Sept. 30, 1930. H. HOLZWARTH 1,776,832

GAS TURBINE COOLED BY STEAM

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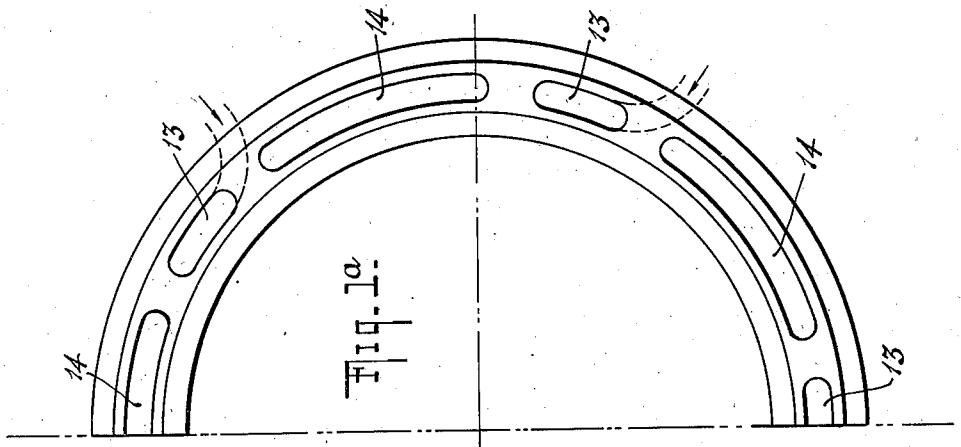


Fig. 1a.

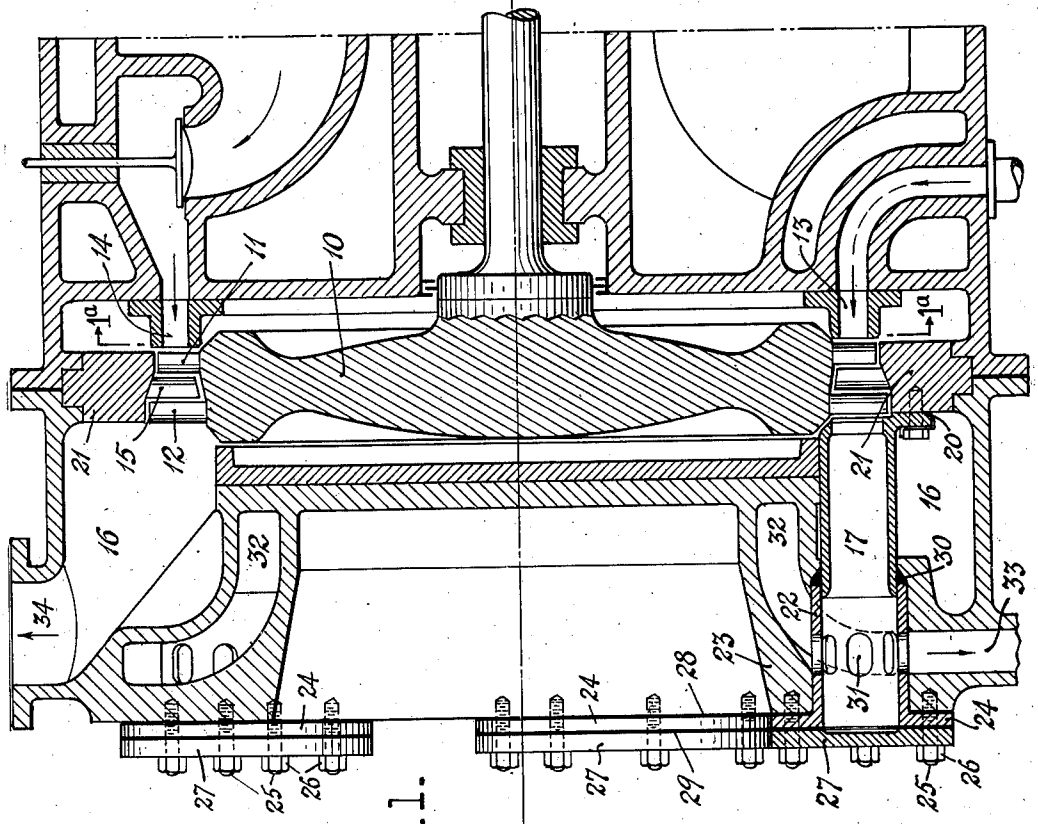


Fig. 1.

WITNESS

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Fig. 3.

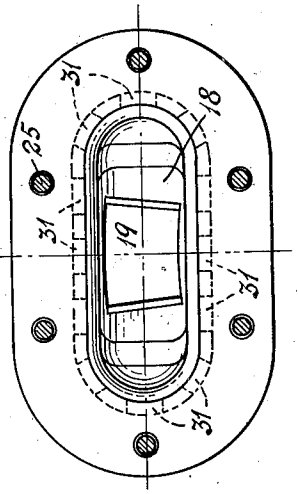


Fig. 2.

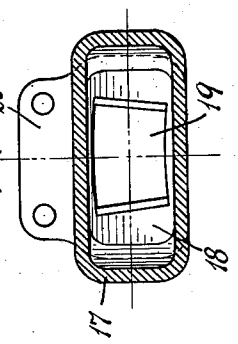


Fig. 4.

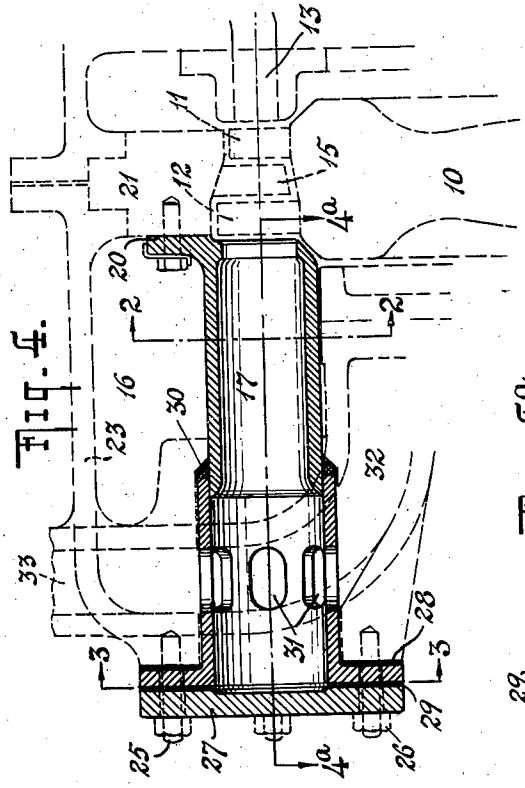
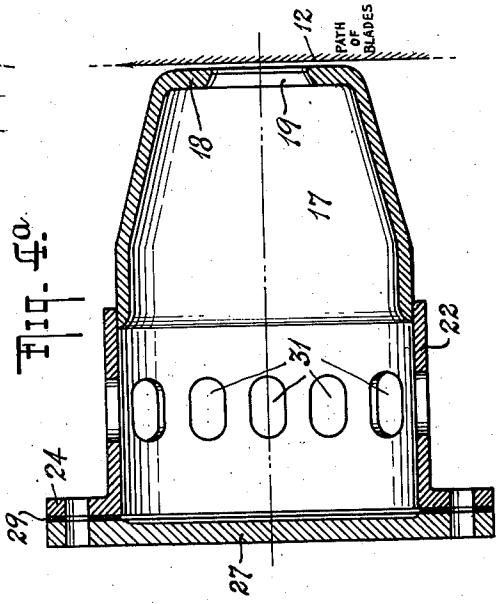


Fig. 4a.



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Fig. 7.

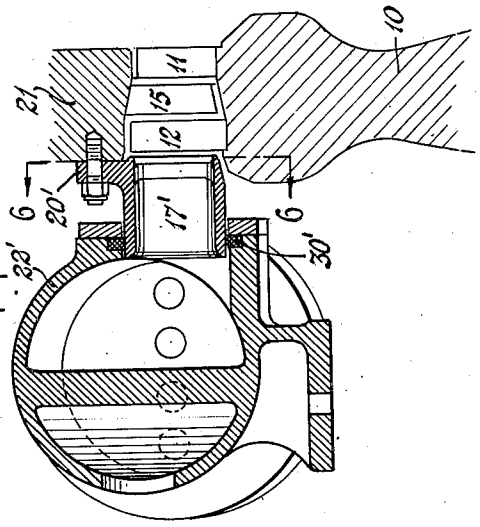


Fig. 6.

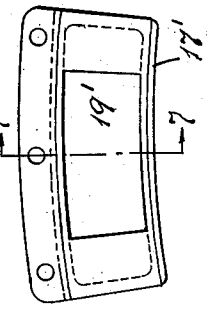


Fig. 7a.

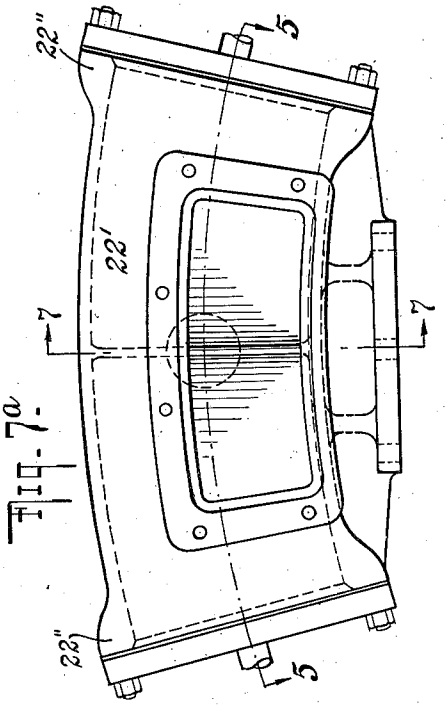
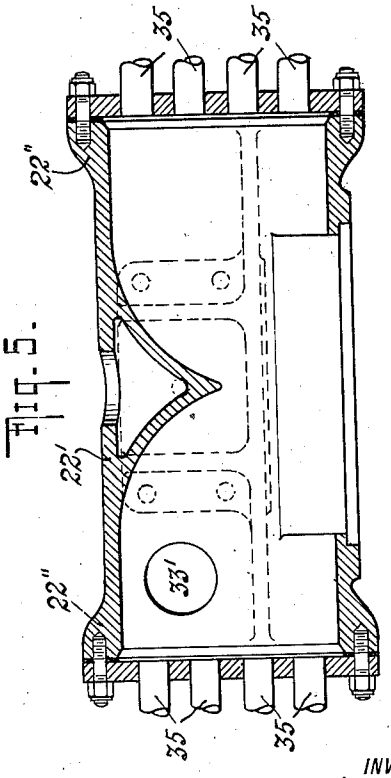


Fig. 5.



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Fig. 8.

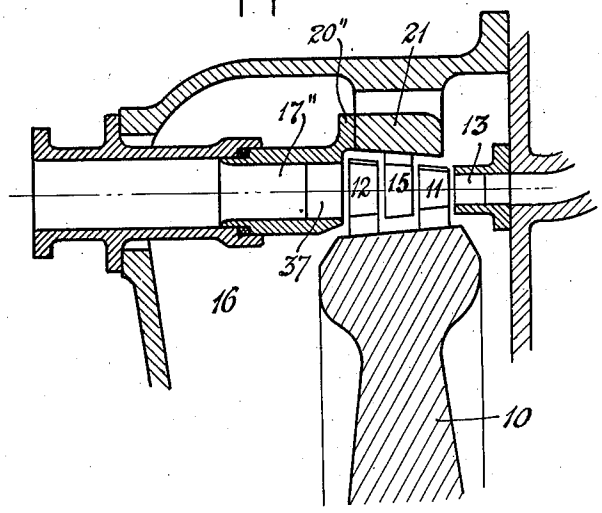
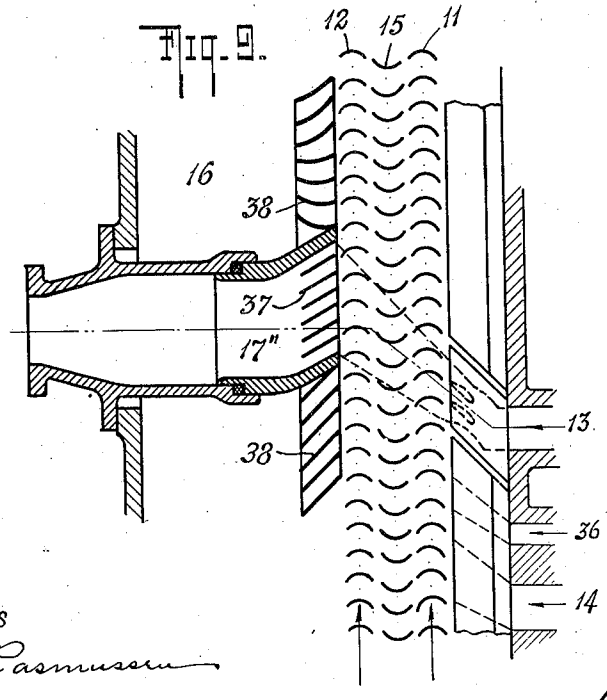


Fig. 9.



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Fig. 10.

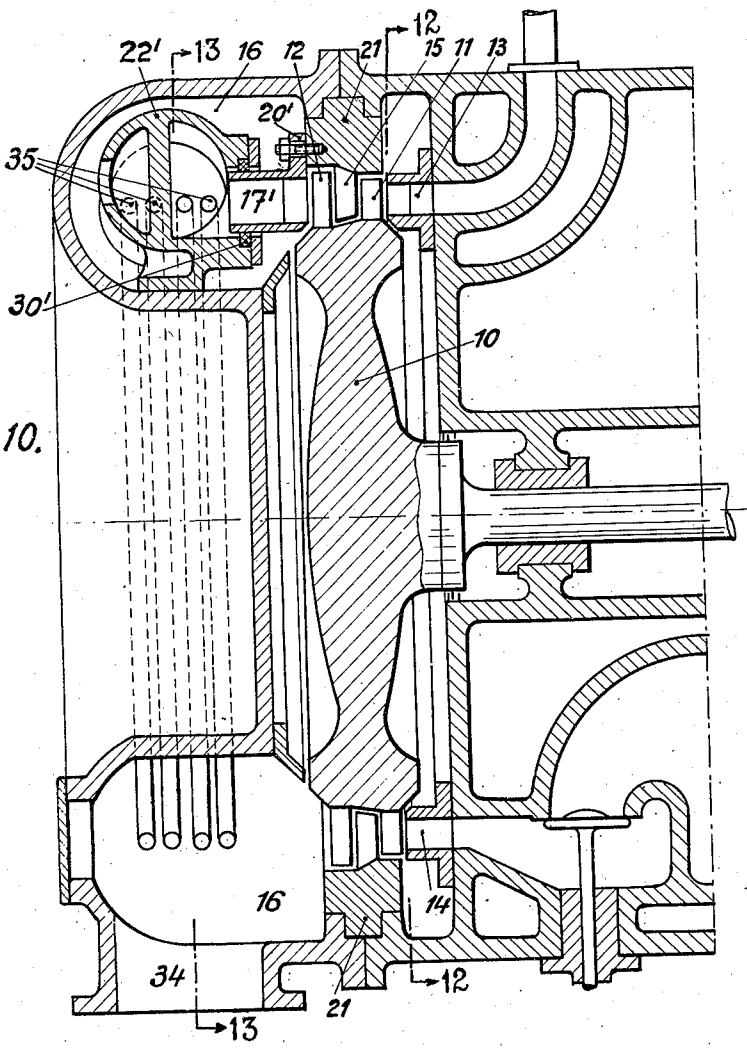
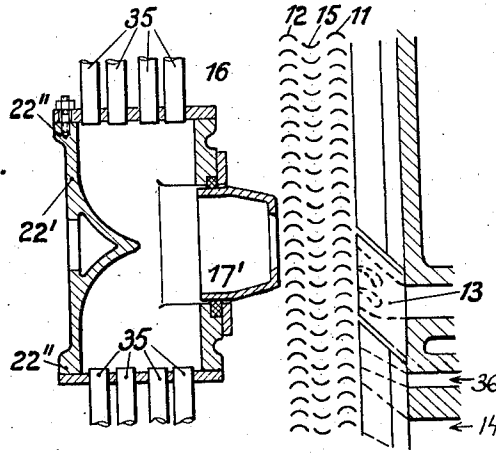


Fig. 11.



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Fig. 12.

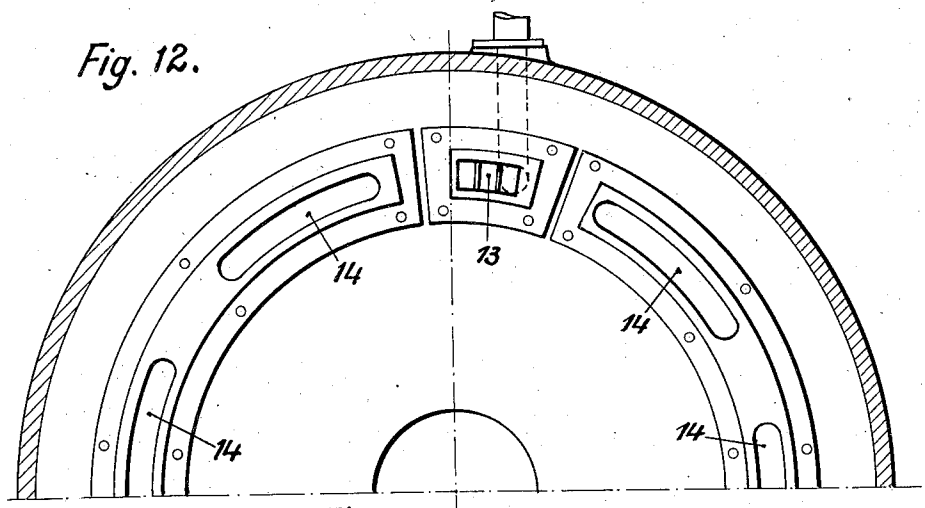
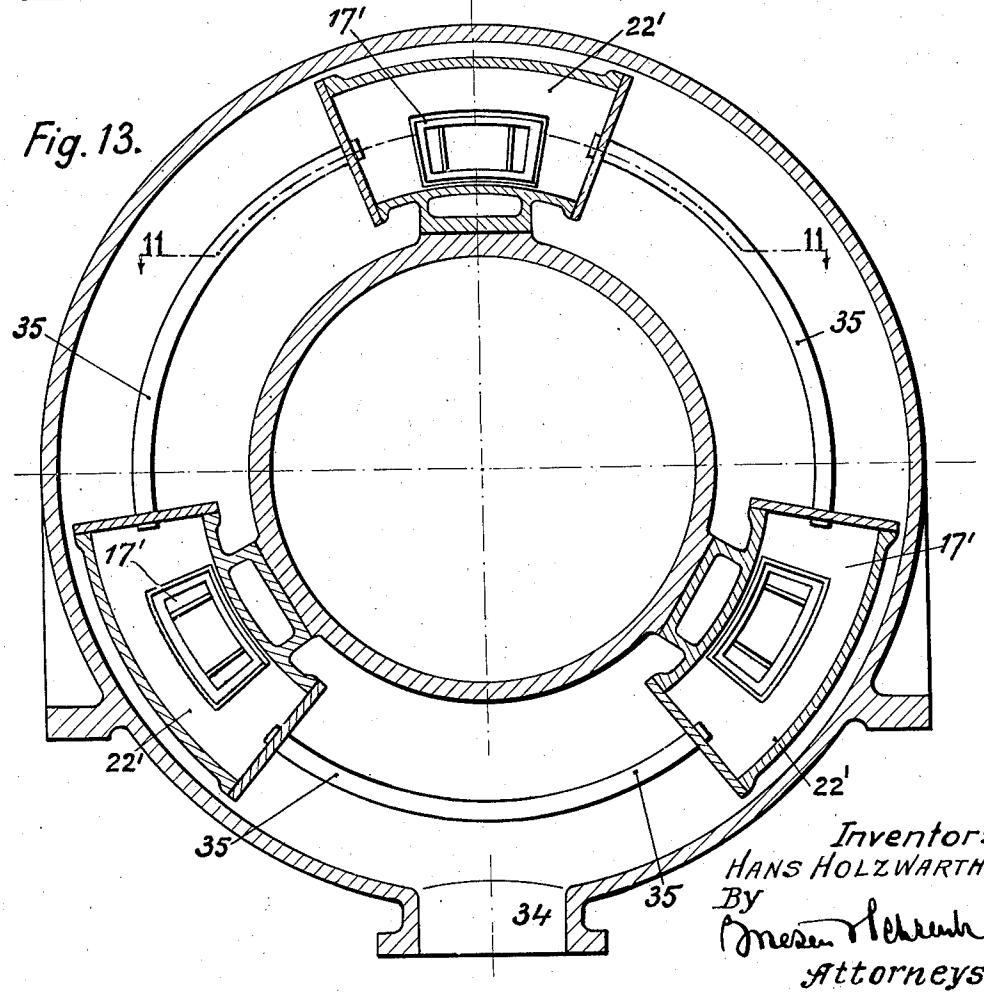


Fig. 13.



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UNITED STATES PATENT OFFICE

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GAS TURBINE COOLED BY STEAM

Application filed March 18, 1927. Serial No. 176,441.

In my application for Letters Patent of the United States, Serial No. 47,422, filed August 1, 1925, I have disclosed a turbine having combustion gas nozzles alternating with nozzles in which high-pressure steam is allowed to expand to the back pressure prevailing in the rotor chamber, whereupon said steam is discharged into the blade channels of the turbine rotor to pass through them at a high velocity and thus cool the blades. After passing through the blade channels, this steam is collected in catch nozzles, separately from the exhaust combustion gases, to be superheated by such gases and then caused to perform further work in a low-pressure turbine.

My present invention has for its particular purpose to improve the means employed for catching or collecting the steam issuing from the blade channels of the rotor. The object is to catch practically all the steam, to avoid, as far as possible, the entrance of combustion gases into the catch apparatus, and to construct the latter in such a manner that it will not follow the slight movements which the exhaust cover performs under the influence of temperature changes, but will be connected as rigidly as possible with the stationary sector carrying the guides for reversing the direction of the driving fluid as it passes from one series of rotor blades to another, in cases where the rotor has two or more sets of blades.

Satisfactory and preferred embodiments of my present invention are illustrated by the accompanying drawings, in which Fig. 1 is an axial section of a turbine embodying my invention; Fig. 1ª is a view taken along the plane indicated by the lines 1ª—1ª in Fig. 1; Fig. 2 is a cross-section through one of the catch nozzles; Fig. 3 is an end view of one of said nozzles; Fig. 4 is a detail longitudinal section of such nozzle; Fig. 4ª is a section along the plane indicated by the lines 4ª—4ª in Fig. 4; Fig. 5 is a partial circumferential section showing another form of my invention; Fig. 6 is an end view of the nozzle employed in this second form; Fig. 7 is a cross-section on line 7—7 of Fig. 6; Fig. 7ª is a front view of the nozzle shown in Fig. 5; Fig. 8 is a partial axial section of certain additional features desirable for use in connection with the catch nozzles; Fig. 9 is a partial circumferential section, substantially through the axes of the nozzles 13 and 17; Fig. 10 is an axial section of a turbine similar to that shown in Fig. 1 but having embodied therein the catch nozzle and steam chamber illustrated in Fig. 7; Fig. 11 is a partial circumferential section illustrating the steam chamber shown in Fig. 5 combined with the catch nozzle 17″ shown in Fig. 9 and is taken along the line 11—11 of Fig. 13; Fig. 12 is a view similar to Fig. 1ª, taken along the line 12—12 of Fig. 10 and includes a front view of the partitioned charging steam nozzle shown in Fig. 9, and Fig. 13 is a section taken on the line 13—13 of Fig. 10.

In the drawings I have indicated a turbine rotor 10 having two sets of blades 11, 12, one of which receives the two driving media, viz. steam and combustion gases under pressure, from alternately arranged stationary nozzles 13 and 14 respectively. After passing through the channels of the blades 11, the driving media come in contact with an annular series of stationary blades 15 which deflect or reverse the flow of the driving media to direct them at an effective angle against the second set of rotor blades 12. From these the combustion gases pass into an exhaust chamber 16, but the steam is gathered by stationary catch nozzles 17 arranged in approximate registry with the steam nozzles 13. Each of these catch nozzles is in the form of a tube which at the end adjacent to the path of the blades 12 is provided with a transverse wall 18 made with an inlet aperture 19 of segmental shape, the arc of such segment having its center on the axis of the rotor 10. At the same end the catch nozzle is provided with a lug 20 for fastening it with a steam-tight joint to the stationary carrier 21 of the reversing blades 15. At the opposite end, the nozzle has a steam-tight sliding or telescopic fit with a tubular housing 22 secured to the cover 23 of the exhaust chamber 16. For this purpose, the outer end of the housing 22 may be provided with a flange 24 held in position by bolts 25 fitted into suitable holes in the cover 23, and nuts 26 screwing on said bolts

to press said flange toward the cover 23. The nuts also press a plate or cap 27 toward the outer surface of the flange 24. Packing rings 28, 29 are preferably interposed between the flange 24 and the cover 23 and caps 27 respectively, and preferably a packing ring 30 is employed at the joint of each catch nozzle 17 with the corresponding housing 22.

The housings 22 are provided in their side walls with apertures 31 through which the steam passes out into a chamber or conduit 32 adjacent to or within the exhaust chamber 16, so that the steam in the chamber 32 will be heated or superheated by the combustion gases flowing through the exhaust chamber 16.

The steam chamber 32 has a suitable outlet 33 from which the steam may pass to a place of further use, for instance for driving another turbine rotor (not shown). The exhaust chamber 16 has an outlet 34 leading to a stack or other suitable place.

As I have explained above, one of the objects of my invention is to prevent any combustion gases entering the catch nozzles 17 and the steam chamber 32. The combustion gases and the steam issuing from the rotor blades 12 are thrown outwardly by centrifugal force, and thus there is no danger of their escaping toward the rotor axis, even if there should be considerable play (say, as much as one-sixth of an inch) between said blades and the adjacent ends of the catch nozzles 17. The outward escape of steam (under the influence of centrifugal force) issuing from the blades 12 is prevented by the steam-tight joint of the lugs 20 with the carrier 21, it being noted that these lugs are on the outer sides of the catch nozzles 17, that is to say, on the sides farthest away from the rotor axis. Conversely, just as no steam can escape outwardly past the joints between the lugs 20 and the carrier 21, no combustion gases can get past said joints and enter the catch nozzles 17. There is still the danger that a portion of the steam issuing from the blades 12 will escape laterally (circumferentially) between the said blades and the adjacent ends of the catch nozzles. To overcome this danger, or at least to minimize losses of steam by such lateral escape, the segmental opening 19 is made in a transverse end wall 18 of the catch nozzle 17, instead of simply giving the entire nozzle a cross-section of segmental shape. The provision of this transverse end wall adjacent to the inlet opening 19 of the catch nozzle assists in forming a barrier against the lateral or circumferential escape of the steam between the blades 12 and the catch nozzle, and constricts the gap between said blades and nozzle over a relatively wide area. The shape of the inlet opening 19 corresponds to that of the solid jet of steam issuing from the channels of the rotor blades 12. The structure 18, 19 constitutes as it were an apertured shutter which allows the jets of steam to enter the nozzle 17 but prevents or reduces to a minimum the escape of steam laterally through the gap between the blades 12 and the catch nozzle 17.

Since the inner ends of the nozzles 17 are secured rigidly to the carrier 21 of the stationary reversing blades 15 which are disposed between the paths of the rotor blades 11, 12 respectively, the distance between the inlet ends of said nozzles and the path of the adjacent rotor blades 12 will remain practically constant notwithstanding temperature changes. The cover 23 of the exhaust chamber is subject to rather considerable movements due to fluctuations in temperature, and for this reason I have not secured the outer ends of the catch nozzles 17 directly to said cover, but employ the housings 22 having telescopic joints with the respective nozzles 17. Thus, when the cover 23 moves in response to changes in temperature, the housings 22 will follow such movements of the cover 23, but the nozzles 17 will not, since the housings will slide lengthwise of the nozzles, in a direction parallel to the rotor axis. The joint between the housing and the corresponding nozzle will remain tight notwithstanding such longitudinal movement, the packing 30 being of a character suitable for this purpose.

In the construction illustrated by Figs. 6, 7, and 7a the steam issuing from the channels of the blades 12 enters catch nozzles 17′ of a type similar to the one described above, the main difference in the catch nozzle residing in the fact that the entire nozzle 17′ is given a segmental shape, and not merely the inlet opening 19′ thereof. Instead of the housing 22, I employ a housing 22′ having a packing 30′ in sliding engagement with the nozzle 17′, said housing having lateral bends or elbows 22″ extending in a lateral (circumferential) direction and communicating with tubes 35 which connect adjoining housings 22″ and are located within the exhaust chamber 16. The superheated steam from the housings 22′ and tubes 35 is delivered through a suitable outlet 33′. As in the construction first described, the catch nozzles have lugs (20′) at their inner ends securing them to the carrier 21, while the housings (22′) are secured to the cover 23 of the exhaust chamber, and when the housings (22′) move with said cover under the influence of temperature changes, they slide lengthwise of the nozzles (17′), in a direction parallel to the rotor axis. The advantages are the same as in the form of my invention first described.

If the steam nozzles 13 are in such a position (allowing for the velocity of the rotor) that the steam will pass from them through the rotor directly into the catch nozzles 17 or 17′, such steam, evidently, would drive before it and blow into the catch nozzles, a

portion of the combustion gases which the rotor blade channels have received from the preceding combustion gas nozzles 14. To overcome this result, and to prevent this blowing of combustion gases into the catch nozzles, I may place these nozzles, or at least their inlet openings, slightly ahead in the direction of rotation, so that the first puff of steam will drive the combustion gases out of the rotor blade channels into the exhaust gas chamber 16, and only after these channels have been cleared will the steam pass from them into the catch nozzles. Instead of this expedient (which is also partly disclosed in my earlier application referred to above), I may employ supplemental nozzles 36 (Fig. 9) located between the combustion gas nozzles 14 and the steam nozzles 13 and arranged to blow the contents of the rotor blade channels into the exhaust gas chamber 16 before the steam from the nozzles 13 passes through said channels into the catch nozzles 17 or 17'. The medium discharged through the nozzles 36 may be compressed air, gas, or steam.

The catch nozzles 17 or 17' will therefore receive only steam, while the exhaust chamber 16 will receive the combustion gases, together with such steam or other medium as may have been employed to blow the combustion gases out of the rotor blade channels before the latter come into operative relation to the catch nozzles.

The steam passing through the rotor blade channels is of a temperature below that of the combustion gases, and therefore exerts a cooling effect on such blades, as mentioned in my earlier application referred to above.

Figs. 8 and 9 show certain additional features which I consider desirable in connection with the catch nozzles at the steam-receiving ends thereof. Within the inlet end of the catch nozzle 17'', I have shown stationary partitions or vanes 37 which may be straight or curved, and having their entrance edges arranged in the path of the steam coming from the rotor blades 12. As soon as the steam enters the cells or compartments which the partitions 37 form in the nozzle 17'', its flow is no longer affected by the motion of the blades 12, but proceeds steadily lengthwise within the nozzle. When the partitions 37 are omitted, the fan action of the rotating blades 12 causes the jet of steam issuing from said blades to be carried circumferentially and widened, thus bringing the edge portions of the steam jet into contact with the combustion gas jets and breaking it up, at least in part. At each side of the catch nozzle 17'' I have shown stationary guide vanes 38 the purpose of which is to direct the combustion gases properly adjacent to said nozzle, as a further safeguard against a disturbing action of the combustion gas jets on the steam entering said nozzle.

Figs. 10, 11, 12 and 13 show a construction in which the housing of Fig. 7 and the catch nozzle of Fig. 9 are substituted for the housing and catch nozzle shown in Fig. 1 and in which the stationary guide vanes of Fig. 9 are added to the construction shown in Fig. 1.

Various modifications may be made without departing from the nature of my invention as set forth in the appended claims.

I claim:

1. In a turbine, a rotor having blades, stationary nozzles for discharging steam and combustion gases respectively against said rotor blades, and catch nozzles arranged to receive the steam which has passed from the steam nozzles through the rotor blade channels, said catch nozzles having inlets close to the path of the adjacent rotor blades and transverse walls extending close to said path both ahead and in the rear of the said inlets to minimize the escape of steam circumferentially through the gap between the said catch nozzles and rotor blade path.

2. In a turbine, a rotor having blades, stationary nozzles for discharging steam and combustion gases respectively against said rotor blades, and catch nozzles arranged to receive the steam which has passed from the steam nozzles through the rotor blade channels, said catch nozzles having transverse end walls close to the path of the adjacent rotor blades and inlets in said walls, such inlets being of a cross-sectional area smaller than the interior cross-section of the catch nozzle body.

3. In a turbine, a rotor having blades, stationary nozzles for discharging steam and combustion gases respectively against said rotor blades, and catch nozzles arranged to receive the steam which has passed from the steam nozzles through the rotor blade channels, said catch nozzles having transverse end walls close to the path of the adjacent rotor blades, and segmental inlets in said walls.

4. In a turbine, a rotor having blades, stationary steam nozzles and combustion gas nozzles in operative relation to said blades, an exhaust chamber to receive the combustion gases which have passed from the combustion gas nozzles through the rotor blade channels, catch nozzles arranged to receive steam which has passed from said steam nozzles through the rotor blade channels, said catch nozzles being secured to a stationary part of the turbine, and housings communicating with said catch nozzles to receive steam therefrom, said housings being secured to a wall of said exhaust chamber and having a telescopic connection with said catch nozzles.

5. In a turbine, a rotor having blades, stationary steam nozzles and combustion gas nozzles in operative relation to said blades, an exhaust chamber to receive the combustion gases which have passed from the combus-

tion gas nozzles through the rotor blade channels, catch nozzles arranged to receive steam which has passed from said steam nozzles through the rotor blade channels, said catch nozzles being secured to a stationary part of the turbine, and housings communicating with said catch nozzles to receive steam therefrom, said housings being secured to a wall of said exhaust chamber and having a telescopic connection with said catch nozzles, to slide relatively thereto in a direction parallel to the rotor axis.

6. In a turbine, a rotor having blades, stationary steam nozzles and combustion gas nozzles in operative relation to said blades, an exhaust chamber to receive the combustion gases which have passed from the combustion gas nozzles through the rotor blade channels, catch nozzles arranged to receive steam which has passed from said steam nozzles through the rotor blade channels, and means for securing said nozzles with a steam-tight joint to a stationary part of the turbine, on their outer portions, farther from the rotor axis than the catch nozzle inlets.

7. In a turbine, a rotor having a plurality of sets of blades, a stationary carrier provided with reversing blades interposed between adjacent sets of rotor blades, stationary steam nozzles and combustion gas nozzles in operative relation to said blades, an exhaust chamber to receive the combustion gases which have passed from the combustion gas nozzles through the channels of said blades, catch nozzles arranged to receive steam which has passed from said steam nozzles through the channels of said blades, said catch nozzles being secured to said carrier, and housings communicating with said catch nozzles to receive steam therefrom, said housings being secured to a wall of said exhaust chamber and having telescopic connection with the respective catch nozzles.

8. In a turbine, a rotor having a plurality of sets of blades, a stationary carrier provided with reversing blades interposed between adjacent sets of rotor blades, stationary steam nozzles and combustion gas nozzles in operative relation to said blades, an exhaust chamber to receive the combustion gases which have passed from the combustion gas nozzles through the channels of said blades, catch nozzles arranged to receive steam which has passed from said steam nozzles through the channels of said blades, said catch nozzles being secured to said carrier, and housings communicating with said catch nozzles to receive steam therefrom, said housings being secured to a wall of said exhaust chamber and having a telescopic connection with the respective catch nozzles to slide relatively thereto in a direction parallel to the rotor axis.

9. In a turbine, a rotor having blades, stationary steam nozzles and combustion gas nozzles in operative relation to said blades, an exhaust chamber to receive the combustion gases which have passed from the combustion gas nozzles through the rotor blade channels, catch nozzles arranged to receive steam which has passed from said steam nozzles through the rotor blade channels, said catch nozzles being secured to a stationary part of the turbine, housings communicating with said catch nozzles to receive steam therefrom, said housings being secured to a wall of said exhaust chamber and having movable connections with the respective catch nozzles, and a steam chamber receiving steam from said housings through outlets therein.

10. In a turbine, a rotor having blades, stationary steam nozzles and combustion gas nozzles in operative relation to said blades, an exhaust chamber to receive the combustion gases which have passed from the combustion gas nozzzles through the rotor blade channels, catch nozzles arranged to receive steam which has passed from said steam nozzles through the rotor blade channels, and a steam chamber arranged within said exhaust chamber to gather the steam from said catch nozzles.

11. In a turbine, a rotor having blades, stationary steam nozzles and combustion gas nozzles in operative relation to said blades, an exhaust chamber to receive the combustion gases which have passed from the combustion gas nozzles through the rotor blade channels, catch nozzles arranged to receive steam which has passed from said steam nozzles through the rotor blade channels, housings communicating with the respective catch nozzles to receive steam therefrom, and steam conduits connecting said housings and located within said exhaust chamber.

12. In a turbine, a rotor having blades, stationary steam nozzles and combustion gas nozzles in operative relation to said blades, an exhaust chamber to receive the combustion gases which have passed from the combustion gas nozzles through the rotor blade channels, catch nozzles arranged to receive steam which has passed from said steam nozzles through the rotor blade channels, and supplemental stationary nozzles arranged in advance of the respective steam nozzles to scavenge the rotor blade channels clear of combustion gases before steam passes from such channels into said catch nozzles.

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