Nov. 19, 1940. G. SCHAPER 2,221,816

COOLED NOZZLE SEGMENT FOR COMBUSTION TURBINES

Filed March 17, 1939 2 Sheets-Sheet 1

Fig. 1.

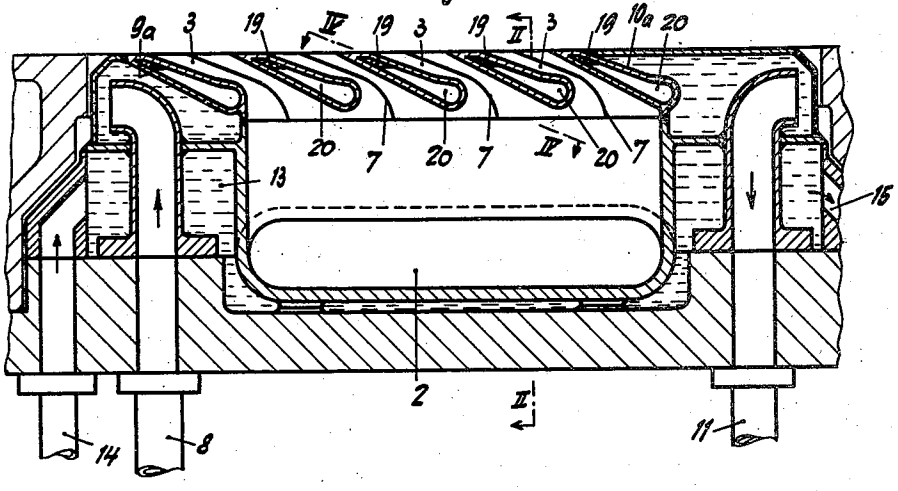


Fig. 2

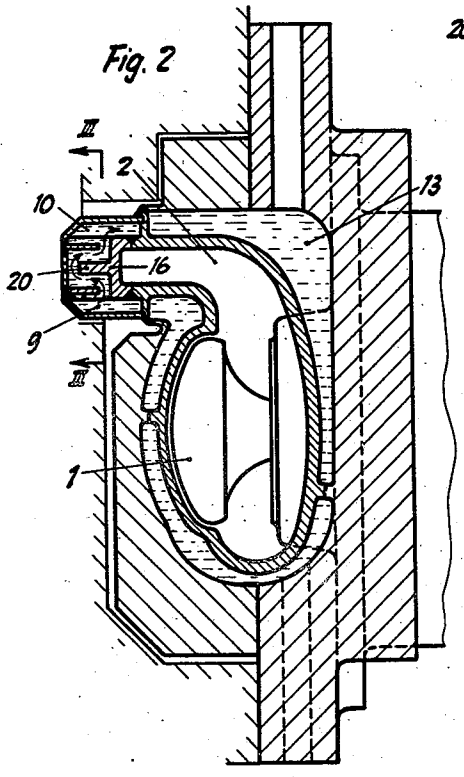


Fig. 3

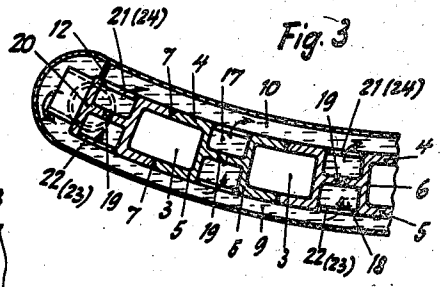
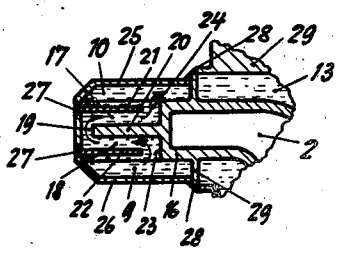


Fig. 4



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Filed March 17, 1939 2 Sheets-Sheet 2

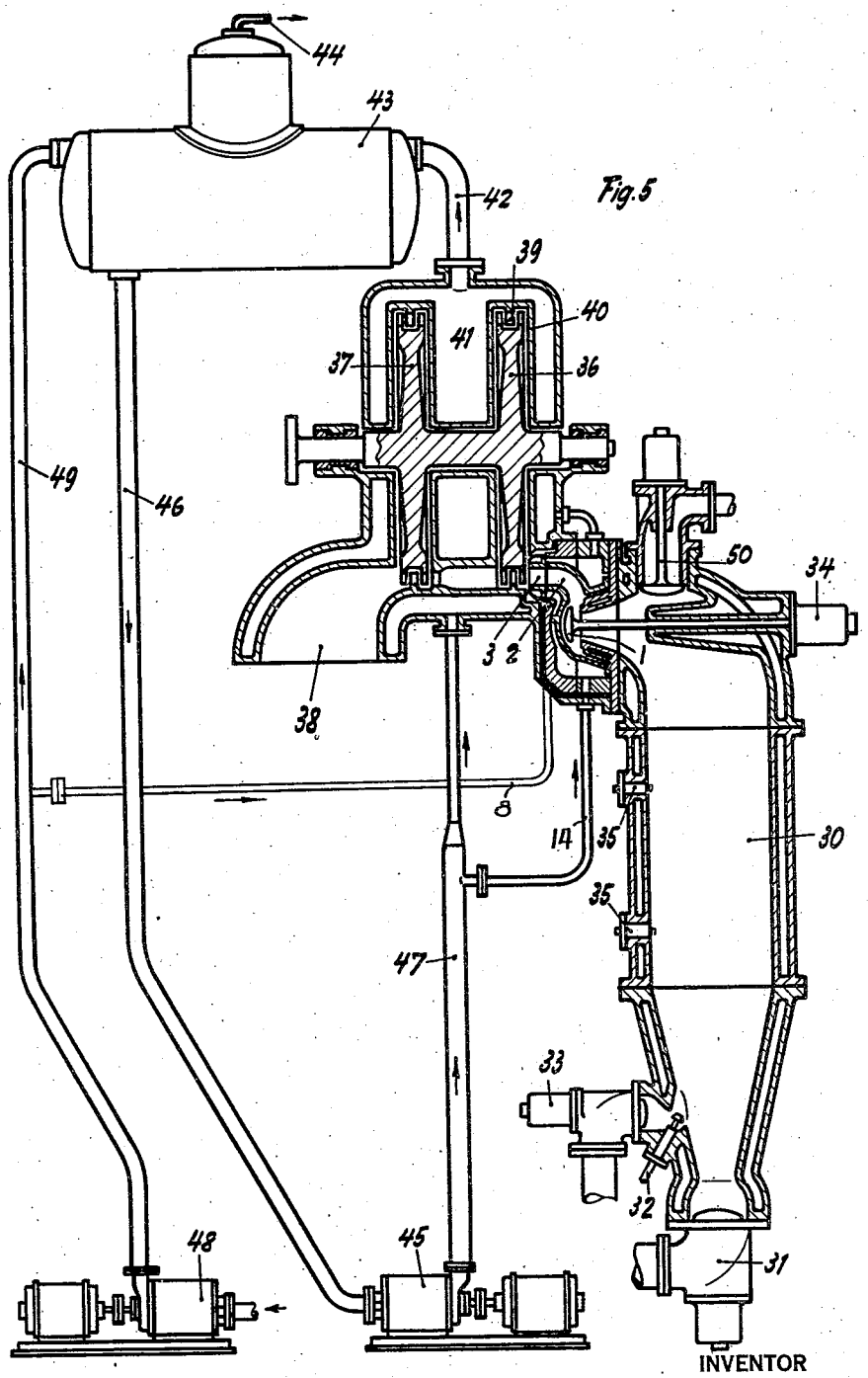

Fig. 5

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UNITED STATES PATENT OFFICE

2,221,816

COOLED NOZZLE SEGMENT FOR COMBUSTION TURBINES

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Application March 17, 1939, Serial No. 262,427
In Germany March 19, 1938

10 Claims. (Cl. 60—41)

The present invention relates to an improved construction of cooled nozzles and nozzle segments for combustion turbines, and particularly of nozzle segments which consist of cooled individual parts united to the finished nozzle assembly, and in which the side pieces which between them receive the cooled nozzle sections are likewise cooled.

The impingement of the turbine wheel blading in combustion turbines occurs in similar fashion to steam turbines, by way of nozzle groups. These nozzle groups consist of individual nozzles which in cross-section are throughout of more or less rectangular shape, the individual nozzles being separated from each other by intermediate walls. In explosion turbines there generally occur super-critical velocities in these nozzles, so that the nozzles must be constructed with a widened portion corresponding to the shape suggested by Laval. This widening brings with it the result that the intermediate walls between the individual nozzles terminate at the gas discharge end in a more or less sharp tip. This construction of intermediate walls leads to serious difficulties because the walls are contacted upon both sides by combustion gases of rather high temperature and of super-critical velocity. As the heat transmission values increase greatly and in part suddenly with increase of the gas velocities, particularly in the super-critical region, destruction of the intermediate walls by incandescence and burning can be prevented only by strongly cooling such walls. The intermediate walls must, therefore, be built hollow, as hollow nozzle leaves or sections and be traversed by a cooling agent. However, the circumstances that the highest rate of heat transmission occurs at the tips of the nozzles and that at such tips the space available for cooling agent is smallest, make it extremely difficult to provide adequate cooling of the nozzle tips, which requires preventing of vaporization with resultant formation of insulating vapor pockets, and attendant deposition of scale.

It is the general object of the invention to provide a nozzle and nozzle segment construction wherein adequate cooling can be secured in a simple and reliable fashion.

According to the present invention, the nozzles are composed of sections provided with integral lateral extensions which are united, as by welding, into a unitary construction. This is advantageously effected by joining together a plurality of nozzle sections of H-cross-section by way of lateral flanges produced, for example, by milling, the joints or seams running longitudinally of the nozzle median lines. The central web of the H-structure is made to act as a baffle and extends for approximately the length of the nozzle and divides the cooling space between each two nozzles into an upper and a lower compartment. The cooling liquid is introduced at the receiving end of the nozzles and is compelled to flow, parallel to the flow of the gases in the nozzles, along the length of the nozzles for a portion of the height of the latter to the tips of the nozzles, where it flows through bores in the webs into the other cooling compartment and then travels in reverse direction toward the receiving end of the nozzles. A body of water or other cooling liquid of large cross-section thus sweeps the sides of the nozzles, the rate of flow at the nozzle tips being sufficiently large to prevent vaporization. The resistance to flow of the cooling agent is reduced and danger of scale formation with resulting clogging are eliminated. Further features of the invention will appear from the more detailed description hereinbelow.

The drawing shows by way of example a preferred embodiment of the invention. In said drawings:

Fig. 1 represents a section through the nozzle group of an explosion turbine in the circumferential direction and developed in the plane of the drawing;

Fig. 2 shows a radial section through the nozzle arrangement along the line II—II of Fig. 1, the plane of the section containing the turbine axis;

Fig. 3 illustrates a vertical cross-section through the nozzle arrangement according to the lines III—III of Fig. 2;

Fig. 4 shows a vertical, longitudinal section through a nozzle section according to the line IV—IV of Fig. 1, while

Fig. 5 is a schematic view, partly in section, of an explosion turbine plant having my invention incorporated therein.

The numeral 1 designates the nozzle valve of an explosion chamber, upon whose opening the high pressure and highly heated combustion gases generated in the explosion chamber enter by way of the nozzle antechamber 2 into the nozzle channels 3 which are constructed in the manner of a Laval nozzle, and in which the combustion gases are expanded and likewise accelerated. The nozzles 3 are defined by the flanges 4 and 5 of the nozzle sections and also by their lateral surfaces 6. The flanges 4, 5 may advantageously be provided by suitable milling of the nozzle section castings. Each two neighboring flanges 4 and 5 are united with each other by the welding seams

7, such seams, as can be seen from Fig. 1, coinciding approximately with the median lines of the nozzles 3.

The nozzle sections themselves are constructed hollow and are cooled with water which enters through a conduit 8 into a cooling space 9 (see Figs. 2–4) provided below the nozzles, flows through the cooling spaces of each nozzle section, as will be explained below, and reaches the cooling chamber 10 arranged above the nozzles, being withdrawn from the chamber 10 by way of conduit 11. The chambers 9 and 10 are collecting spaces for the inflowing and outflowing cooling liquid and are common to all the nozzles. As shown in Fig. 1, the inlet and outlet points 8 and 11 for the cooling agent are provided at the lateral ends of the impingement arc containing the nozzle group, the chambers 9 and 10 embracing respectively the end members 9a and 10a and effecting cooling thereof. The chambers 9 and 10 are separated from each other by the intermediate wall 12 (see Fig. 3) in order to compel the flow of the cooling agent through the cooling spaces of the nozzle sections, a similar separating wall being provided at the other end of the nozzle assembly.

The cooling space 13 of the nozzle antechamber is fed with hot water or other liquid under pressure through conduit 14 (Fig. 1) independently of the cooling of the nozzle sections, which is preferably accomplished with a cold medium, such as cold water. The withdrawal of the hot cooling agent for the antechamber occurs at 15.

As can be seen with particular clarity from Figs. 3 and 4, the nozzle sections are constructed of approximately H-cross-section, the sides 6 of the nozzles forming the legs of the H, while the horizontal web 20 acts as an intermediate wall or baffle in the interior of each section dividing each nozzle section 16 into two longitudinal spaces or compartments 17 and 18. The intermediate wall or baffle 20 has a through passage 19 at the tip of the section whose function will be explained below. The intermediate wall 20 lies approximately at the middle of the height of the nozzle section. It thus supports at the same time the lateral walls 6 of the nozzle section against each other, as can be seen especially from Fig. 3, so that they cannot be altered in their shape under the influence of the combustion gas pressure.

The longitudinal spaces 17 and 18 of each nozzle section, which are advantageously produced by milling, are covered from above and below by plates 21 and 22, respectively, welded or soldered into the nozzle section body. These cover plates act as baffles in cooperation with the baffle 20 and are provided with openings for the entry and outflow of the cooling water at 23 and 24 (Fig. 4). In Fig. 3, the cover plates 21 and 22 can be seen in elevation because the section is taken at the point at which the openings or cutouts 23 and 24 lie.

The inflow and outflow collecting spaces 9 and 10 for the cooling water are constructed of thin and elastic walls 25 and 26. They are welded on the one hand, at 27, with the tips of the nozzle sections, and on the other hand, at 28, with the carrier body 29 for the nozzle group. In this way the result is attained that the nozzle group can expand freely in every direction upon becoming heated, so that cracking due to expansion is entirely avoided.

The mode of operation of the described apparatus is as follows:

The cold cooling water or other agent, charged by conduit 8, fills first of all the inflow collecting space 9 and passes from the latter, by way of the opening 23 in the bottom cover plate or baffle 22, into the longitudinal space 18 of each nozzle section. The nozzle section is thus traversed in the direction of flow of the combusion gases from the rear of the section to the tip of the section by a cooling agent stream which extends for approximately half of the nozzle section height. At 19 there occurs inside of the nozzle section tip the reversal of the cooling agent stream, whereupon longitudinal space 10 is traversed counter-current to the direction of flow of the combustion gases from the tip of the section to the rear thereof by a cooling stream which again occupies approximately half of the nozzle section height. The cooling agent streams discharging at 24 unite in the discharge space 10 and are led off by the conduit 11.

In this way not only is every nozzle section effectively traversed by cooling agent along its whole length and height, but the whole quantity of cooling agent is compelled to flow past the inner walls of the nozzle tips and thus effectively cools such tips. The flow cross-sections which are available to the cooling agent in this connection, are comparatively large, so that sufficient quantities of cooling agent can be conducted through the cooling spaces, whereby not only is an adequate heat withdrawal afforded without any danger of steam formation but also the tendency toward clogging is eliminated.

An explosion turbine plant embodying the nozzle construction described hereinabove is illustrated schematically in Fig. 5. One of a plurality of explosion chambers 30, working out of phase, is illustrated in such figure, the chamber being provided with a scavenging air inlet valve 31, a fuel inlet member 32 and an additional valve 33 for air of higher pressure for effecting atomization of a liquid fuel. The outlet valve 1 controlled, for example, by a hydraulically operated piston moving within a chamber 34, effects discharge of the high temperature, high pressure gases generated by the explosion, brought about by the spark plugs 35, of an ignitable mixture of air and fuel in the chamber 30, the gases being directed by the nozzles 3 to the first or impulse wheel 36. From the latter they flow, preferably after intermediate equalization of their pressure, to a continuously impinged rotor 37, the exhausted gases being discharged at 38. The guide or stator blades 39 are in heat-conducting connection with the wall 40 forming part of a cooling jacket 41 which is connected by pipe 42 with an evaporator or steam separator 43. The separated steam of high pressure is withdrawn by the conduit 44 and conducted to a high place of use, while the hot water is sucked by the pump 45 from the evaporator through the conduit 46 and recharged into the cooling space 41 by way of conduit 47. The water supply is replenished by a feed water pump 48 which is connected with the interior of the evaporator 43 by the pipe 49. The operation of the explosion chamber and its associated inlet and outlet mechanisms, the latter including also an auxiliary outlet valve 50 for the combustion gases of low pressure head, and also of its timing mechanism (not shown) is known and need not, therefore, be described herein.

I claim:

1. Cooled nozzle segment for combustion turbines comprising a plurality of individual sections assembled to the finished nozzle segment

and including lateral end pieces which receive between them the nozzle sections, and means providing cooling chambers for said nozzle sections and end pieces, said individual sections having lateral flanges integral therewith and being united by way of these flanges into a unitary nozzle segment structure.

2. Nozzle segment according to claim 1, characterized by the fact that the nozzle sections are of H-shape in cross section and are united with each other through said flanges by seams running along the nozzle median lines.

3. A nozzle segment comprising a plurality of united sections, at least a number of such sections each comprising a member of H-cross-section having lateral flanges at both sides thereof adapted to be united with similar lateral flanges of an adjoining member to provide a nozzle passageway for a driving medium charged by the nozzles, a casing about the nozzle segment and providing separate collecting spaces for inflowing and outflowing cooling medium, the approximately central web of the H-cross-section forming a separating wall between the two cooling spaces except at the outer tip of the nozzle whereat said wall is provided with an aperture connecting the two spaces, and inlets and outlets for the cooling agent at a point remote from the tip of the nozzle, whereby the entering cooling medium is compelled to flow along the length of the nozzle for a portion of the height thereof, is reversed at the tip of the nozzle, and then flows in the opposite direction along the rest of the height of the nozzle.

4. A nozzle segment comprising a plurality of nozzles adapted to charge a hot driving medium, a common jacket for said nozzles, imperforate plates dividing the jacket space into separate spaces for the inflowing and outflowing cooling agent; a baffle arrangement between each pair of nozzles, said baffle arrangement being provided with an aperture connecting the collecting spaces and so arranged as to compel the cooling agent to flow along the nozzles in one direction along a portion of the height of the nozzles, to be reversed at the end of the nozzles and flow in the opposite direction along the length of the nozzles along the remainder of the height thereof.

5. A nozzle segment as set forth in claim 4, wherein the baffle arrangement comprises three superposed plates, the top and bottom plate being provided with apertures at one pair of corresponding ends, while the middle plate is provided with a connecting aperture at its end opposite such ends.

6. A nozzle segment as set forth in claim 4, wherein the nozzles are composed of united sections of approximately H-cross-sections, the middle baffle constituting the web of such H-structure and the top and bottom baffles comprising plates connected to the H-structures at the top and bottom thereof.

7. A nozzle segment as set forth in claim 4, wherein the nozzles are composed of united sections of approximately H-cross-sections, the middle baffle constituting the web of such H-structure and the top and bottom baffles comprising plates connected to the H-structures at the top and bottom thereof, said H-structure including integral lateral flanges forming the body of the nozzles.

8. A jacketed nozzle comprising a tubular passageway for a hot driving medium charged by the nozzle, a jacket about the nozzle, and baffles at the sides of the nozzle and within the jacket and provided with openings for the cooling agent so disposed that the latter is compelled to flow along the length of the nozzle for a portion of the height thereof to an end of the nozzle wherein it is reversed and compelled to flow in the opposite direction along the rest of the height of the nozzle, and conduits connected to the inlet and outlet sides of the jacket for charging a cooling agent thereto and withdrawing the same therefrom.

9. A nozzle according to claim 8, wherein the baffles comprise three superposed plates, the middle plate having a through opening at one end thereof and the top and bottom plates having similar openings at their ends remote from said end.

10. A nozzle according to claim 8, wherein the baffles comprise three superposed plates, the middle plate having a through opening at the discharge tip of the nozzle, and the top and bottom plates having similar openings at the opposite end of the nozzle.

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