Jan. 1, 1929.

1,697,174

G. FORNER

STEAM TURBINE STAGE

Filed Aug. 11, 1924

2 Sheets-Sheet 1

Fig. 1.

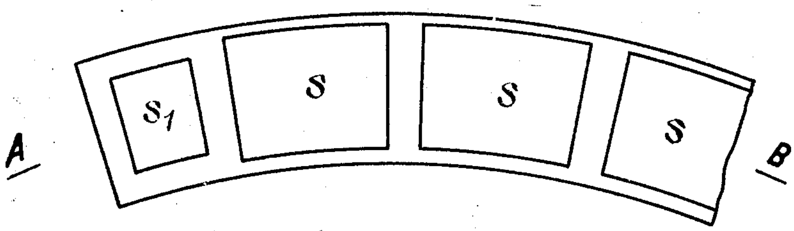
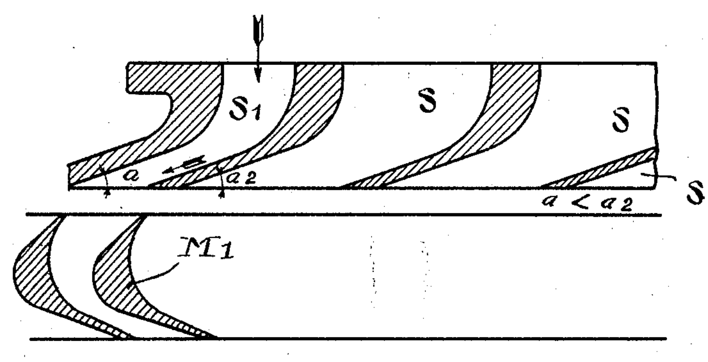


Fig. 2.



Inventor
G. Forner
By Marks & Clerk
Attys.

Jan. 1, 1929. 1,697,174

G. FORNER

STEAM TURBINE STAGE

Filed Aug. 11, 1924 2 Sheets-Sheet 2

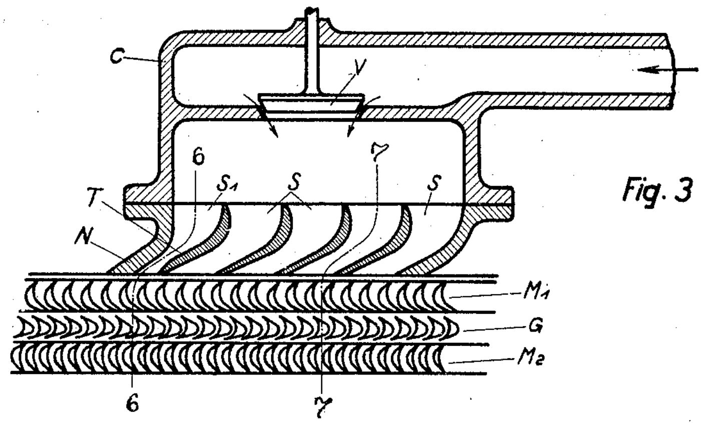


Fig. 3

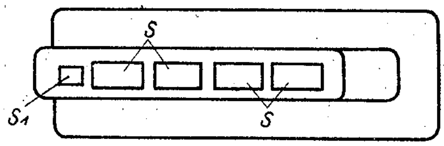


Fig. 4

Fig. 5

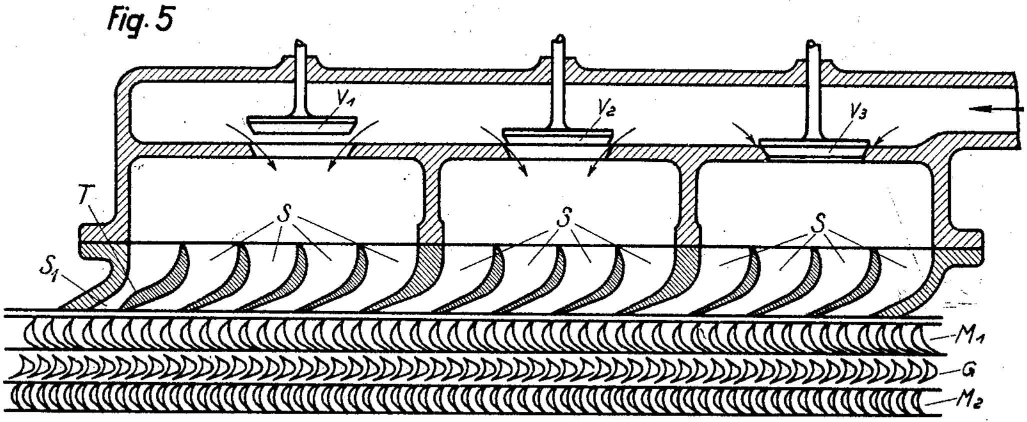
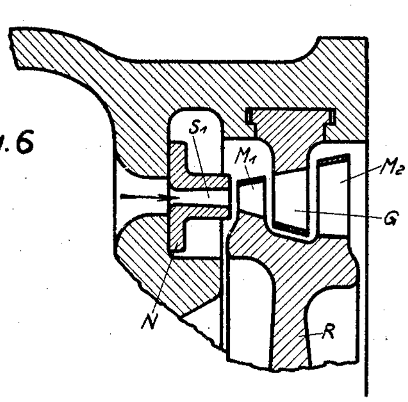


Fig. 6



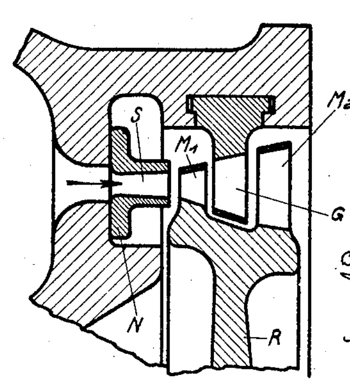


Fig. 7

G. Forner
by
Marks & Clerk
Attys.

Patented Jan. 1, 1929. **1,697,174**

UNITED STATES PATENT OFFICE.

GEORG FORNER, OF BERLIN, GERMANY, ASSIGNOR TO AKTIENGESELLSCHAFT BROWN, BOVERI AND CIE., OF BADEN, SWITZERLAND.

STEAM-TURBINE STAGE.

Application filed August 11, 1924, Serial No. 731,475, and in Germany August 16, 1923.

This invention relates to improvements in steam turbines of the type wherein the working fluid expands chiefly within the first guide means or nozzles and the velocity energy and the residual pressure are subsequently fractionally absorbed by one or more sets of rotor blades alternating with stationary guide blades.

In steam turbines having stepped velocity (Curtis) stages in which expansion takes place in the stationary blading, a higher pressure exists in that part of the gap which lies between the active nozzles and the first row of moving blades than in any other of the gaps or clearances between the stator and rotor. Owing to this higher pressure a portion of the steam issuing from the nozzles leaks into the gap beyond the nozzle area without doing work. This leakage of steam may occur in the radial direction and also in the direction of rotation. As regards the former case, proposals have already been made for reducing the radial leakage. As regards the leakage in the direction of rotation, only the first and the last of the nozzles of a group that is traversed by the steam come into question.

In the case of the nozzle that is rearmost of a group in the direction of rotation, the leakage is relatively slight, because in this nozzle the direction of the outflow of the steam from the nozzle and the direction of the discharging steam leakage are opposed to each other, and because the surrounding steam which is carried into the gap by the rotation of the rotor acts in opposition to the direction of the steam leakage. The reverse is the case in the foremost nozzle, for which reason the steam leakage is greater in this nozzle. If, as is mostly the case, the Curtis stage is used as the first turbine stage, there is almost always a nozzle regulation employed, so that the number of nozzles that are open will be different under different conditions of working. The nozzles may be arranged to be opened in succession by individual valves for each nozzle or one valve for a group of nozzles. The last of the nozzles or group of nozzles to be closed by the governor may either be the foremost nozzle or the rearmost nozzle in the direction of rotation. The maximum advantage of a device for preventing peripheral leakage of steam will be obtained when the device is associated with that nozzle or group of nozzles which is the last to be closed by the governor, since this nozzle or group of nozzles will always be delivering steam to the rotor while the turbine is running.

According to the present invention the foremost nozzle or group of nozzles is the first to be opened by the governor. This is advantageous because as hereinbefore stated the steam leakage is greater at this nozzle than at the rearmost nozzle, and therefore a diminution of the leakage is of greater value. In order to best avoid leakage at this point it is advisable to make the dimensions of the nozzle such that the steam will expand in it or in the gap wholly or almost wholly down to the pressure of the surrounding space.

According to the present invention this object is achieved by reducing the radial height of the nozzle orifice so that its steam can flow, without becoming congested, through the blades that receive steam from the said nozzle. Obviously the efficiency of this steam is somewhat diminished as compared with the efficiency of the steam flowing out of the other nozzles.

This drawback is reduced according to the present invention by making the exit cross section area of the foremost nozzle smaller than that of the next following nozzle. It is advisable for this purpose to make the cross section such that the steam of the foremost nozzle is able to enter, at most, two blade passages at one and the same time. This is effected by making the clear inside exit width of the nozzle, in the peripheral direction, not more than equal to the pitch of the blades. In most cases the steam issuing from the foremost nozzle is deflected away from the nozzle axis as the result of the greater degree of expansion. For this reason it is advisable to give a more acute angle to this nozzle than to the other nozzles, so as to obtain steam entrance approximately without shock. In certain cases, however, this expedient is not necessary, especially where, even in the case of a deflected jet of steam, owing to the higher exit velocity, an entrance takes place approximately without shock. In this case, however, the wall between the foremost nozzle and the second nozzle should have a thickness such that the exit jets of the two nozzles will meet only in the immediate vicinity of the entrance edge of the blades, so that a disturbing influence of the two jets upon each other is avoided.

The accompanying drawings illustrate by way of example one way of carrying the invention into effect.

In the drawings:

Figure 1 represents the outlet openings of a group of nozzles;

Figure 2 represents a section on the line A—B of Figure 1;

Figure 3 is a diagrammatic sectional view of a group of nozzles fed through a common valve V;

Figure 4 is a view of the exit orifices of the nozzles of Figure 3;

Figure 5 is a diagrammatic sectional view corresponding to that of Figure 3 but showing a compound group of nozzles.

Figures 6 and 7 are part sections of Figure 3 on the lines 6—6 and 7—7 respectively.

In the drawings, according to Figure 1 the leading nozzle of the group is represented by S_1 and is made, according to the invention, smaller in its cross section and in its radial dimension than the succeeding nozzles S, S, S. M_1 represents the first row of rotor blades.

Figure 2 shows the discharge angle a of the nozzle S_1 to be more acute than the corresponding angle a_2 of the nozzles S, S, S.

Figures 3, 4, 6 and 7 represent a nozzle segment or group N supplied with steam through a valve V which is controlled by the usual governor. In these figures the leading nozzle orifice S_1 is again smaller in its cross sectional area and in its radial dimension than the other nozzles S, S, S, and Figure 3 shows the thickening of the rear wall of the first nozzle S_1 at T, which thickening, in conjunction with the more acute discharge angle of this first nozzle, causes the proximate edges of the jet from S_1 and the next jet from S to meet without interference substantially at the entrance edge of the first rotor rim M_1 and so in the usual manner through the guide rim G and succeeding rotor rim M_2. The rims M_1 and M_2 are fixed to the common rotor R, and the guide rim G to the casing of the turbine.

Figure 5 shows a compound group of nozzles consisting of three groups fed from a common steam chest through valves V_1, V_2 and V_3 respectively.

In this case the action of the governor is arranged to operate on the three valves V_1, V_2 and V_3 in succession, the valve V_1 being the last to close and the first to open.

The leading nozzle S_1 of the group fed from the valve V_1 is constructed as hereinbefore described with a smaller cross-sectional area and radial dimension than the remaining nozzles S and is also furnished as in Figure 3 with a thickening T on its rearmost wall.

The advantage of this invention resides in the fact that at the foremost point or end of the nozzle segment, where the leakage would be greatest in the case of a higher pressure at the gap, there will take place almost no discharge of steam into the gap without doing work, and the maintenance of the higher pressure in the gap is thereby assured provided that the dimensions of the blades have been correctly chosen.

What I claim is:—

1. In a turbine, a group of guide nozzles of which the leading nozzle has a discharge orifice of smaller cross sectional area than those of the other nozzles.

2. In a turbine, a group of guide nozzles of which the leading nozzle has an outlet orifice of less radial extent than the outlet orifices of the other nozzles.

3. In a turbine, a group of guide nozzles of which the leading nozzle has a discharge orifice of less width in the circumferential direction than the discharge orifices of the other nozzles.

4. In a turbine, the combination with rotor blading, of a group of guide nozzles of which the leading nozzle has a discharge orifice having a width not to exceed the pitch of the rotor blading.

5. In a turbine, the combination with a bladed rotor, of a group of guide nozzles of which the leading nozzle has a smaller discharge area and a smaller discharge angle than the nozzle posterior to it in the group.

6. In a turbine, the combination with a bladed rotor, of a group of guide nozzles of which the leading nozzle has a smaller discharge angle than the adjacent posterior nozzle, said nozzles arranged to direct their jets to meet without interference substantially at the entrance edge of the rotor blading.

7. In a turbine, the combination with a bladed rotor, of a group of guide nozzles of which the leading nozzle has a smaller discharge orifice than the adjacent posterior nozzle, said nozzles arranged to direct their jets to impinge without interference approximately at the entering edge of the rotor blading.

8. In a turbine, the combination with a bladed rotor, of a group of guide nozzles of which the leading nozzle has a smaller discharge orifice than the adjacent posterior nozzle, said leading nozzle having an expanding discharge throat.

9. In a turbine, the combination with guide nozzles arranged in groups, of valve mechanism for controlling admission of working fluid to the groups respectively, the admission valve of the leading group being the first to open and the last to close, and the leading nozzle of the leading group

having a smaller discharge orifice and a smaller discharge angle than the posterior nozzles of said group.

10. In a steam turbine, the combination with a stage of rotor blading, of a group of nozzles for feeding same, the leading nozzle of the group being constructed to expand the steam passing therethrough down to approximately the final pressure of the rotor stage.

11. In a steam turbine, the combination with a stage of rotor blading, of a group of nozzles serving same, the leading nozzle of said group being arranged to deliver steam to the blading stage at approximately the exist steam pressure of the stage, said leading nozzle having a smaller discharge angle than the other nozzles of the group, and said other nozzles being constructed to deliver steam to the blading at a pressure higher than its exit pressure from the stage.

In testimony whereof I have signed my name to this specification.

GEORG FORNER.