No. 867,611. PATENTED OCT. 8, 1907.

R. SCHULZ.

STEAM TURBINE.

APPLICATION FILED MAR. 6, 1906.

4 SHEETS—SHEET 1.

Fig. 1.

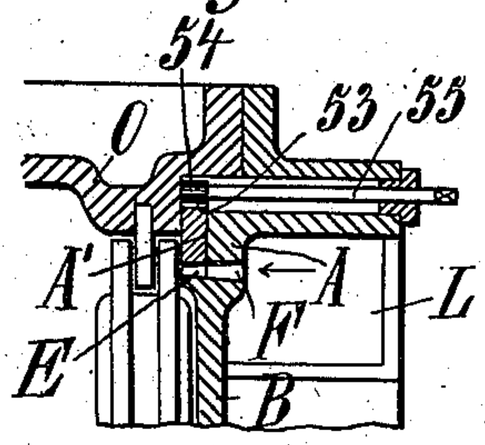


Fig. 2.

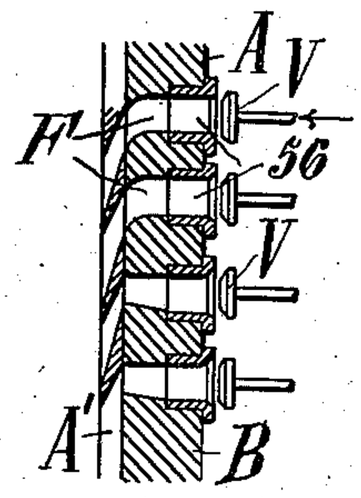


Fig. 3.

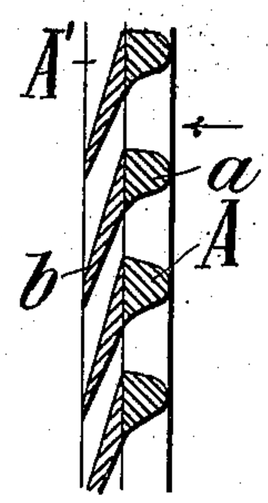


Fig. 7.

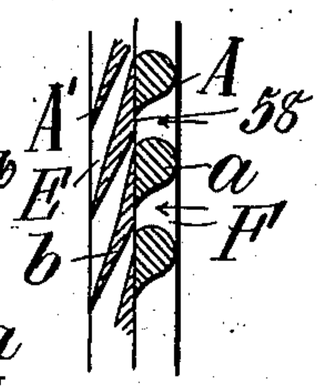


Fig. 1a

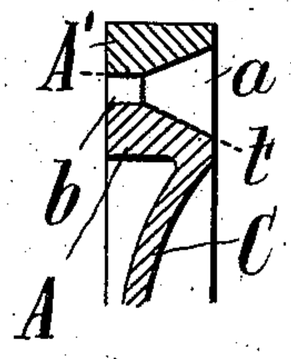


Fig. 1b.

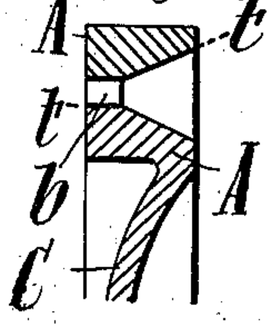


Fig. 2a

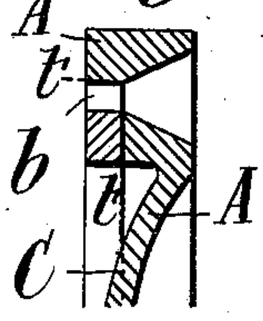


Fig. 2b

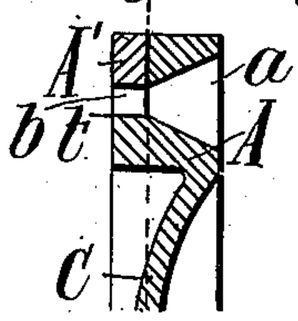


Fig. 3a

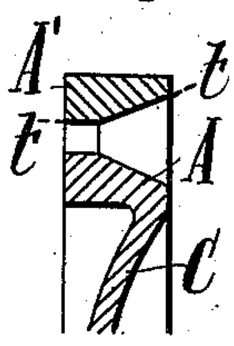


Fig. 3b.

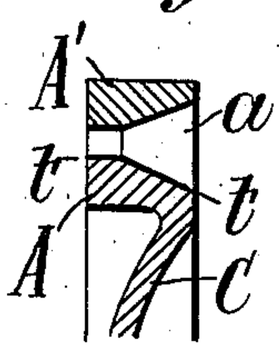


Fig. 4a

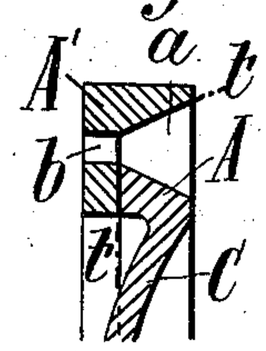


Fig. 4b

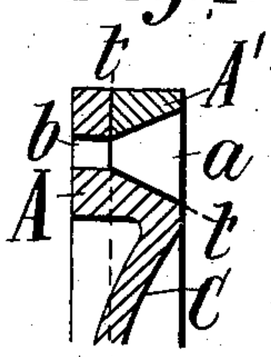


Fig. 8.

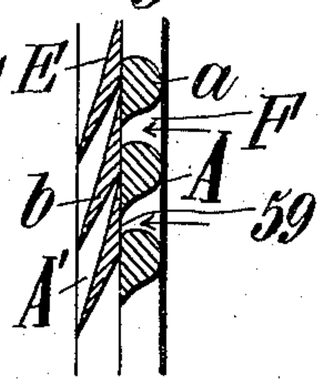


Fig. 11a

Fig. 11b

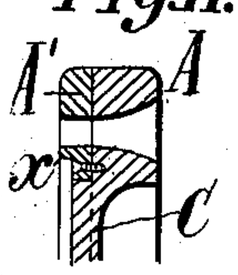
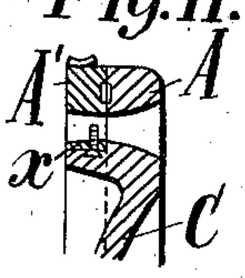


Fig. 11c.



Witnesses.
H. L. Amer.
P. Sommers

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4 SHEETS—SHEET 2.

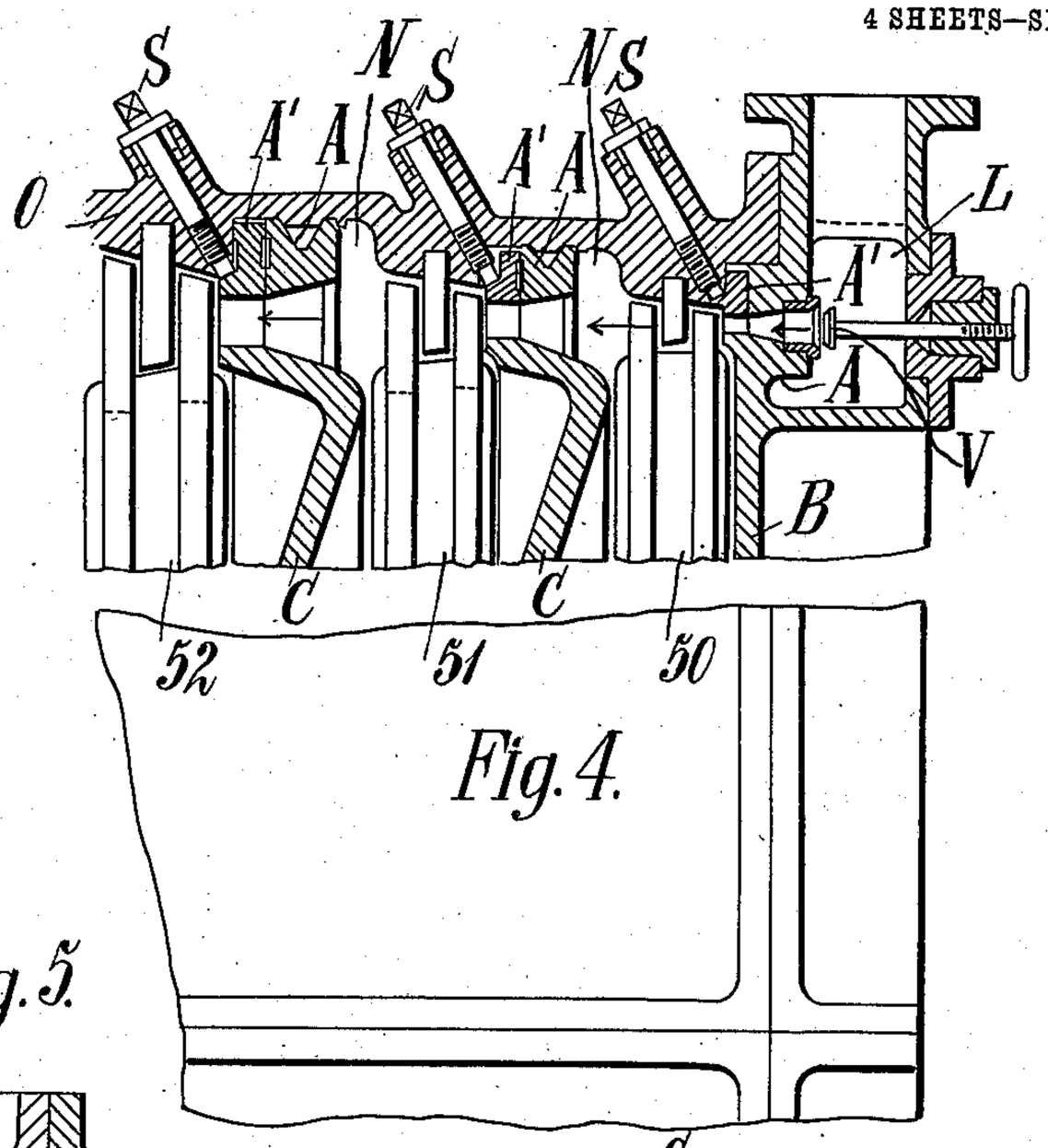
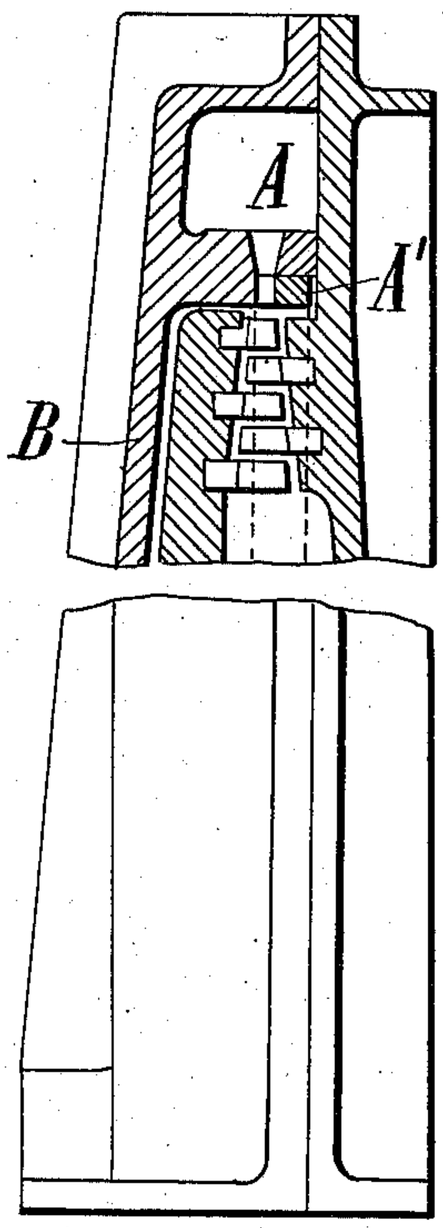


Fig. 4.

Fig. 5.



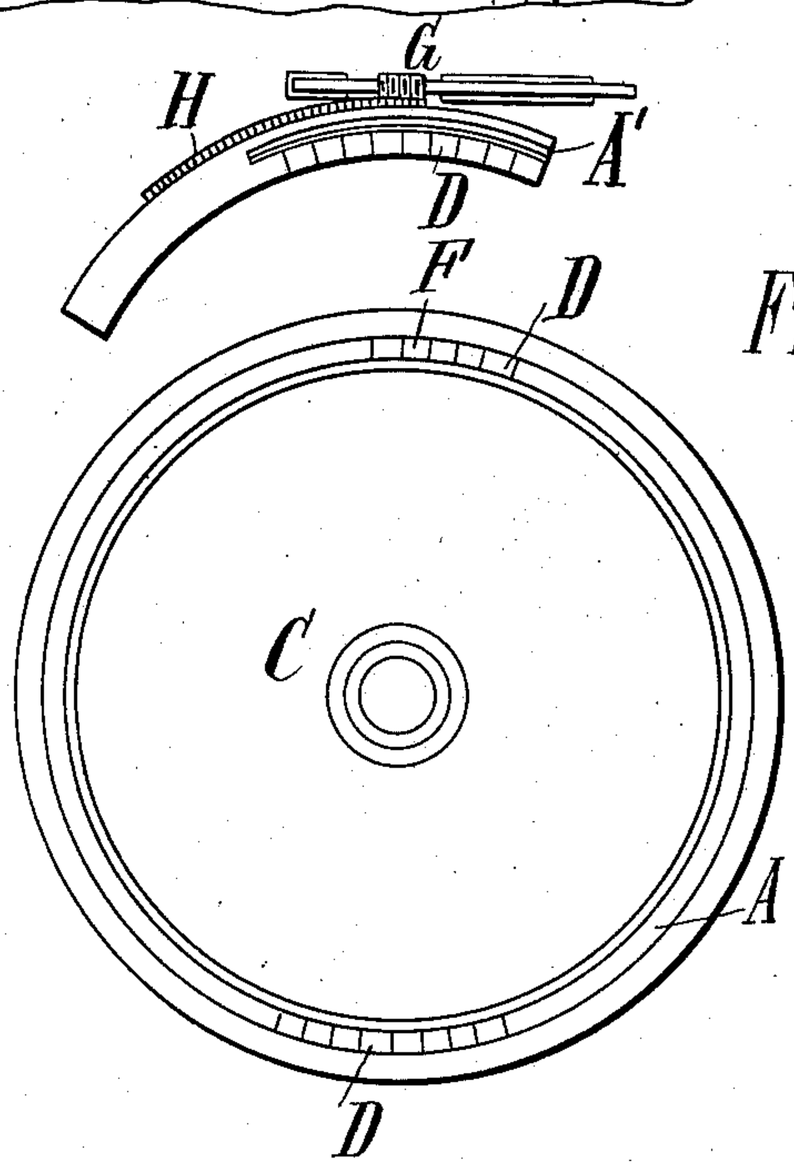


Fig. 6.

Witnesses.
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4 SHEETS—SHEET 3.

Fig.9.

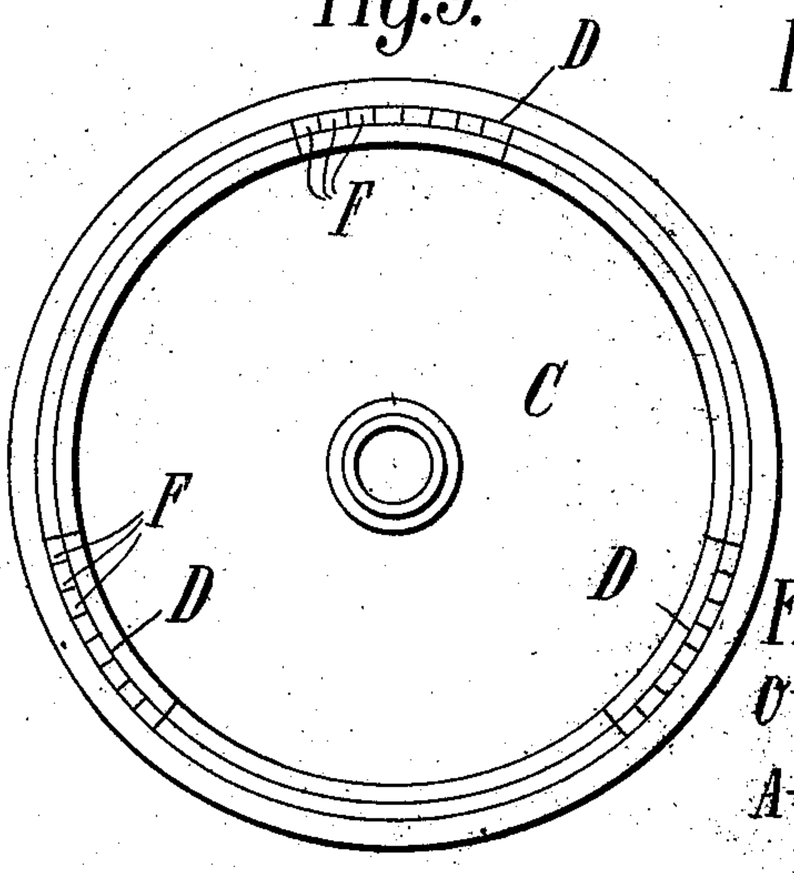


Fig.11.

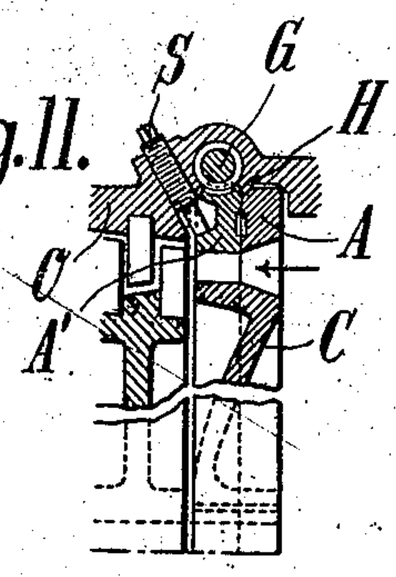


Fig.12.

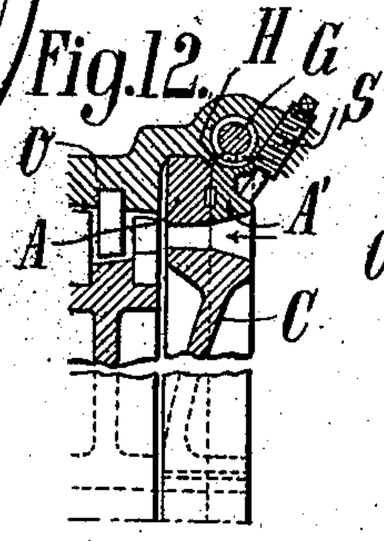


Fig.13.

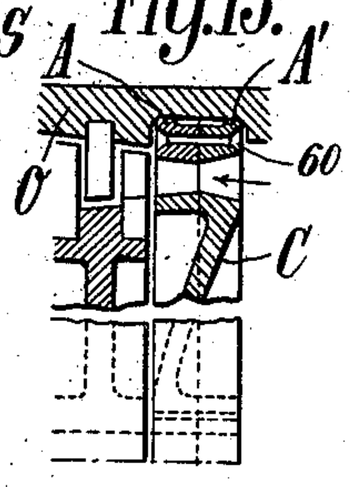


Fig.10.

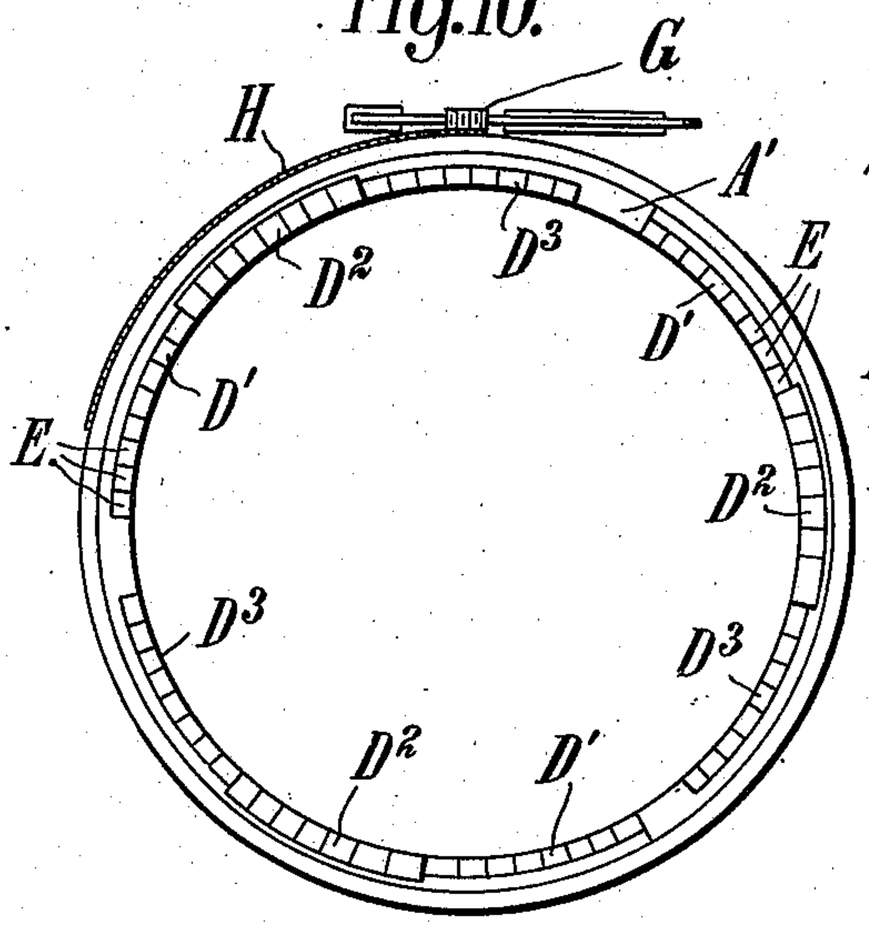


Fig.14.

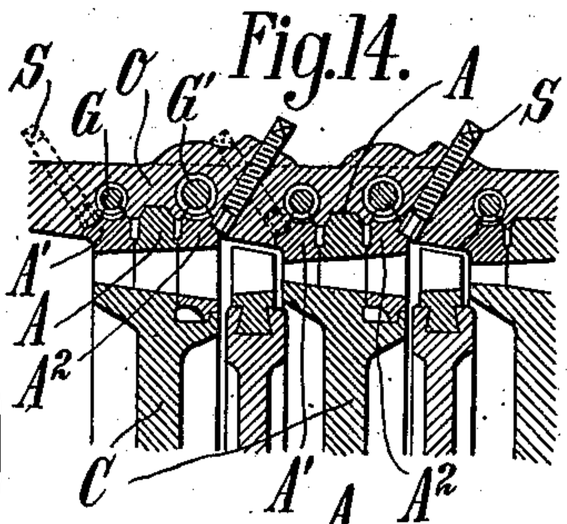
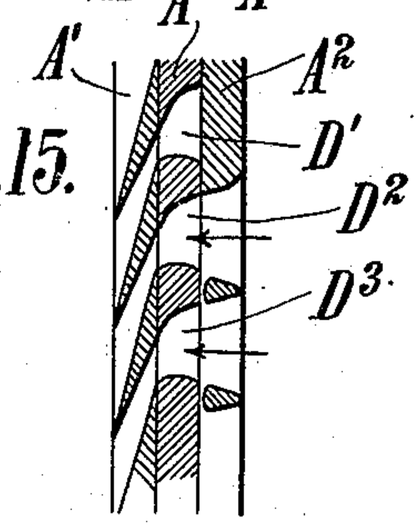


Fig.15.



Witnesses.
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by Henry Orth & Co atty.

No. 867,611. PATENTED OCT. 8, 1907.

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STEAM TURBINE.

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4 SHEETS—SHEET 4.

Fig.17.

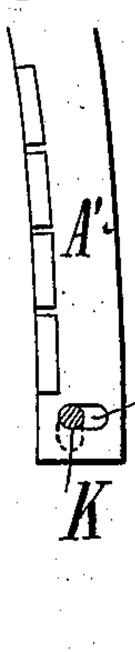


Fig.16.

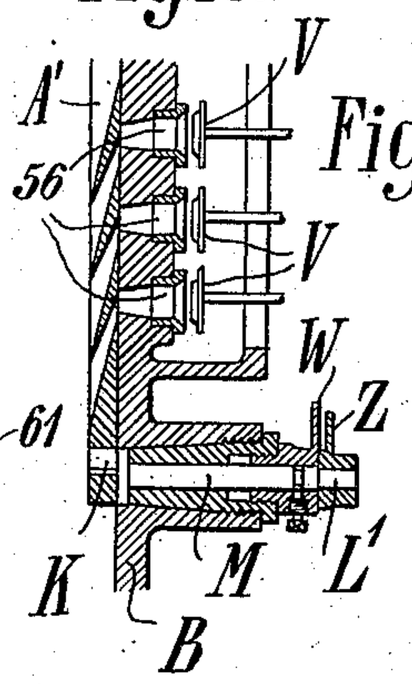


Fig.18.

Fig.19.

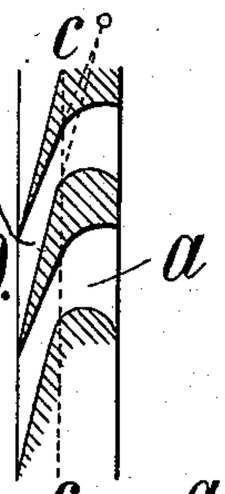


Fig.17a.

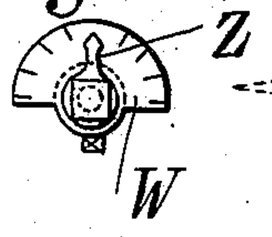


Fig.20.

Fig.21.

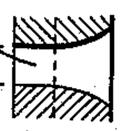


Fig.22.

Fig.23.

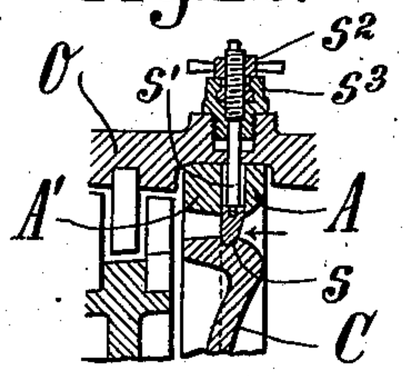


Fig.24.

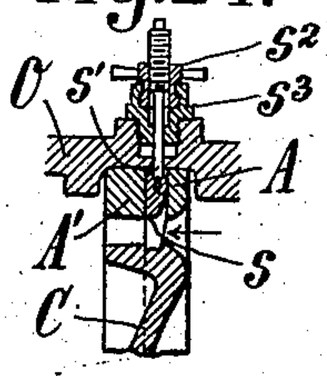


Fig.26.

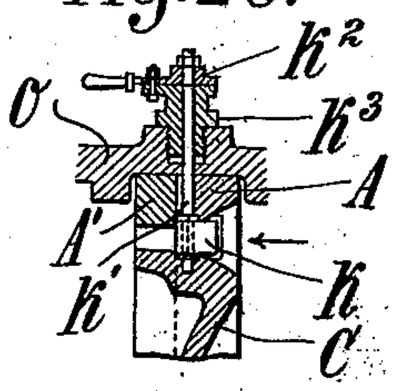


Fig.25.

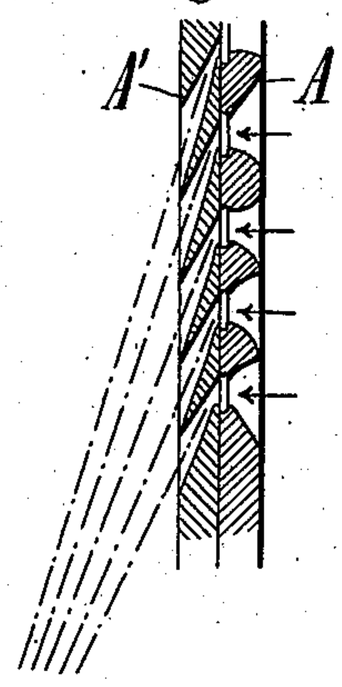


Fig.27.

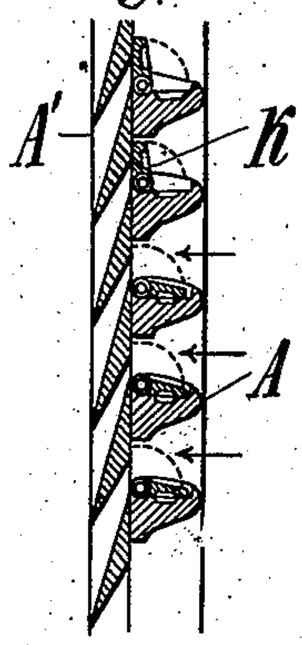
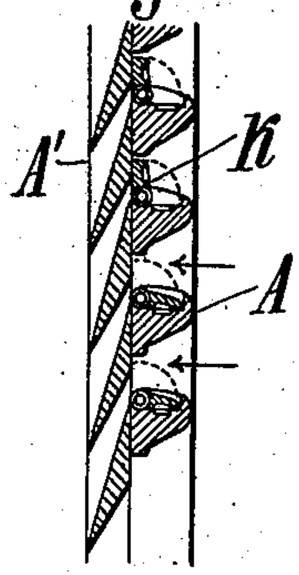


Fig.28.



Witnesses.
H. L. Amer.
B. Sommers

Inventor.
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by Henry Orth Jr atty.

UNITED STATES PATENT OFFICE.

RICHARD SCHULZ, OF BERLIN, GERMANY.

STEAM-TURBINE.

No. 867,611. Specification of Letters Patent. Patented Oct. 8, 1907.

Application filed March 6, 1906. Serial No. 304,521.

To all whom it may concern:

Be it known that I, RICHARD SCHULZ, a subject of the King of Prussia, residing at Berlin, Flensburgerstrasse 2, Germany, have invented certain new and useful Improvements in the Nozzle-Containing Element of Steam-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.

This invention relates to impact steam turbines having one or more pressure stages and more particularly to the construction of guide apparatus *i. e.* the element containing the nozzles whether the turbine be of the axial or radial type and the invention has for its object to construct the nozzle containing element of a plurality of parts as hereinafter described, whereby these nozzles can be more readily shaped and constructed; the nozzles be given a different form of exit or entrance or both without reconstructing the turbine; the steam be directed and controlled or entirely cut off and which at the same time will permit the use of a standard part for several forms of nozzles with or without various forms for controlling the passage of steam through them as will hereinafter more fully appear.

Referring to the drawings, in which like parts are similarly designated.—Figure 1 is a nozzle or steam channel containing element for the first stage of pressure in an axial impulse turbine in longitudinal section of the latter; Figs. 1ª to 4ª and 1ᵇ to 4ᵇ show various forms of joint between the parts of a two-part element containing the steam passages or nozzles. Figs. 2 and 3, are substantially horizontal sections through a two-part nozzle containing element for the first and second pressure stage. Fig. 4 is a view partly in elevation and partly in vertical longitudinal section showing the nozzle for several pressure stages in an axial turbine. Fig. 5 is a like view through a radial impact turbine. Fig. 6 shows the fixed and a movable part of the nozzle containing element of an impact turbine steam being supplied at two points of the circumference of the wheel. Figs. 7 and 8 show two forms in horizontal section of the fixed and movable part of the nozzle, containing element. Fig. 9 is an elevation of the fixed part of a nozzle containing element. Fig. 10 is a like view of the movable supplementary part of said element. Fig. 11 is a view, partly in section and partly in elevation, showing means for holding the supplementary part or ring of the nozzle containing element in operative position. Figs. 11ª—11ᶜ show in section through the channels some ways of arranging an auxiliary ring. Figs. 12 and 13 are like views showing modifications. Figs. 14 and 15 show in longitudinal and in a substantially horizontal section respectively the three-part nozzle containing element. Figs. 16, 17 and 17ª are modifications illustrating means for moving the part containing the exit end of the nozzles and independent valves for controlling the inlet of steam. Figs. 18 to 22 are sectional views of various forms of steam channels or nozzles. Figs. 23 to 25 are sectional views showing independent slide valves controlling the steam channels or nozzles. Figs. 26 to 28 are like views showing another form of valve.

In the drawings O indicates the casing of the turbine, B a removable end cover and C the partitions dividing the casing O into chambers N in which the turbine wheels rotate, the partitions in an axial impact turbine providing the means for causing the steam to expand in stages and having a crown containing the nozzles.

Steam is supplied from a steam inlet chamber L, Figs. 4 and 5 formed on the end cover B at the inlet side of the turbine from which the steam passes through nozzles or steam channels into the first chamber N containing the turbine wheel 50 on which it acts by impact, the steam being expanded in the nozzles. These nozzles may be uniformly distributed around the circumference or they may be arranged in sets symmetrically in a circle to cause the steam to act on the blades of the wheel and rotate the latter.

Now in each of the partitions C and on the end cover B near the peripheries thereof are situated the nozzles forming the nozzle crown and it is the construction of this nozzle crown that forms an independent part of this invention. It will thus be seen that besides many advantages of operation of such a construction, the manufacture of the nozzle crowns is very greatly facilitated since the steam channels can be cut by a milling tool for instance.

In all the examples the fixed rim mounted on the cover B or the partition C is indicated by A and the supplementary part which appears separated by a fitting joint (see joint lines *t t* in Figs. 1ª—4ᵇ) by A′.

Where the entrance portion *a* of the nozzle is made on one part and the exit portion made on another, one of the parts can be made movable with respect to the other, see Figs. 6 to 15, so that they act valve-like, one with respect to the other to increase and diminish the opening in the nozzle. Also the supplementary removable part A′ may be made of other metal than the fixed part A. When it is desirable, one of the parts may be removed in order to substitute another having a different form or length of entrance or exit or both may be changed into a three-part nozzle crown as illustrated in Figs. 14 and 15.

The movable part of the crown can be so made as to partially or completely cut off the steam passage when moved with respect to the stationary fixed part,

as shown in Figs. 7 and 8, where the supplementary part A′ consisting of a ring or ring piece is movable relatively to the fixed part or rim A. Thus it will be seen that the fall of the steam pressure, the speed of rotation, power, etc. of such a machine can be readily controlled, especially when the steam is supplied by one or more groups of nozzles arranged near the periphery of the turbine wheels.

One part of the crown in every case such as the part A forms a part of the fixed stationary member B or C, the other part or parts A′ A² is or are fitted thereto, whether the nozzle be a two or three-part nozzle and whether this fitted part be fixed or movable.

In making the nozzle crown in two parts there may be various forms of surfaces between the parts of the nozzle crown, the line of juncture between the parts A and A′ thereof being indicated by the heavy line *t*—*t*, Figs. 1ª, 1ᵇ, 2ª, 2ᵇ, 3ª, 3ᵇ, 4ª and 4ᵇ.

In Figs. 1ª and 1ᵇ the line of separation *t*—*t* or the division between the parts A and A′ of the nozzle crown is both longitudinally of and transversely to the nozzles. The two opposite nozzle walls nearest to or farthest away from the turbine shaft are designated the "inner" and the "outer" wall respectively, the other two opposite walls being the "side walls." Each of the parts A and A′ carries a portion of the side walls of the nozzles, so that the side walls can readily be given any desired shape by means of a milling tool, the side wall portions *a* and *b* between adjacent nozzles standing comb-like from the part with which they are integral.

According to the drawings the entrance portion *a* of the steam channels is assumed to be longer than the exit portions *b* (axially measured).

In Figs. 2ª and 2ᵇ only the exit end of the nozzle is so formed that a portion *b* of the side walls between the adjacent nozzles form comb-like teeth with the supplementary part A′ with which they are integral.

In Fig. 3ª the whole of the side walls are formed integral with the fixed rim A and in Fig. 3ᵇ with the part A′, while in Fig. 4ª the entrance portions *a* only form tooth-like projections from the fixed rim A and in Fig. 4ᵇ they are formed on the supplementary part A′.

In the example of construction shown in Fig. 1, as in other examples, the supplementary ring A′ contains steam channels E which form together with the channels F of the fixed rim A mounted on the casing cover B the steam channels (nozzles). The ring A′ containing the exit portions of the channels is provided with a rack or equivalent device 53 operated by a pinion or the like 54 moved by a spindle 55, the construction of the nozzles being similar to that shown in Fig. 2ᵇ where A′ slides on A.

In Fig. 2, the nozzles for the steam of the first stage of expansion are shown each nozzle being provided with a valve seat or nipple 56, screwed or otherwise fitted into the entrance portion F of the nozzle and a valve V seating on or in the seat, whereby any one of these nozzles can be cut off independently of the others and still a simultaneous control of the remaining nozzles be maintained by means of the slidable supplementary part A′.

In Fig. 3 a like arrangement, omitting the independent valves V, for the nozzles of the subsequent pressure stage is shown.

The structures of Figs. 2 and 3 are shown embodied in the turbine, Fig. 4, where A is the fixed stationary part of the nozzle crown and A′ is the removable part that may or may not be movable. The removable supplementary part A′ of the nozzle crown is shown as held in place by set screws S, Fig. 4, illustrates the arrangement corresponding to Fig. 1 in a radial flow steam turbine. Here the supplementary ring A′ is inclosed by the stationary rim mounted on the casing cover B.

In Fig. 6 I have shown an elevation of one of the intermediate partitions C which separate the chambers 50, 51 and 52 from one another, said partition having two groups D of channels F at diametrically opposite places of the crown A, the latter being fixed and stationary. For each group is arranged a supplementary ring segment A′ provided with a worm rack H engaged by a worm G mounted in the casing O.

Each ring segment A′ has for about half its length a group D′ of channels E corresponding to the channels F in the fixed rim A. By turning the ring segment A′ the channels F in the rim A may be covered by the cut-off face of the webs separating the channels of the ring segment A′ in a larger or smaller number, or all if desired. The two ring pieces A′ may also be connected with one another in order to only render necessary one device for turning them.

As shown in the example in Fig. 7 with a suitable form of the steam channels a regulation may also be obtained, if the cut-off faces of the webs 58 between the channels E of the one group in the segment A′ are allowed to cover more or less the channels of the other group in the fixed rim A. The proportion of the inlet and outlet apertures may here easily be altered and therewith the expansion of the steam in the nozzles. This is of great value, when the turbines work with only small power and when it is desired to fully utilize the boiler pressure. If on the other hand for a certain time a higher boiler pressure is available for certain work the given drop of pressure may be fully utilized.

If it be desired to be able to completely close the steam channels or nozzles, as shown in Fig. 8 the webs 59 separating the channels E of the ring segment A′ must correspondingly be made broader.

In Fig. 9 I have shown a partition C provided in its crown or fixed rim A with three groups D of entrance channels F and in Fig. 10 a complete ring A′ that cooperates therewith and contains the exit portions E of the steam channels arranged in corresponding groups and each group composed of three sets D′, D² and D³, each set of a group having a different form of exit channels. These channels may be of different form and dimension in such a way that according as one or other of the sets D′ D² or D³ are brought into action, an alteration of the number of revolutions, or the drop of steam pressure or the power exerted is rendered possible.

In Fig. 11 the part A′ which is separated from A in the manner shown by the junction line *t t* in Fig. 2ᵇ and in Fig. 12, the part A′ is separated from A in the manner shown by the junction line *t t* in Fig. 4ᵇ. Each of the parts A′ in these two figures is provided with a worm rack H operated by a worm G and is held firmly on its seat at the fixed rim A by set screws S after it has been set by the worm G.

In Figs. 11ª, 11ᵇ and 11ᶜ I have shown an auxiliary

ring x which is preferably constructed of better material and forms the wearing surface of the movable part A′ containing the exit portion of the steam channels.

In Fig. 13, the two parts A and A′ are shown held together by means of rivets 60. In this case as also in Figs. 3ª and 3ᵇ when the division between the parts A A′ is only longitudinally of the nozzles a regulation of the steam is not possible, but the sections of the nozzle crown can be made in segmental pieces, thereby facilitating their manufacture.

With a suitable radial division of the removable parts of the crown these can readily be removed after first taking off the upper half of the turbine case and can be replaced by parts having like or differently shaped steam passages as desired without removing the turbine wheels 50, 51, etc., Fig. 4.

In Figs. 14 and 15, there are shown two supplementary nozzle crown parts A′ and A², the one A′ at the rear or exit side of the stationary partition C and the other A² at the entrance side thereof, both being adjustable by worms G and G′ and held in place by setscrews S. In Fig. 15 the ring or partial ring A² has such position as to close the nozzle D′ while the nozzles D² D³ are open. When a lesser number of nozzles are to be used by means of the ring A² they may be cut off in succession from the set, thereby preventing the increased steam friction, loss due to eddies and the like.

It may be stated, that two parts A′ A² serving as slides are preferable for one or other stage of pressure of an impact steam turbine inasmuch as the turning of both does not always merely cause a diminution or enlargement of the steam passage, but also a displacement of the steam course in a tangential direction by the steam taking its shortest course from the nozzles of a pressure stage.

In Figs. 16, 17 and 17ª I have shown a supplementary ring piece A′ for the nozzles supplying the first turbine wheel in an axial turbine, this segment being provided with a slot 61 in which takes the crank pin K on the end of a spindle M whose squared outer end L′ carries an indicator hand Z movable with relation to a fixed scale W, whereby the degree of closure or the degree of movement of the exit portion of the nozzles in the ring piece A′ can be indicated and by means of which all the nozzles can be quickly adjusted. Valves V similar to those in Fig. 2 are also provided for the entrance portion of the nozzles.

As the ring piece A′ only requires to describe a short course to effect the regulation this may preferably take place by means of a governor which on the turbine running away rapidly causes the ring piece A′ to close.

In Figs. 19 and 20 showing sections respectively in a tangential and radial direction through a nozzle the exit portions b of the side walls diverge in the direction of movement of the steam, while the inner and outer wall of the nozzle converge (Fig. 20), in Fig. 21 the latter walls are parallel and in Fig. 22 they also diverge. In such an arrangement the steam jets from several adjacent nozzles to which varying forms may be given may combine into a common steam jet. At the exit portion b (Figs. 19 and 20) of the nozzles the steam jet becomes in dial direction (Fig. 20) narrower in tangential direc on (Fig. 19) broader, so the steam jets encounter one another and obtain still denser condition.

The side walls of the nozzles do not require to be uniform at the exit portion, but may, for instance have a parabolic form as shown in Fig. 18.

In Figs. 23, 24 and 25 I have shown slide valves s seated in recesses on the back of part A and that are moved radially by the hand wheel nuts s^2 acting on the threaded stems s' of the valves s, each hand wheel nut s^2 bearing on a gland s^3, the valves having their seats on the front of the supplementary part A′.

In Figs. 26, 27 and 28 flap valves k are shown turned by handle k^2 on the spindle k' passing through the gland k^3. Such arrangements are preferably used for the nozzles of the last stage or stages of expansion.

The ring A′ is movable with respect to A so that when the valves are opened a regulation of the width of the steam passages through the nozzles may take place.

In Fig. 25 there are exit portions of several nozzles directed at angles approaching one another, whereby several streams may be united into one to act more nearly at a single point on the turbine wheel.

The described division of the nozzle containing element affords the further advantage that a part of the same may be replaced without great cost. As fixed or stationary part of the element is selected the one which is least exposed to wear and has least influence upon the correct leading of the steam streams. It is also essential that the removable part may be made as already said of other metal than the fixed part which is desirable in view of reduced wear and the possibility of rapid alteration of the steam channels or nozzles of the elements.

I claim:—

1. In a parallel flow turbine, a nozzle containing element concentric with the turbine axis and comprising a plurality of concentric stationary elements dividing the nozzles into a plurality of portions along their lengths whereby the exit and entrance ends of the nozzles will be formed in separate pieces coöperating when assembled to form complete nozzles.

2. In a parallel flow turbine, a nozzle containing element comprising a plurality of parts concentric with the turbine axis, one of which parts is stationary, said parts dividing the nozzle lengthwise into a plurality of parts and coöperating when assembled in juxtaposition to form complete nozzles.

3. In a parallel flow turbine, a composite nozzle ring comprising a main part containing a portion of the length of the nozzles and a completing ring containing the remainder of the length of the nozzles and fitted to the main part, whereby each part can be separately finished and assembled in juxtaposition to form the complete nozzle rings.

4. In a steam turbine, a nozzle containing element comprising a stationary part, and a movable part slidable thereon and containing the exit ends of the nozzles.

5. In a steam turbine, a nozzle containing element comprising a stationary middle part, and a part on each side thereof, one containing the exit and the other the entering ends of the nozzles.

6. In a steam turbine, a nozzle containing element comprising a middle part containing the bodies of the nozzles, a part containing the exit ends of the nozzles and a part containing the entering ends of the nozzles, both of the last named parts slidable on the middle part.

7. In a steam turbine, a nozzle containing element comprising a middle stationary part and sliding parts in juxtaposition thereto, some of said parts having portions of the side walls of the steam nozzles as comb-like projections.

8. In a parallel flow steam turbine, a stationary nozzle ring in which the nozzles are arranged in groups, the combination of a slidable ring coöperating therewith and having one end of the nozzles arranged in like groups therein and slidable in relation to the stationary ring.

9. In a steam turbine, the combination with a stationary nozzle part in which the nozzles are arranged in groups, of an element carrying the exit ends of the nozzles arranged in similar groups, and each group divided into sets.

10. In a steam turbine, the combination with a stationary nozzle part in which the nozzles are arranged in groups, of a movable element having the exit ends of the nozzles arranged in similar groups, each group divided into sets, each set of exit ends being different from the other sets of the group and means to move the movable element to bring a set of nozzles into coöperation with the nozzle portions in the stationary part.

11. In a steam turbine, the combination with a middle stationary nozzle part in which the nozzles are arranged in groups, of a movable element having the exit ends of the nozzles arranged in similar groups and each group divided into sets and each set of nozzle ends differing in form and direction from those in the other set or sets, a rack on the movable part and a worm to operate said part in relation to the stationary part.

12. A nozzle containing element comprising a plurality of parts, one of which is stationary, the division between the parts being both longitudinally of and transversely to the nozzles, one of the parts having only portions of the side walls of the nozzles.

13. In a parallel flow steam turbine, a composite nozzle containing ring comprising a stationary part containing steam passages, a movable ring having steam passages to complete the nozzles capable of registering with those in the stationary part and means to move the movable ring to successively close the passages in the stationary part, the two parts arranged side by side to form the complete parallel flow nozzle.

14. A nozzle containing element comprising a stationary and a movable part, each part containing portions of the steam passages and an independent valve for each steam passage.

15. In a parallel flow turbine, a composite nozzle having a main portion containing the entrance ends, the body portions and a part of the exit ends of the nozzles and a coöperating part to complete the formation of the nozzles at their exit ends.

16. In a steam turbine, the combination with the casing, a stationary element containing a portion of each steam passage, of a removable element containing also a portion of the steam passages and seated thereon, and set screws passing through the casing and engaging the removable element.

17. In a steam turbine, the combination with the casing, of a nozzle crown for the first stage of expansion composed of two parts, one of which has side walls of the nozzles formed comb-like thereon and independent valves to control each nozzle entrance.

18. In a steam turbine, the combination with a casing, of a nozzle crown for the first stage of expansion having a fixed and a removable part, both parts containing portions of the steam passages, an independent valve to control the passage of steam to each nozzle, a nozzle containing element for intermediate stages of expansion comprising a stationary part and a slidable part, one of the last named parts having the side walls of the nozzles formed of comb-like projections thereon and inclined set screws through the turbine casing to hold the sliding part on the stationary part.

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

RICHARD SCHULZ.

Witnesses:
JOHANNES HEIN,
HENRY HASPER.