the most economical manner both when running at high speed and also when running at low speed and when developing low power because it is the latter that is more often used. Attempts have been heretofore made to control multi-stage turbines when developing lower powers and speeds by closing one or more nozzles in one or several or all of the pressure stages but in the same proportion in all stages that are to be controlled, whereby the steam expands approximately to the same extent when developing both high and low powers and speeds. This manner of regulating turbines does not take into consideration that the steam alters in specific volume and in water content in certain proportions to the decrease of power developed and that for better utilizing this energy at low speeds the ratio of the number of open nozzles in the lower stages to the number of open nozzles in the high stages, must be greater.

In view of the above my invention has for its object to regulate the several stages so that the steam admission will be decreased to all of the stages for every decrease of power, but the percentage of decrease, *i. e.*, the number of nozzles closed in relation to the whole number of nozzles, is greater for the high pressure stages than for the low pressure ones and for this purpose each nozzle or group of nozzles are controlled by valves of any suitable construction, said valves being automatically operated from hand with or without the aid of an auxiliary motor and in the case of a stationary turbine from a centrifugal governor driven from the turbine shaft.

The present known methods of controlling turbines does not suffice especially if the regulable stages discharge into an unregulable stage receiving steam around the whole of its circumference or only around part thereof and this is especially the case in war vessels. In this case the same imperfections are present as in a multi-stage turbine in which only the first stage is controlled while the pressure when developing low power falls within unregulated stages, more and more below the end pressure that they have when developing full power. It is therefore obvious that a part of the energy of the steam is not used and the loss of energy is greater the smaller the power developed since the steam passing from the last regulated stage must expand into a very large volume in the next lower stage in order to fill or supply all the nozzles in this latter stage. To illustrate the above, let us say that in the multi-stage turbine there are seven high pressure stages through which the pressure of steam will fall from fifteen to one atmosphere and that beyond these stages there is any suitable number of stages through which the steam expands with a fall of pressure from one atmosphere to one-tenth or lower. Now if it is desired to develop in high pressure stages 60, 40, 20% etc. the steam can not enter the last or eighth stage, as when running under full steam, at a pressure of one atmosphere and the pressure will be smaller and smaller in accordance with the decrease of steam consumption, the steam pressure therefore falls below one atmosphere and for the greater part is useless for developing power.

In my invention by the regulation of multi-stage impact turbines the steam is used to the greatest possible extent at any

desired development of low power and the regulation is such that when developing different powers it does not always work within the same fall of pressure, therefore not as in the above given example, from fifteen to one atmosphere in seven stages with the same proportionate opening of nozzles for all seven pressure stages; but the smaller the desired power to be developed and the steam consumption, working lower and lower under one atmosphere the greater will be the number of open nozzles in the last pressure stages compared with the number of open nozzles in the first pressure stage, and inversely in accordance with the power developed. The following examples will explain this for the regulation of a steam turbine as above described having as shown in Figs. 1 and 2 seven regulable pressure stages discharging into an eight unregulable pressure stage. It is assumed the number of open nozzles be indicated for each stage in the known manner of regulation in accordance with the following table:

Steam consumption for—	Stages.							
	I	II	III	IV	V	VI	VII	VIII
100%.....	25	25	25	25	25	25	25	60
60%.....	15	15	15	15	15	15	15	60
40%.....	10	10	10	10	10	10	10	60
20%.....	5	5	5	5	5	5	5	60

The same turbine if regulated in accordance with the present invention would have different numbers of steam nozzles open in the several stages in accordance with the following table:

Steam consumption for—	Stages.							
	I	II	III	IV	V	VI	VII	VIII
100%.....	25	25	26	27	29	34	43	60
60%.....	15	20	21	22	24	29	38	60
40%.....	10	15	16	17	19	24	33	60
20%.....	5	5	6	7	9	14	23	60

In Fig. 1 of the drawings I have shown an impact turbine A having seven stages each stage regulable by slide valves *s* and the eighth stage discharging into a low pressure turbine B the eight stages of the impact turbine A receiving steam only around part of their circumferences and the low pressure turbine B receiving steam around its full circumference.

Fig. 4 shows that there is an annular series of nozzles *a* arranged only around part of the circumference. The slide *s* is provided with teeth on its outer edge, a worm *w* on a spindle *w'* engaging these teeth, thereby enabling to displace the slide and to close or open more or less nozzles successively. In Fig. 3 three of such slides marked *s s' s²* are shown. All the turbines are shown as mounted on a single power shaft, W, they may, however, be distributed on several shafts, the separate stages being suitably connected to one another by steam pipes as is customary with turbine builders. The valves *s* for the several stages of the impact turbine A are slide plates that slide in front of the nozzles A in the nozzle rings L and are slidable by any suitable mechanism, the various positions of these slides being shown in dotted lines. For the development of the lowest power, *i. e.* 20% five nozzles are open in the two higher stages of the turbine A while in the seventh stage more than half of the nozzles are open *i. e.* 23 out of 43 and in every case below the maximum developed H. P. the smaller the power to be developed the less will be the number of nozzles open, the percentage of decrease of open nozzles is greater for the higher pressure stages than the lower pressure stages. In other words the cross sectional area from one stage to another changes inversely as the power develops. The initial pressure for various speeds need not be the same as the number of nozzles of the various stages may be controlled or regulated in accordance with the initial pressure. In this manner when any lower power is to be developed, the whole fall of pressure from initial pressure to exhaust whether the initial pressure changes or not, will be most economically expanded and utilized since in each stage the steam will have a better and more advantageous expansion than heretofore and will attain its maximum speed and develop its maximum energy in the several stages under the conditions therein capable of existing.

By this method of regulating turbines steam can in several of the stages give up its inertia only and in others its expansion may be partly utilized in accordance with the selected cross sectional area of the inlet nozzles of the several stages in which the power is developed. The turbine wheels may have one or more sets of blades in each stage in accordance with the speed to be developed and the turbines of the higher pressure stages may be constructed so as to be cut out from the others especially for war vessels.

The above described methods of operating turbines prevents a loss of energy if the turbine only carries the turbine wheels A and if the stages are regulated but there will exist in the exhaust a variable pressure by reason of the variation of vacuum due to condenser action. The pressure in the exhaust pipe when developing smaller powers can under certain circumstances be much below that resulting from the use of the larger quantity of steam.

I claim:—

1. The method of regulating multi-stage steam turbines in accordance with the power

to be developed, which comprises decreasing the number of nozzles supplying steam to the stages with a decrease of power, the percentage of decrease in the number of nozzles of the higher pressure stages being greater than in the lower pressure stages.

2. The method of regulating multi-stage turbines in accordance with the power to be developed, which comprises decreasing the number of nozzles supplying steam to the stages, with a decrease of power, the percentage of decrease in the number of nozzles being greatest in the highest pressure stage and decreasing toward the lowest regulable stage.

3. The method of regulating parallel flow multi-stage turbines in accordance with the power to be developed, which comprises decreasing the number of nozzles discharging onto the periphery of the wheels in each regulable stage, the percentage of decrease in the number of nozzles in the stages following the highest pressure stage decreasing to the lowest regulable stage and being in accordance with the increase in volume and the water content of the steam as it passes from the highest to the lowest regulable stage.

4. The method of regulating multi-stage turbines in accordance with the decrease of power to be developed, which comprises decreasing the number of nozzles discharging into the regulable stages, the percentage of decrease progressively decreasing from the highest to the lowest regulable stage while maintaining a substantially constant difference in the number of nozzles between any two successive stages following the high pressure stage for all degrees of regulation.

5. The method of regulating multi-stage turbines in accordance with the decrease of power to be developed, which comprises decreasing the number of nozzles discharged onto the periphery of the wheels in each regulable stage, the percentage of decrease in the number of nozzles in each stage progressively decreasing to the lowest regulable stage and the number of nozzles in each regulable stage that follows the high pressure stage differing from the number of nozzles in the next lowest stage by substantially a constant number for all degrees of regulation.

In testimony that I claim the foregoing as my invention, I have signed my name in presence of the subscribing witnesses.

RICHARD SCHULZ.

Witnesses:
WOLDEMAR HAUPT,
JOHANNAS HEIN,
HENRY HASPER.