No. 714,074. Patented Nov. 18, 1902.

C. WEICHELT.

STEAM TURBINE.

(Application filed Sept. 7, 1901.)

(No Model.) 4 Sheets—Sheet 1.

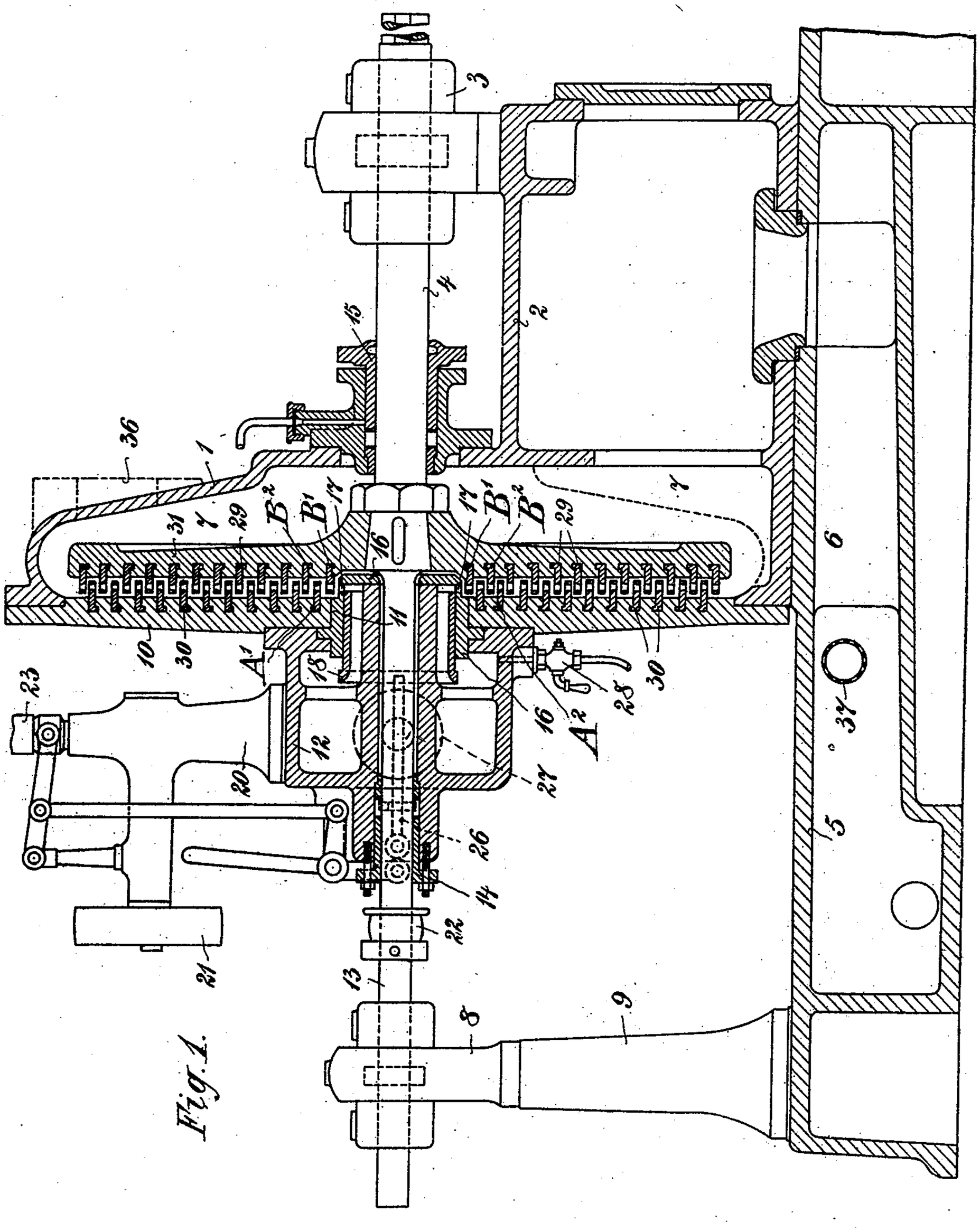

Fig. 1.

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(No Model.) 4 Sheets—Sheet 2.

Fig. 2.

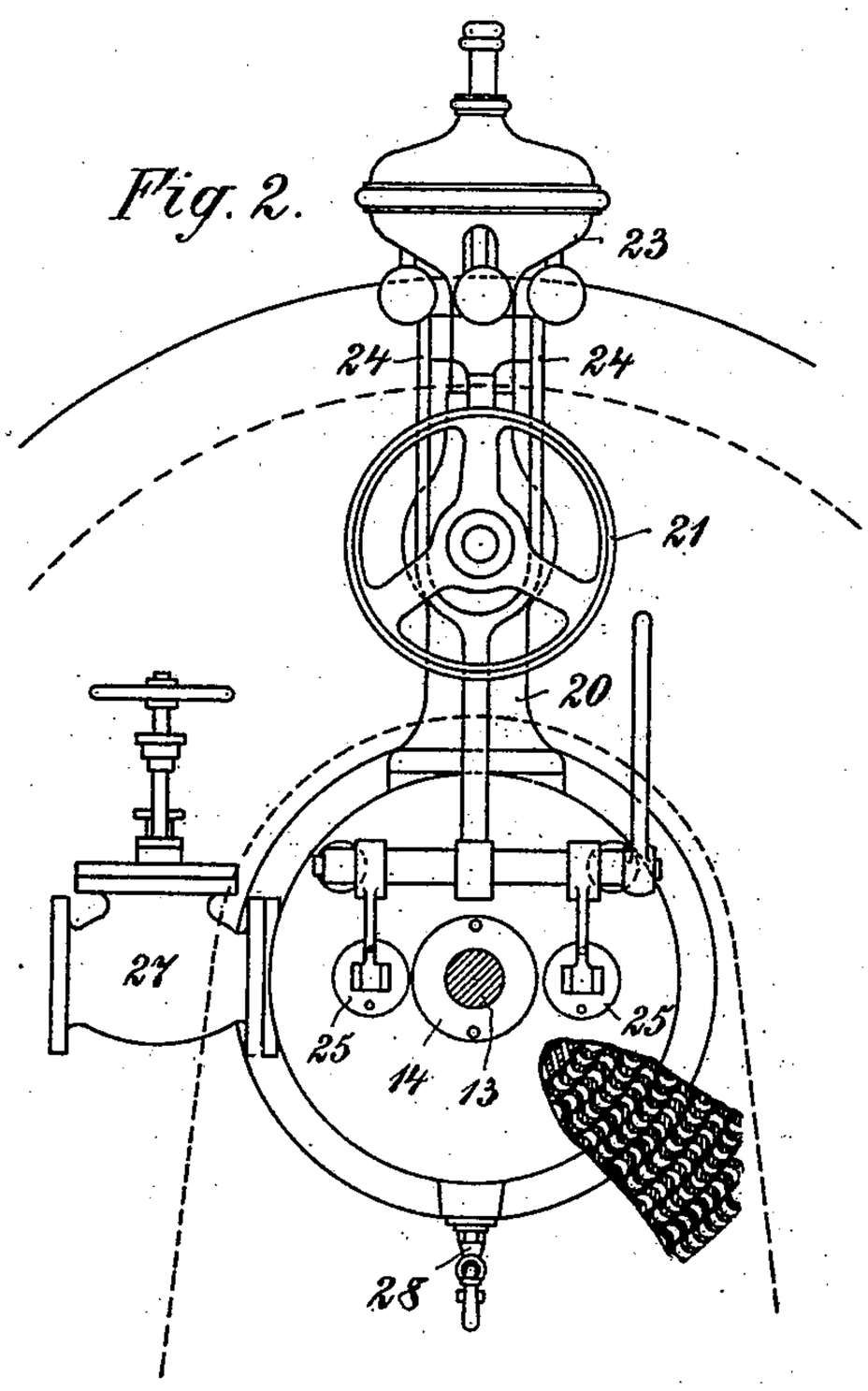


Fig. 3.

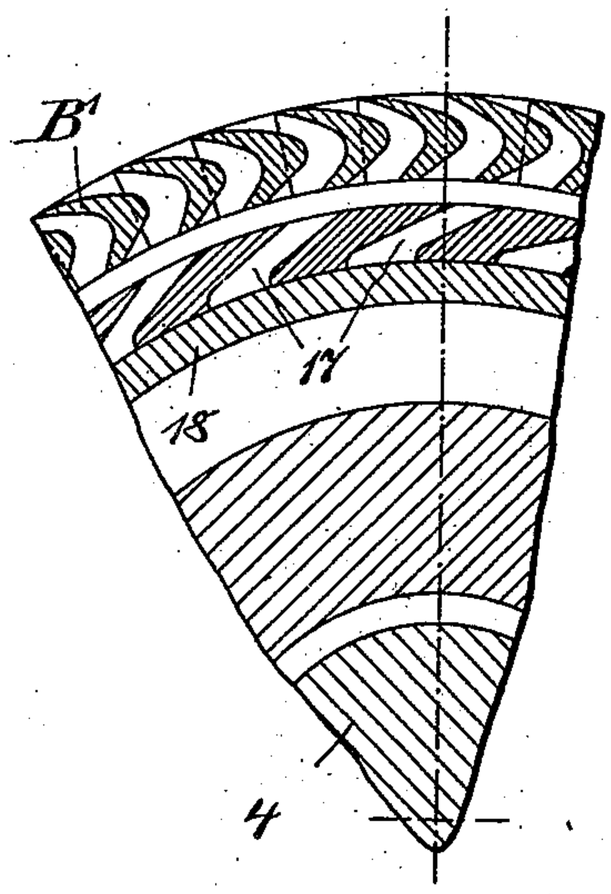
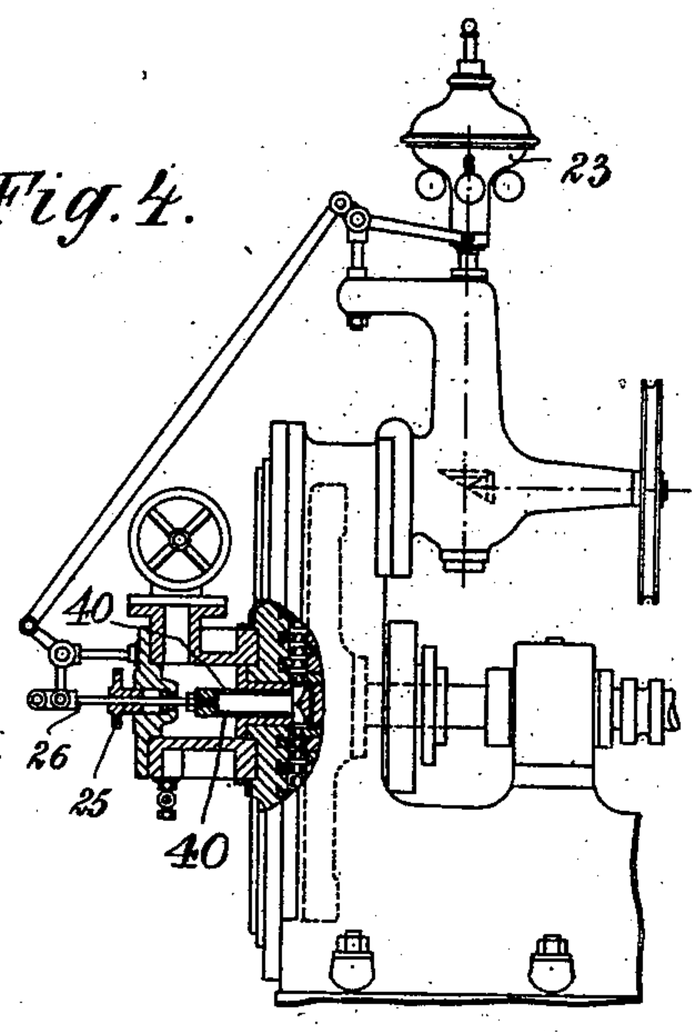


Fig. 4.



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(No Model.) 4 Sheets—Sheet 3.

Fig. 5.

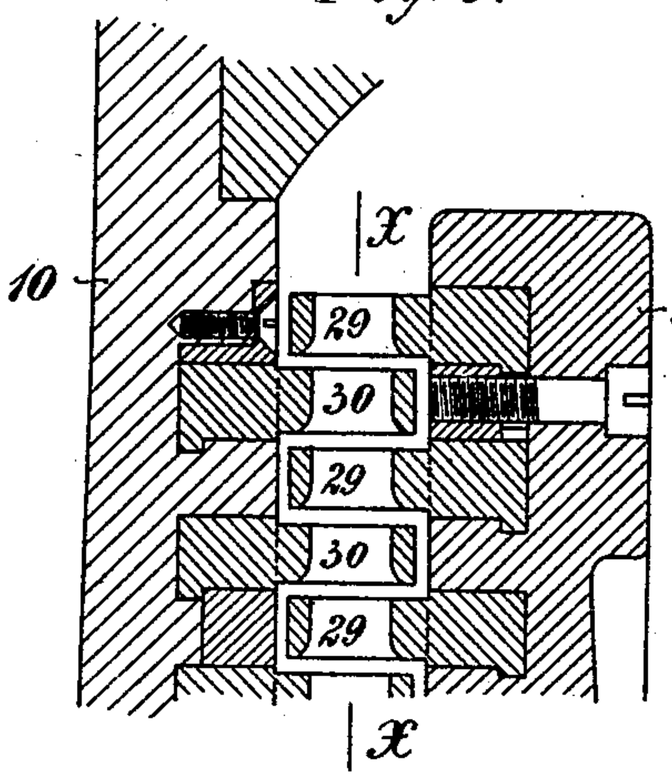
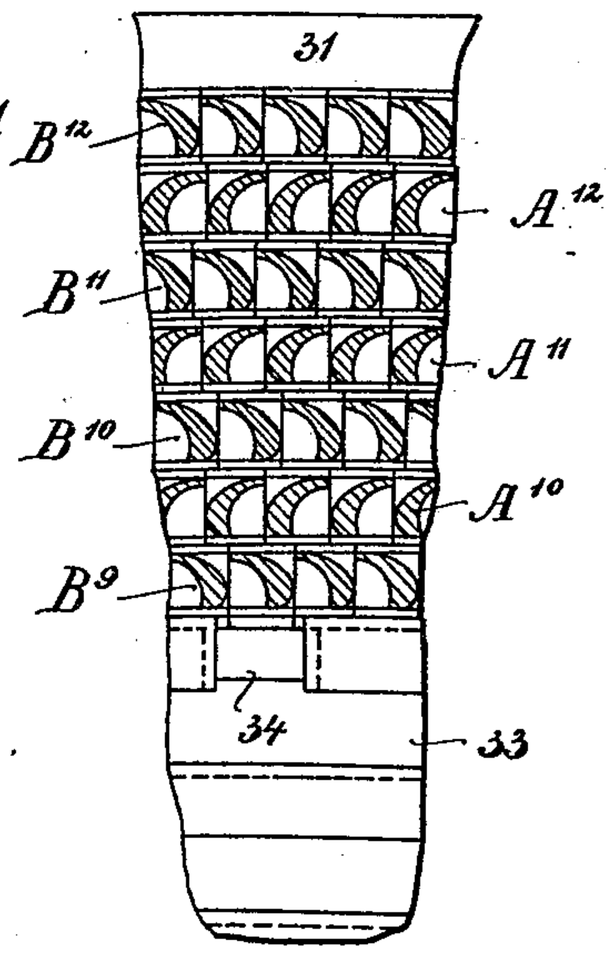


Fig. 6.



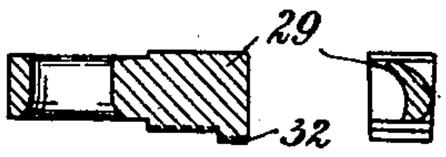


Fig. 7.

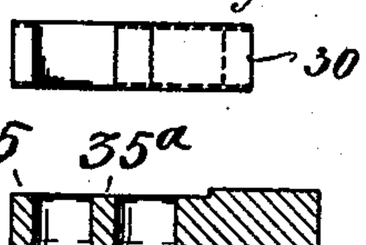
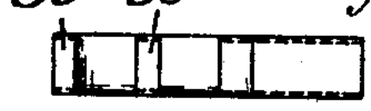


Fig. 8.



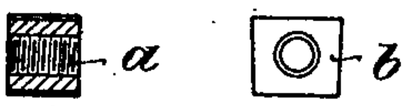


Fig. 12.

Fig. 13.

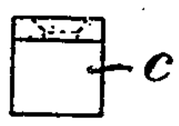


Fig. 10.

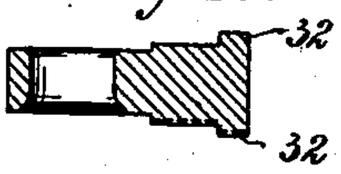


Fig. 9.

Fig. 11.

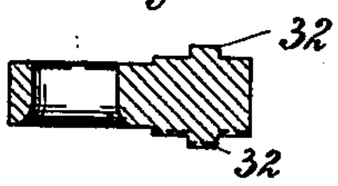


Fig. 14.

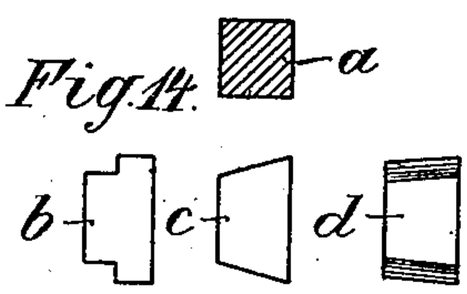


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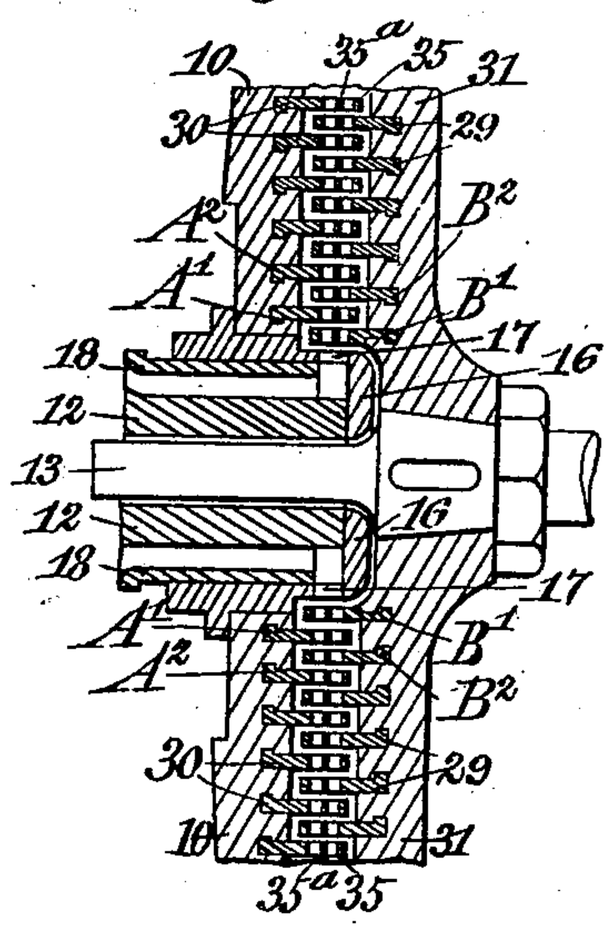
Fig. 15.



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UNITED STATES PATENT OFFICE.

CARL WEICHELT, OF MOSCOW, RUSSIA.

STEAM-TURBINE.

SPECIFICATION forming part of Letters Patent No. 714,074, dated November 18, 1902.

Application filed September 7, 1901. Serial No. 74,616. (No model.)

To all whom it may concern:

Be it known that I, CARL WEICHELT, engineer, a subject of the Czar of the Russian Empire, and a resident of 1 Charitonenski, Pereulok, Moscow, Russia, have invented certain new and useful Improvements in Steam-Turbines, of which the following is a full specification.

Even the latest forms of steam-turbines exhibit various defects, of which the principal are as follows: Prejudicial axial pressure upon the turbine-wheel disk. The various parts are difficult of axis, or the construction of the turbine-wheel disk and that of the guide-wheel blade is extremely complicated, troublesome, and costly, quite apart from the fact that in case of any damage to the blades the disks carrying them must be supplied again in their entirety, as a ready exchange of the damaged blades is impossible. Finally, the devices hitherto employed for regulating the supply of steam do not meet the requirements and present the grave defect that they are arranged upon the main steam-conduit leading to the turbine-casing and not upon the guide-wheel itself, and when it is not desired to run the turbine at its full capacity the cross-section of the steam-conduit is reduced in order to permit less steam to enter while the cross-section of the passages of the guide-disk remain unaltered. As a result the steam is supplied to the passages of the guide-disk at reduced tension and passes through the turbine-wheel with reduced velocity. The decrease of velocity resulting from this may be so great that it can only be compensated for by a disproportionately large consumption of steam.

The object of this invention is to obviate all these defects. This is effected on the one hand by a special construction of the blades or vanes and the manner of attaching them to the guide-wheel and to the turbine-wheel, respectively, and on the other hand by the provision of a specially-constructed steam-admission regulator which forms a whole with the guide-wheel of a simple steam-turbine or with the first story or step of a multiple turbine and effects the admission of the steam by wholly or partially opening the passages of the single story or of the first story of the guide-wheel by means of a displaceable annular slide-valve, so that the steam enters these passages at its full pressure, issues from them with the velocity corresponding to this pressure, and enters the passages of the first story of the turbine-wheel. This is necessary in order to attain high efficiency with steam-turbines. It follows from this that the regulation of the steam admission must be such that the supply of steam is not previously decreased, but takes place first of all directly at the guide-wheel.

In the accompanying drawings, Figure 1 is a longitudinal section through the turbine as a whole with its governor. Fig. 2 is an external elevation of the governor. Fig. 3 is a cross-section through the passages of the governor and of the first series or story of the turbine-wheel. Fig. 4 shows the arrangement of the annular slide-valve in the case of small turbines. Fig. 5 is a longitudinal section through a portion of the guide-blade disk and the turbine-wheel disk, showing the special arrangement of the blades or vanes of both. Fig. 6 is a cross-section on the line X X of Fig. 5. Fig. 7 represents a one-step vane, upon one side of which is provided a projection at its extremity. Fig. 8 is a multiple step vane, upon one side of which is provided a projection at one extremity. Fig. 9 is a vane provided with a projection upon one side somewhat removed from its extremity. Fig. 10 shows a vane having projections provided on both sides at its extremity. Fig. 11 shows a vane having a projection provided upon both sides a little removed from its extremity. Fig. 12 illustrates the closing-piece of the last series of vanes upon the turbine-wheel. Fig. 13 represents the closing-piece of the last row of blades upon the guide-blade wheel. Fig. 14 shows the closing-piece for the slot of the annular grooves for the reception of the vanes; and Fig. 15 is a vertical central section on the same plane as Fig. 1, illustrating the employment of blades having two cross-walls.

Similar characters of reference indicate corresponding parts.

The multiple-storied radial steam-turbine (illustrated in Figs 1 and 2) is characterized by its simplicity of construction, the readiness with which it may be executed, and the accessibility of its parts.

The turbine-wheel casing 1, Fig. 1, is fixed in a steam-tight manner by means of a long box-shaped foot 2, which supports one bearing 3 of the turbine-shaft 4 to the box-shaped sole-plate 5, the interior of which communicates with the interior 7 of the wheel-casing 1. The other bearing 8 of the turbine-shaft is arranged upon a special support 9 upon the sole-plate 5.

The circular open side of the casing 1 is closed by means of a cover 10, in the middle of which is provided a circular aperture 11, which is closed by means of a box or boss-shaped cover 12, bolted to the cover 10. One extremity 13 of the turbine-shaft 4 passes through a circular aperture in the center of the cover 12, at the extremity of which latter it is rendered tight by means of a stuffing-box 14. Upon the other side of the casing 1 the shaft 4 is rendered tight by means of a stuffing-box 15.

The open inner side of the cover 12 is closed by means of a boss-shaped end or cover 16, which, together with the cover 12 of the casing, forms the steam-admission device of the turbine, for which purpose it is provided with passages 17, Figs. 1 and 3. Within the cover 16 the annular slide-valve 18 is adapted to slide axially, this slide-valve serving for the regulation of the quantity of steam passing through the passages 17 by covering these passages to a greater or less extent. The displacement of the slide-valve 18, above referred to, is effected by means of a centrifugal governor 23, which is mounted on a foot 20 upon the cover 12 and driven by means of the pulleys 21 22, the movement of the said governor being transmitted to two or more small spindles 26, which pass through stuffing-boxes 25, Fig. 2, and are connected to the annular slide-valve 18. Upon one side of the cylindrical wall of the cover 12 is provided the main steam-admission valve 27 and below this a draw-off cock with pipe for carrying off the condensation-water.

The steam-admission device for small turbines, Fig. 4, differs from that already described only by reason of the fact that the turbine-shaft 4, which is only mounted in bearings upon one side of the guide-disk, does not pass through the steam-admission device, owing to which it is not necessary to provide the cylindrical aperture in the box 12. In this case the centrifugal governor 23 is mounted upon the turbine-casing itself, and the annular slide-valve is provided only with one small spindle 26, passing through the front wall of the box 12 in a stuffing-box 25, this spindle being suitably attached to the front end of the annular slide-valve 18 in such a manner that the steam is able to enter this valve through suitable openings 40.

The vanes 29 and 30, Figs. 1, 3, and 5, the intervals between which constitute the steam-passages, are arranged in circular concentric rows A' A^2 upon the cover 10 of the casing 1, forming the guide-blade disk, and in rows B' B^2 upon the disk 31, Fig. 5, constituting the turbine-wheel and fixed upon the turbine-shaft, respectively. The arrangement is such that the passages 17 of the steam-admission device are surrounded by the first circular series B' of blades mounted upon the turbine-wheel, while these are surrounded by the first circular series A' of blades upon the guide-disk, and so on alternately to the last row or series B^{12} of the turbine-wheel.

Upon one extremity of the turbine-shaft may be provided a coupling for transmission of the power.

The one-step vanes 29 30, Figs. 1, 3, 5, and 7, (and also the multiple-step form shown in Fig. 8,) of the guide-disk and of the turbine-wheel are formed either upon one side, Figs. 7 and 8, or upon both sides, Fig. 10, with hook-shaped projections 32, which are inserted in concentric undercut grooves 33 upon the inner side of the casing-cover and upon one side of the turbine-wheel through suitable slots 34, Fig. 6, giving access to these grooves, and when inserted are pressed close up to one another. The blades are tapered in cross-section in inward direction—*i. e.*, toward the center of the wheel—as shown by the end views, Figs. 7 and 8, and in Fig. 6. The outer cross-wall 35 and intermediate cross-wall 35^a are likewise tapered. When a single foot or projection 32 is used, it is placed upon the inner side of said inner portion of the blade, as shown, so as to impart to the blade resistance to the pressure of the steam passing outward in radial direction. For closing the admission-openings 34 in the annular grooves closing-pieces are used, which, corresponding to the form of the openings, are either step-shaped, as shown in side view at *b* in Fig. 14, or laterally beveled, as shown at *c d* in Fig. 14. Fig. 14 also shows at *a* a transverse section through the last-named closing-piece. The closing-piece for the last series A'' of the guide-disk blades is shown in Figs. 5 and 13, *a b c*, and that for the last series of blades on the turbine-wheel B^{12} in Figs. 5 and 12, *a b c*. The said projections may either be formed quite at the extremity of the blades in the case of thin turbine-wheel disks, for example, Figs. 7, 8, and 10, or somewhat removed from the extremity in the case of thicker disks, Figs. 9 and 11.

The turbine above described may also be constructed as a double turbine with a common turbine-wheel provided upon both sides with the vanes referred to.

The operation of the steam-turbine is as follows: The steam supplied through the steam-pipe of the turbine passes through a valve 27 into the steam-admission device and enters the inner space of the annular slide-valve 18, through which it proceeds, through the passages 17, more or less opened by the latter into the first annular series B' of vane-passages of the turbine-wheel, which it causes to rotate, yielding up a portion of its velocity and force. Thence it proceeds to the first

vane-passage of the first series A′ of vanes on the guide-blade disk, which imparts to it the required discharge direction, but absorbs a still further portion of its velocity. With this decreased velocity the steam then passes into the vane-passage series B^2 of the turbine-wheel, imparting again to this latter a portion of its force and velocity and then enters the vane-passage series A^2 of the guide-blade disk, and so on in succession until it finally issues from the last series B^{12} of vanes upon the turbine-wheel with small velocity into the chamber 7 of the wheel-casing, either passing out into the open air through the aperture 36 or into the chamber 6, where it is condensed by a spray of water injected through the pipe 37, when it may be removed in the form of water by means of a centrifugal pump.

When blades having two cross-walls, one at the outer end and one intermediate the same and the inner portion of the blade, are used, then in case of the valve 18 being moved so as to permit passage of steam through only a portion of the supply-port 17 only that channel or radial steam-passage through the blades which is located adjacent the inner end of the blades of the wheel is supplied with the steam-blast, and the other channel remains unsupplied. Owing to the intermediate cross-wall 35^a, there is therefore no loss in effective action, as the same prevents the escape of the steam in lateral direction. When, however, the valve 18 opens the port 17 more than one-half of the same—say, three-fourths of the width of the port—then the first channel mentioned is completely filled with the incoming steam and a portion also enters the second channel. This one-fourth portion entering the second channel will gradually expand in the same laterally during its outward passage radially of the wheel from a quarter to a half, thereby filling the channel. In consequence of the lateral expansion a small loss of speed and effective action is produced, this, however, being smaller than it would be if the blades had no intermediate or second cross-wall—that is, if only a single large channel were employed. This second transverse wall has therefore a double purpose—first, it adds to the support of the blades one among the others, and, secondly, it effects a diminution of the loss of power when the turbine is not fully supplied with steam.

The advantages of my novel steam-turbine are as follows:

First. Owing to the simple and strong method of attaching the vanes 29 30 by means of hook-shaped projections 32 inserted in special undercut grooves formed for their reception upon the inner side of the disk, constituting the cover of the wheel-casing and in that side of the turbine-wheel which is turned toward the same, the construction of this form of turbine is rendered simple and exact, the vanes may be readily changed, and freedom from interruption of the working is insured.

Second. Owing to the closed form of the passages produced by the transverse wall, arranged upon the outer end of the vanes 29 30, the axial pressure of the steam upon the turbine-wheel is almost completely taken up.

What I claim, and desire to secure by Letters Patent of the United States, is—

1. In a steam-turbine, the combination of a housing having a side wall, a turbine-wheel arranged opposite the same, said housing and wheel being provided with annular concentric fastening-grooves, and laterally-projecting blades in said grooves, having each an inner portion of inwardly-tapering cross-section abutting at its converging sides with the next blade, and a foot or projection extending from said portion, substantially as set forth.

2. In a steam-turbine, the combination of a housing having a side wall, a turbine-wheel arranged opposite the same, said housing and wheel being provided with annular concentric fastening-grooves, and laterally-projecting blades in said grooves, having each an inner portion of inwardly-tapering cross-section abutting at its converging sides with the next blade, a foot or projection extending from said portion at the inner side of the same, and a second projection extending from the outer side of said inner blade portion, substantially as set forth.

3. In a steam-turbine, the combination of a housing having a side wall, a turbine-wheel arranged opposite the same, said housing and wheel being provided with annular concentric fastening-grooves, and laterally-projecting turbine-blades seated in said grooves, and composed each of an inner portion of inwardly-tapering cross-section, an outer cross-wall of similar tapering cross-section, said tapering inner portions and cross-walls of the blades abutting each with the next in circumferential direction of the wheel and housing, and inclined vanes between said cross-walls and the inner portions of said blades, substantially as set forth.

4. In a steam-turbine, the combination of a housing having a side wall, a turbine-wheel opposite the same, said housing and wheel being provided with annular fastening-grooves, laterally-projecting turbine-blades seated in said grooves and composed each of an inner portion of inwardly-tapering cross-section, an outer cross-wall of like tapering cross-section, a second cross-wall of similar cross-section arranged between said outer cross-wall and the inner portion, said tapering inner portions, outer cross-walls and second or intermediate cross-walls of the blades abutting each with the next in circumferential direction of the wheel and housing, vanes between said cross-walls, vanes between the second cross-walls and the inner portions of the blades, a steam-port at the center of the housing extending over both sets of vanes, and a valve for opening or closing said port so as to supply steam to one or both of said sets, substantially as set forth.

5. In a steam-turbine, the combination of a

housing having a side wall, a turbine-wheel opposite the same, said housing and wheel being provided with annular fastening-grooves, laterally-projecting turbine-blades seated in said grooves and composed each of an inner portion of inwardly-tapering cross-section, an outer cross-wall of like tapering cross-section, a second cross-wall of similar cross-section arranged between said outer cross-wall and the inner portion, said tapering inner portions, outer cross-walls and second or intermediate cross-walls of the blades abutting each with the next in circumferential direction of the wheel and housing, vanes between said cross-walls, and vanes between the second cross-walls and the inner portions of the blades, substantially as set forth.

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

CARL WEICHELT.

Witnesses:
GUSTAV HARLWIG,
RUDOLF SCHMIDT.