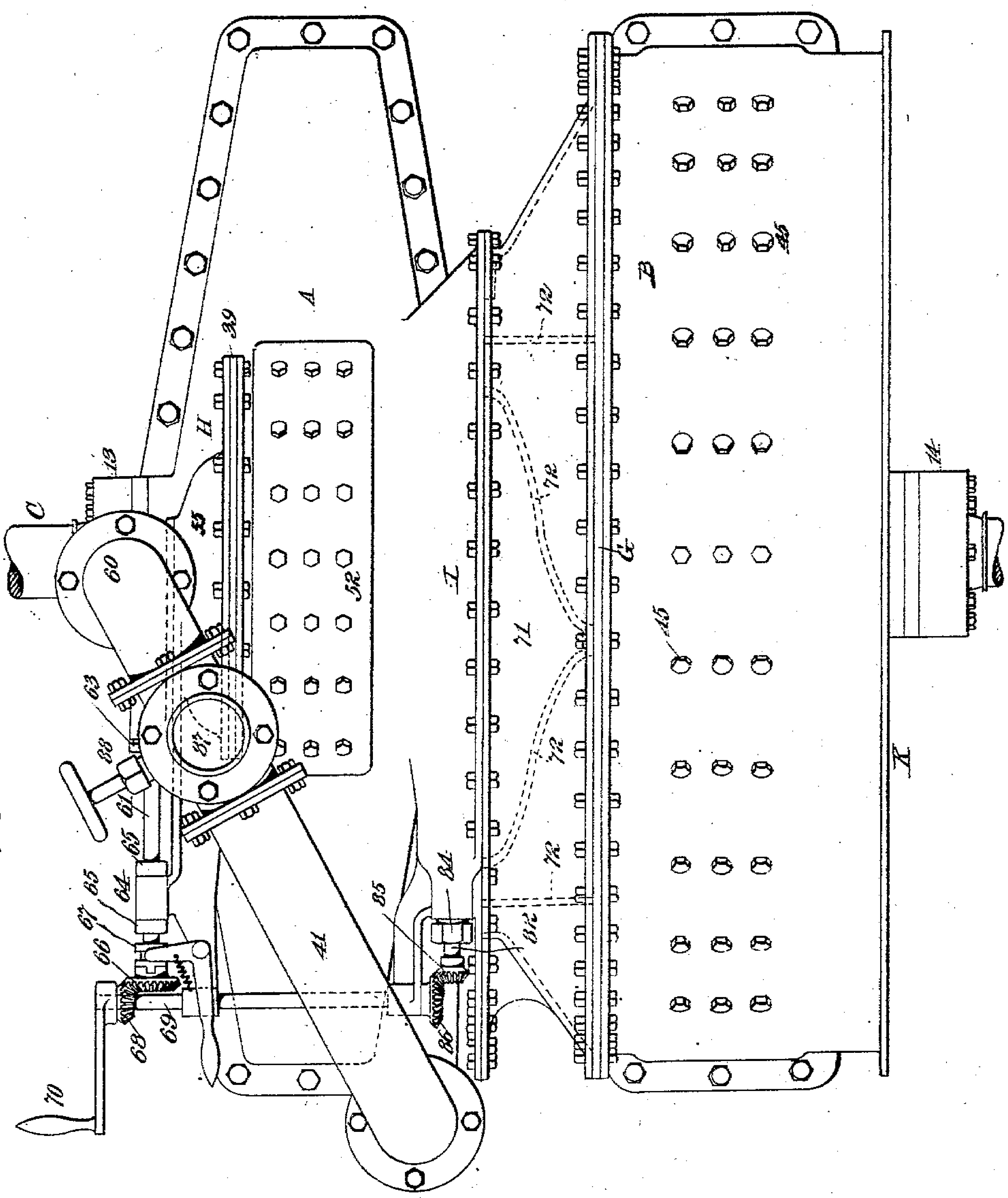
No. 745,575. PATENTED DEC. 1, 1903.

C. G. CURTIS.
ELASTIC FLUID TURBINE.
APPLICATION FILED NOV. 16, 1901.

NO MODEL. 5 SHEETS—SHEET 1.

Fig. 1



Witnesses:
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Attorneys

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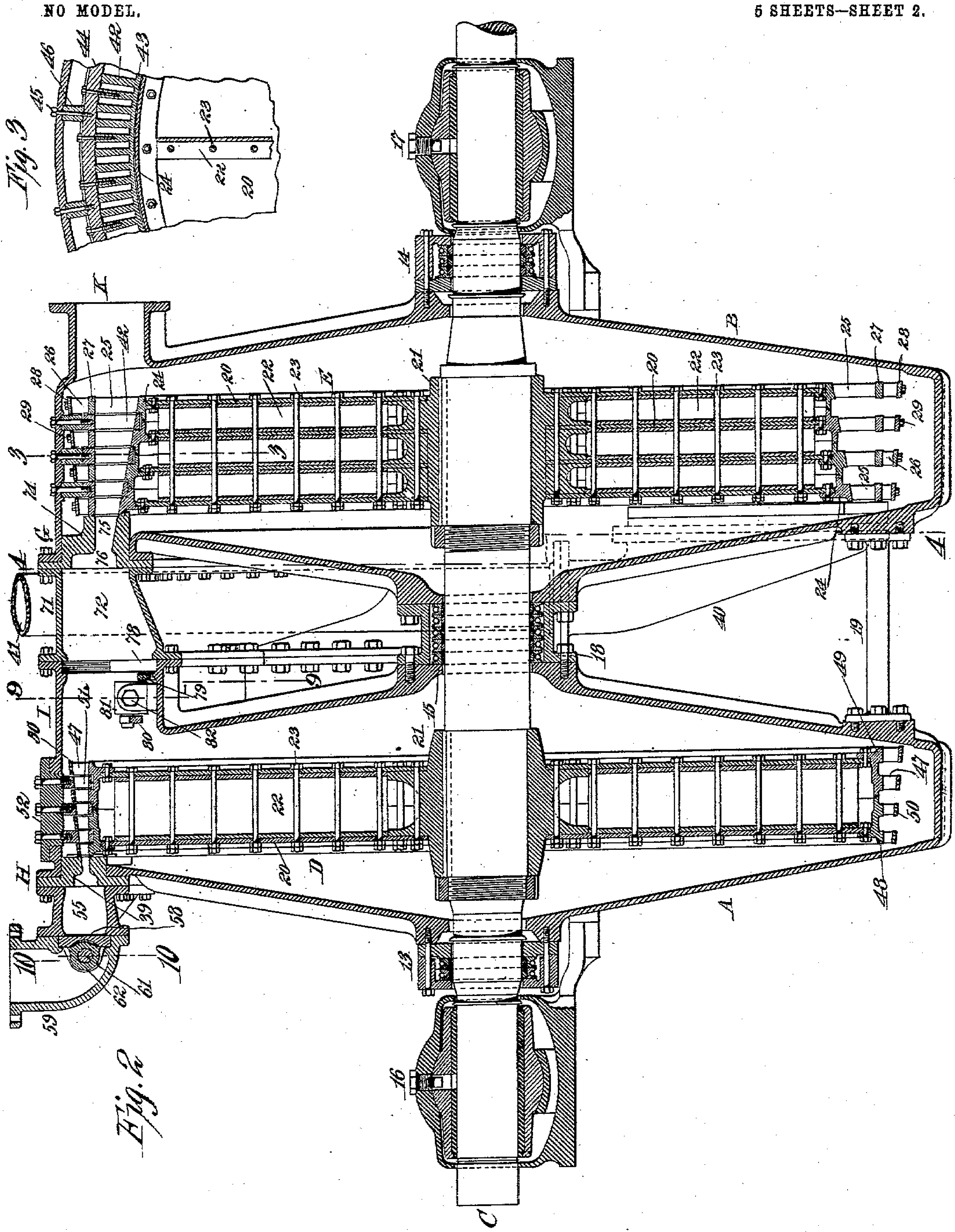
NO MODEL. 5 SHEETS—SHEET 2.



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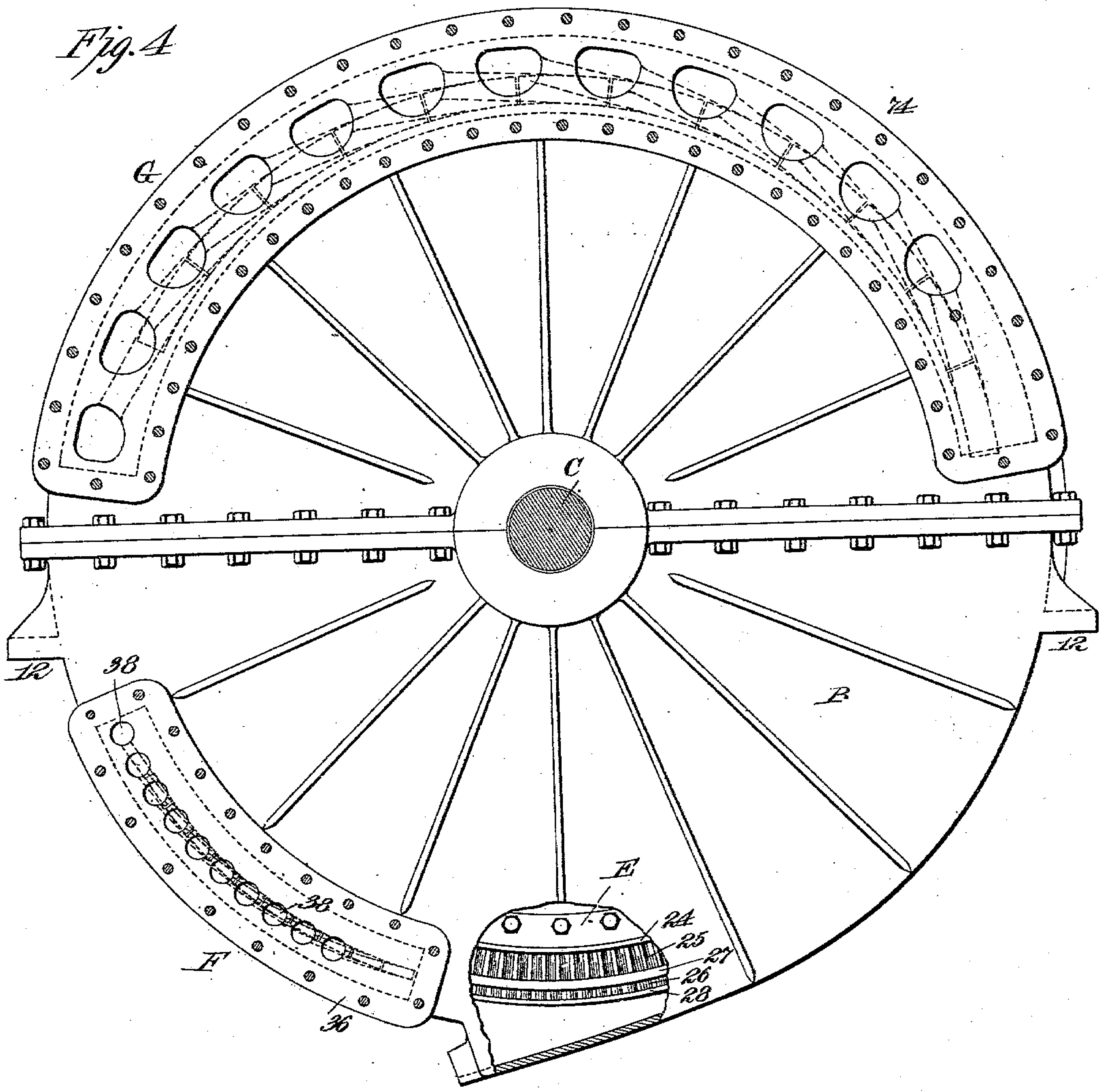
NO MODEL.

5 SHEETS—SHEET 3.



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NO MODEL. 5 SHEETS—SHEET 4.

Fig. 5

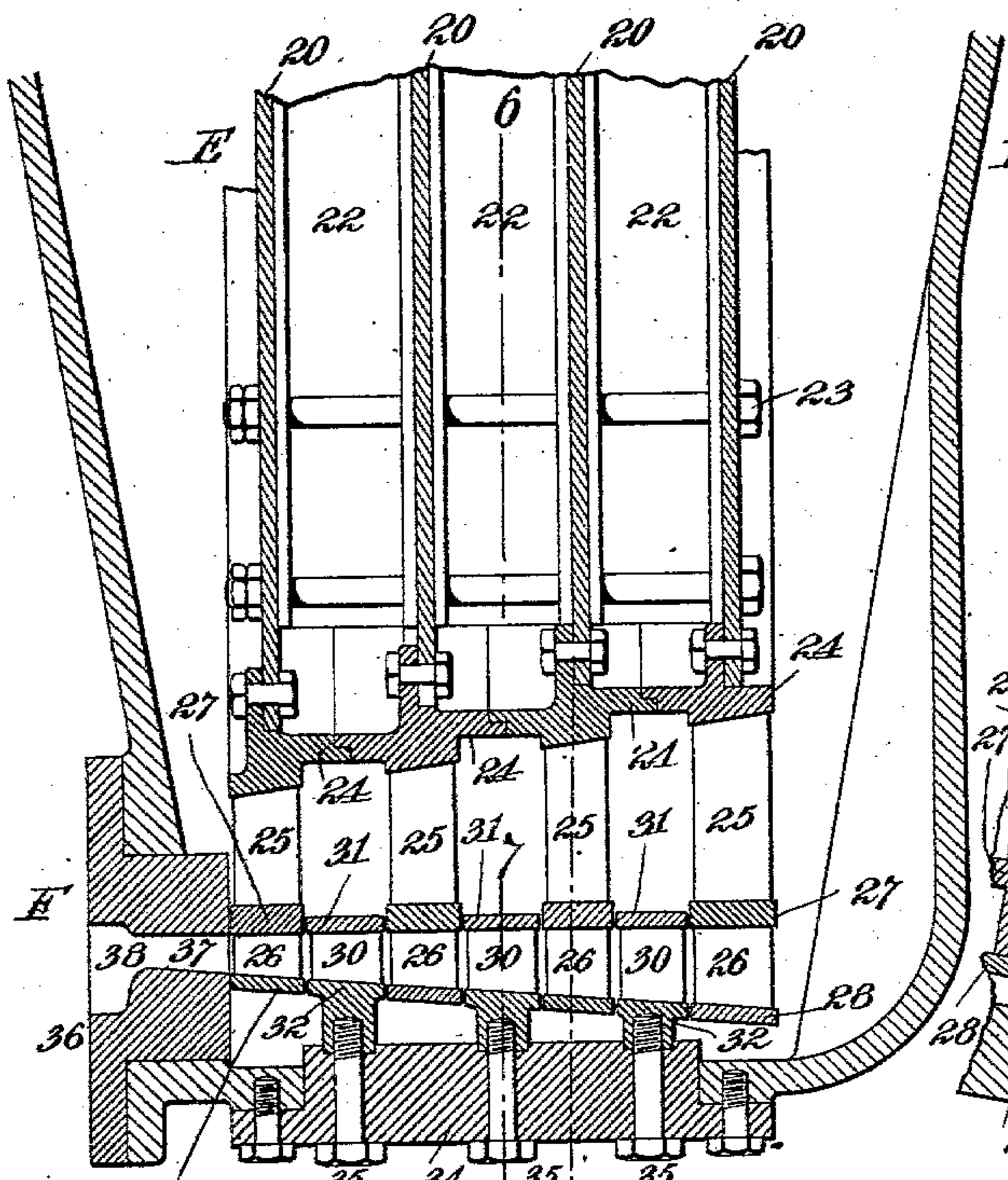


Fig. 6

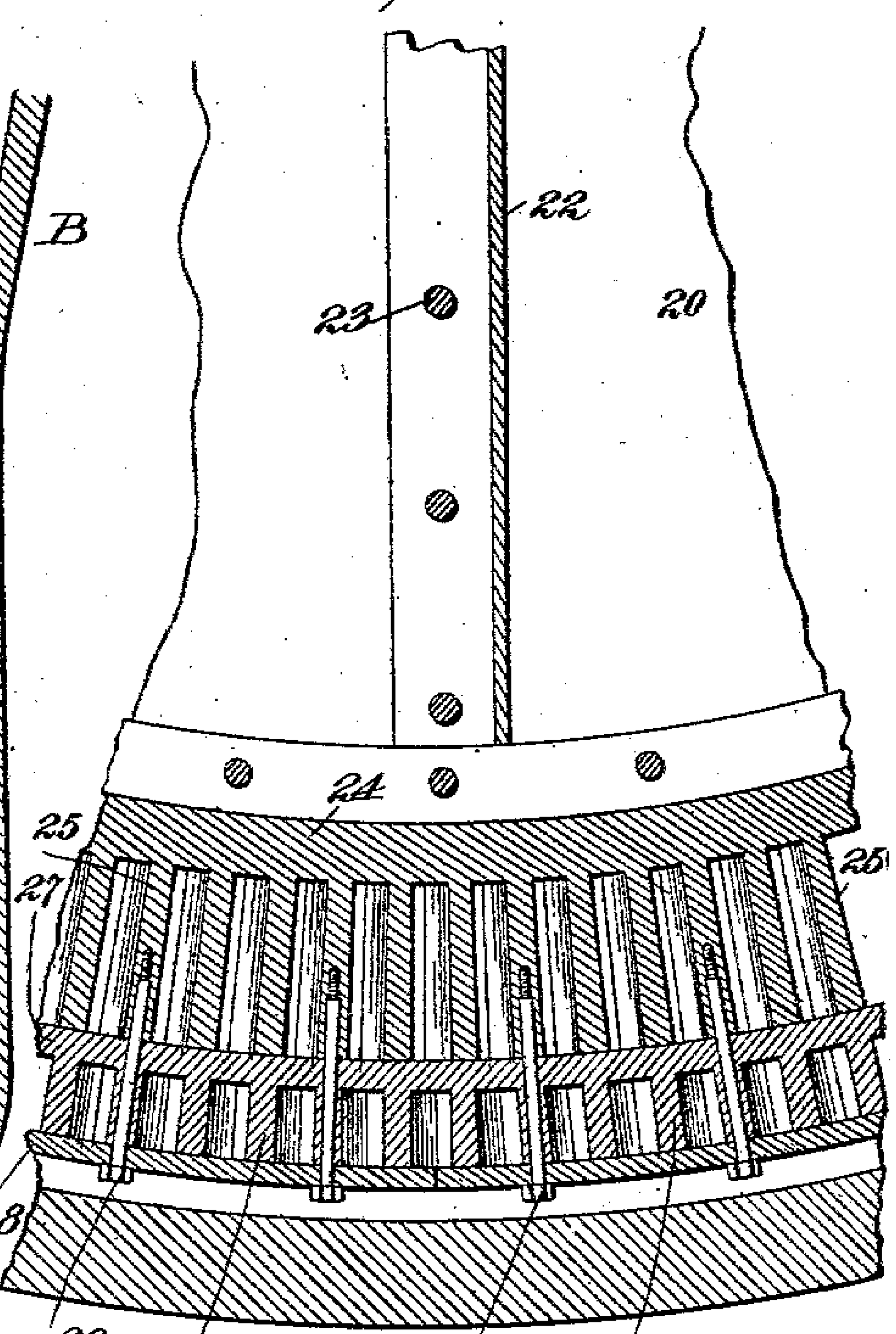


Fig. 8

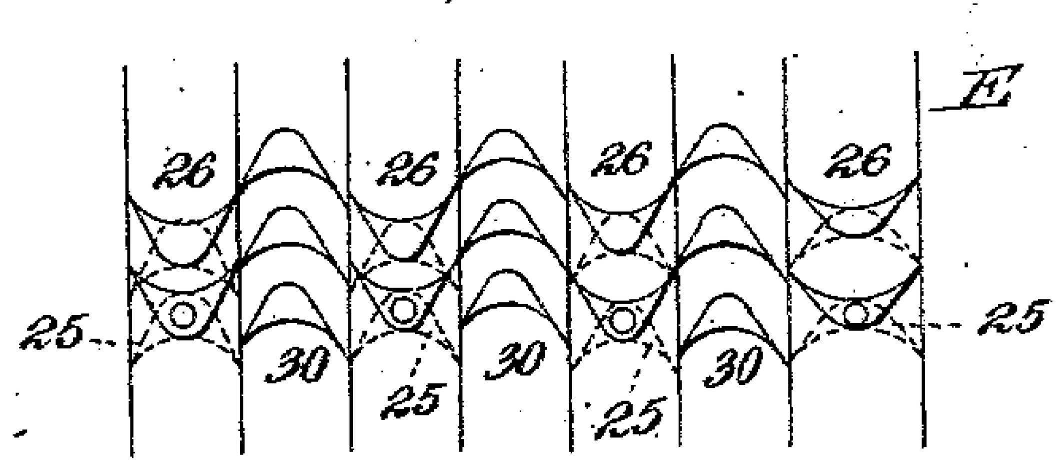
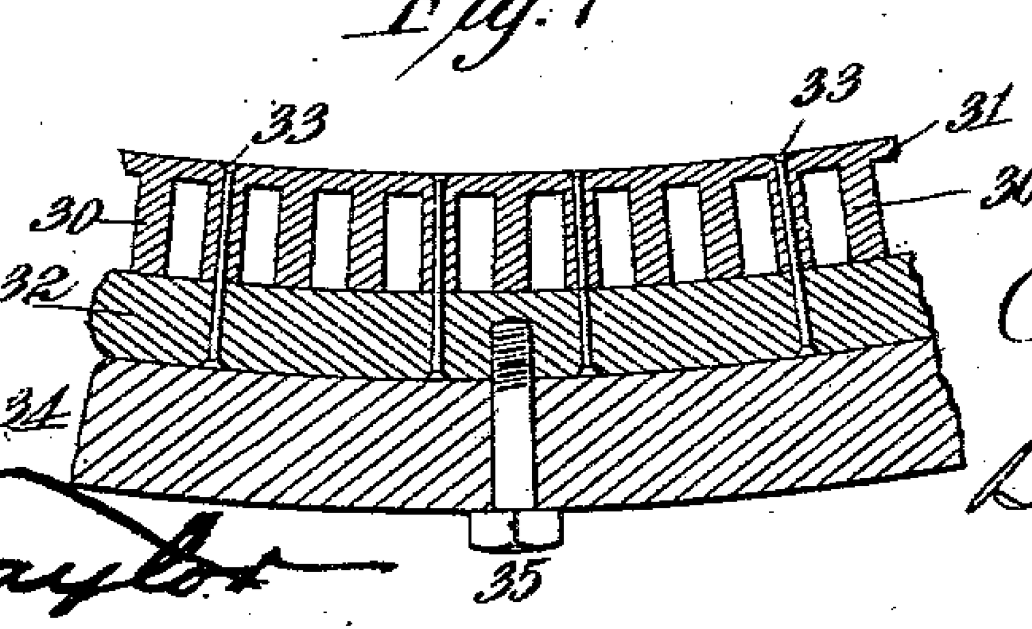


Fig. 7



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THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

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APPLICATION FILED NOV. 16, 1901.

NO MODEL.

5 SHEETS—SHEET 5.

Fig. 9

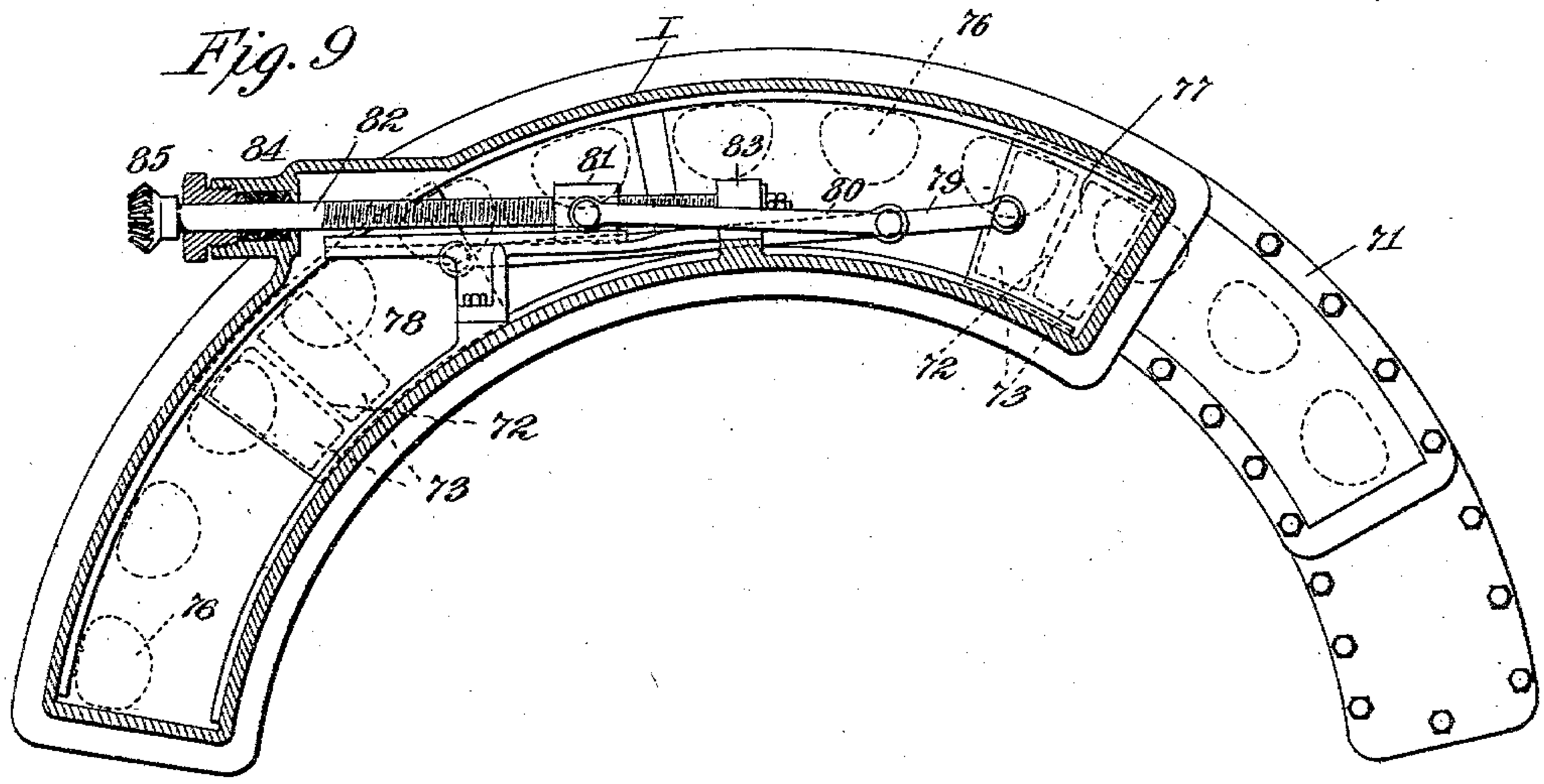


Fig. 10

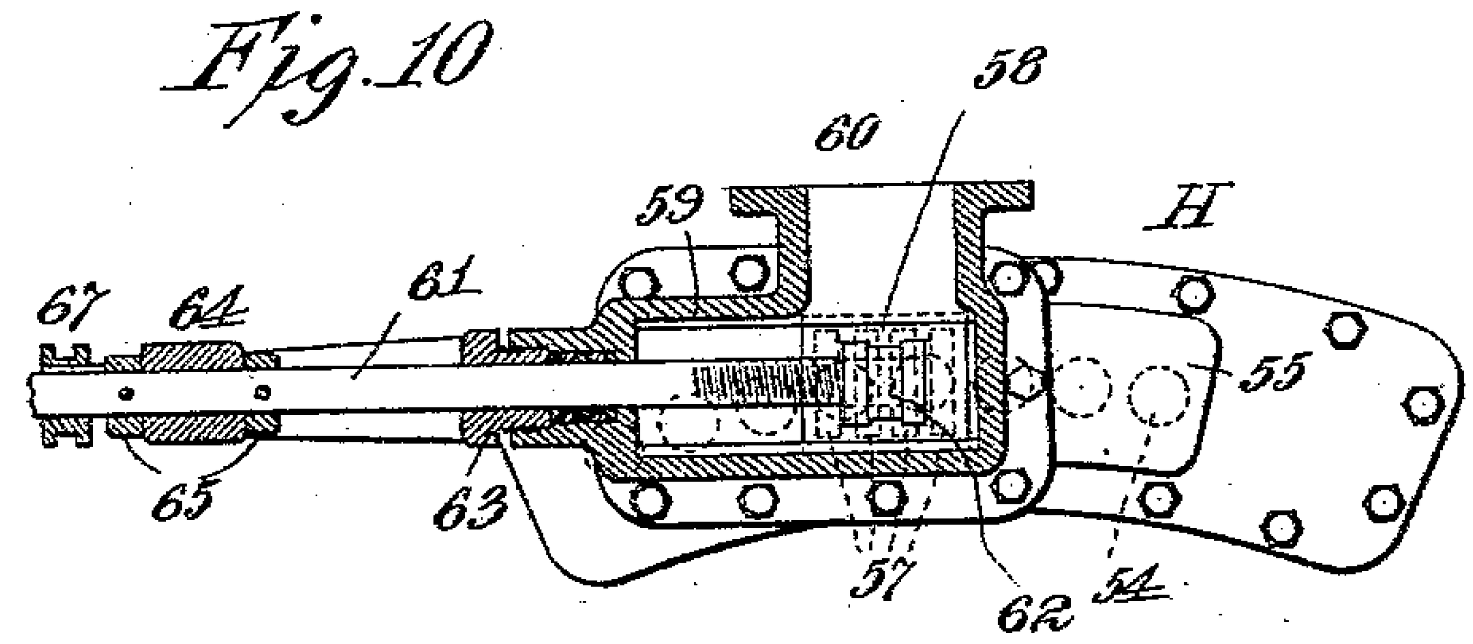
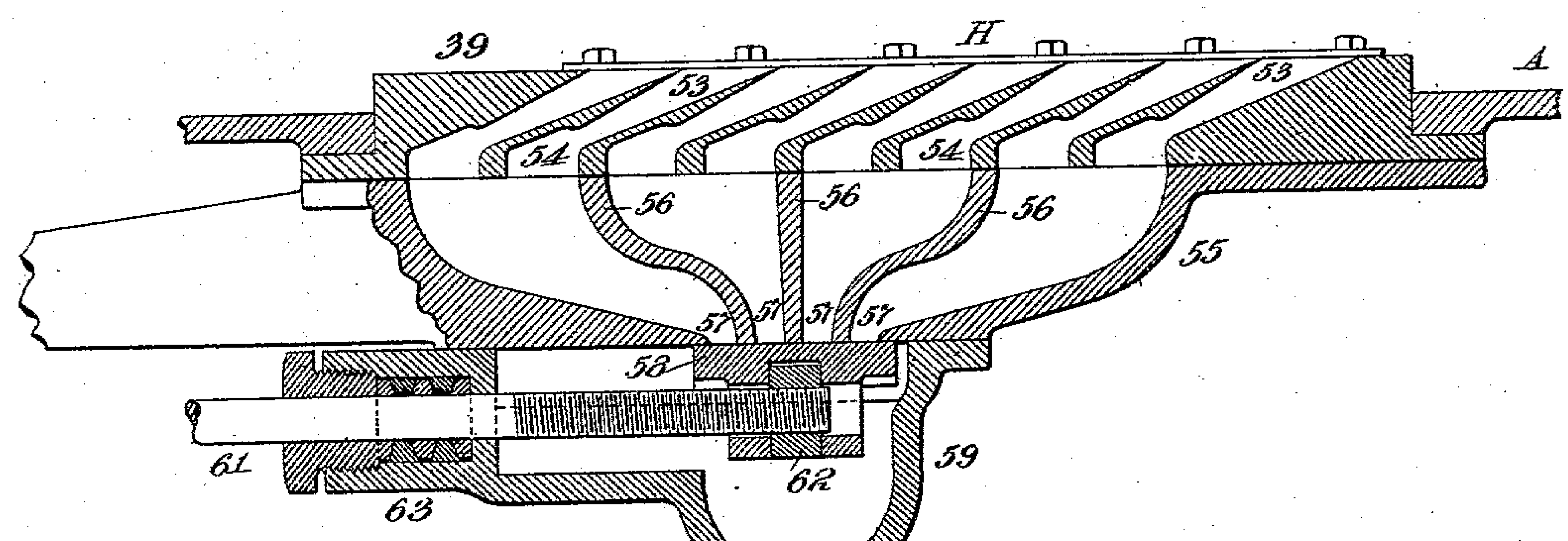


Fig. 11



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No. 745,575. Patented December 1, 1903.

UNITED STATES PATENT OFFICE.

CHARLES G. CURTIS, OF NEW YORK, N. Y.

ELASTIC-FLUID TURBINE.

SPECIFICATION forming part of Letters Patent No. 745,575, dated December 1, 1903.

Application filed November 16, 1901. Serial No. 82,570. (No model.)

To all whom it may concern:

Be it known that I, CHARLES G. CURTIS, a citizen of the United States, residing in the borough of Manhattan, city of New York, State of New York, have invented a certain new and useful Improvement in Elastic-Fluid Turbines, of which the following is a description.

My invention relates to elastic-fluid turbines constructed and operated upon the principle of the turbine of my Patents Nos. 566,967, 566,968, and 566,969.

The object of my invention is primarily to provide compound elastic-fluid turbines with effective means for reversing the direction of rotation, a result which has not heretofore been practically accomplished and which is of great importance, especially for marine turbines. In carrying out this feature of my invention in a compound turbine in which two or more sets of moving vanes and intermediate stationary vanes are inclosed in a single shell I provide for each of the two or more annular sets of moving vanes an additional annular set of moving vanes set in the opposite direction. These additional sets of vanes are the reversing-vanes, designed to reverse the direction of rotation of the turbine. To coöperate with these reversing-vanes, I provide the necessary number of sets of stationary intermediate vanes, which are supported from the shell preferably at some other point of the circumference than that occupied by the stationary intermediate vanes which coöperate with the regular sets of moving vanes. The direct and reversing sets of stationary intermediate vanes are supported at different distances from the center in order to properly coöperate with the corresponding sets of moving vanes. In line with the reversing intermediate stationary vanes there is mounted upon the shell a suitable nozzle for delivering the elastic fluid to the compound moving and stationary reversing-vanes. Both the direct and reversing nozzles are preferably sectional nozzles—such as that described in my application, Serial No. 666,379, filed January 12, 1898—and both may be provided with regulating-valves for opening and closing more or less of the sections to secure variations in the volume of the elastic fluid passing through the nozzle while maintaining a practically constant expansion; but in cases, such as marine turbines, where a high degree of efficiency in the use of the elastic fluid is not essential in reversing, the volume of the elastic fluid passing through the reversing-nozzle may be controlled by a throttle common to all the sections of the nozzle.

The arrangement so far described is applicable to the case of a single-shell turbine as well as to the sections of a multiple-shell turbine, the two or more shells being connected together with respect to the reversing-vanes as they are with respect to the direct vanes; but in turbines of the latter type—*i. e.*, those constructed to operate upon the stage-expansion principle described in my Patent No. 566,969 and involving two or more compound sections inclosed in separate fluid-tight shells connected in succession—I have found that it is only necessary to provide the compound moving and stationary reversing-vanes in one of the sections of the turbine, since in the case of a two-section turbine provided with reversing-vanes only in one section there can be secured from such reversing-vanes for the same flow of steam as used on the direct vanes a proportion of the power developed by the direct vanes varying from sixty-five to eighty per cent., according to the degree of expansion provided in the reversing-passage, because the terminal pressures of the entire turbine are available in the reversing-passage. If a greater power is desired for reversing, the reversing-passage can be designed to take a greater flow of steam than the direct passage. I prefer to locate the set of compound moving and stationary reversing-vanes in the low-pressure shell of the turbine, because, due to the lower pressure and greater rarefaction of the atmosphere in the shell of this section, the power which will be lost by the churning action of the moving reversing-vanes when the turbine is running in the normal direction will be reduced to a minimum, and, further, because the construction is simplified on account of the fact that no additional exhaust connection has to be made for the reversing-vanes, since the elastic fluid passing through such vanes can be discharged directly into the shell and will pass out of the regular exhaust-opening in that shell.

My present invention further relates to improvements in the construction of the sectional nozzle of my turbine and in the valve mechanism employed therewith, as well as in improvements in the wheel construction and in various other details, as fully hereinafter set forth.

In the accompanying drawings, Figure 1 is a top view of a two-section turbine embodying my improvements. Fig. 2 is a vertical section lengthwise of the shaft of the same turbine. Fig. 3 is a section at right angles to Fig. 2 on line 3 3 in Fig. 2, illustrating the construction of and method of mounting the direct stationary intermediate vanes of the low-pressure section of the turbine. Fig. 4 is a vertical section on line 4 4 in Fig. 2 looking to the right at the shell of the low-pressure section of the turbine and showing the bowls of the sections of the direct and reversing nozzles, the shell being broken away to show an edge view of one set of direct and reversing moving vanes. Fig. 5 is a radial section lengthwise of the shaft of the lower portion of the low-pressure section of the turbine, taken through one of the sections of the reversing-nozzle. Fig. 6 is a section at right angles to Fig. 5 on line 6 6 in Fig. 5. Fig. 7 is a cross-section taken on line 7 7 in Fig. 5. Fig. 8 is a view showing some of the moving and stationary reversing-vanes developed, with the position of the adjacent moving direct vanes indicated in dotted lines. Fig. 9 is a section on line 9 9 in Fig. 2 looking to the right, illustrating the valve movement for controlling the sections of the direct nozzle for the second stage of the turbine. Fig. 10 is a sectional view on line 10 10 in Fig. 2, illustrating the valve movement for controlling the sections of the direct nozzle of the first stage of the turbine; and Fig. 11 is a sectional view through the sections of the nozzle of the first stage of the turbine. Figs. 5, 6, 7, 8, and 11, it will be observed, are on a larger scale than the other figures of the drawings.

A and B are the shells of the two sections of the turbine, which are placed side by side and have passing through them centrally the shaft C. The shells are made in upper and lower halves bolted together, the lower halves being provided with lugs 12 for supporting them from the base. (Not shown.) Stuffing-boxes 13 14 15 are provided where the shaft passes through the shells, while on the outer heads of the two shells are bearings 16 17, by which the shaft is supported. The shells are secured together at their centers by means of an annular angle-casting 18, which is bolted to the two shells, while one or more braces 19 may also be employed to maintain the relation of the shells to each other. D and E are the wheels, which are mounted upon the shaft within the two shells.

Referring now particularly to the second section of the turbine, the wheel E is composed of a number of wrought-metal disks 20, there being preferably as many of these disks as there are sets of moving vanes carried by the wheel. These disks are clamped upon a hub 21, which is mounted upon the shaft within the shell B. Between the disks are angle stiffening-bars 22, which extend radially from the hub 21 to practically the peripheries of the disks, and clamping-bolts 23, passing through the disks and the stiffening-plates, hold the several parts firmly together. Upon the peripheries of the disks 20 are secured rings 24, of wrought metal, which abut against each other with rabbet joints, so as to furnish mutual support and also to close the space between the disks against the entrance of the elastic fluid and to connect the clearances on opposite sides around the stationary vanes, so as to diminish the effect of leakage. The annular sets 25 of direct moving vanes are carried by the rings 24, being cut therein from the peripheral faces of the rings, so as to be integral therewith. Surrounding each set of moving direct vanes 25 is a set of moving reversing-vanes 26. Each set of moving reversing-vanes is cut in the peripheral face of a wrought-metal ring 27, which is shrunk over the outer ends of the vanes 25, closing the outer ends of the direct-vane spaces. The outer ends of the reversing-vane spaces are closed by an encircling band 28, which is preferably made in sections and is secured in position by bolts 29, which pass through the band 28, vanes 26, and band 27 into the vanes 25, thus not only securing the covering-band 28 upon the reversing-vanes, but also securing the entire reversing-vane structure to the direct vanes. The centers of the direct and reversing moving vanes are placed in line, as illustrated in Fig. 8, so that the bolts 29 can be passed directly through both sets of vanes. The intermediate stationary reversing-vanes are located, preferably, in the lower half of the shell B and have a length sufficient to embrace the entire width of the jet of elastic fluid delivered by the reversing-nozzle and flowing through the moving reversing-vanes. The sets of stationary reversing-vanes 30 are constructed integral with a wrought-metal band 31, upon which they are supported, by being cut in the outer face of a curved block, of which said band forms the inner face. The outer ends of the stationary vanes 30 are covered by curved plates 32, which are secured to the stationary vanes by rivets 33. The sets of stationary reversing-vanes are secured to a pad 34, which is bolted in an opening in the shell B by means of bolts 35, which hold the curved plates 32 in channels on the inner face of the pad 34. The reversing-nozzle F passes through an opening in the inner head of the lower half of the shell B, so as to deliver the elastic-fluid jet to the first set of moving reversing-vanes 26 in line with the intermediate stationary reversing-vanes 30. The reversing-nozzle F is composed of a casting 36, in which are formed nozzle-sections 37 and bowls 38, forming a sectional nozzle of the character described in my application before referred to. The nozzle-sections and bowls 37 38 formed in the casting 36 of the reversing-nozzle are the same as the similar sections formed in the casting 39 of the nozzle for the first stage of the turbine, Fig. 11, which will be presently described, except that the nozzle-sections are turned in the opposite direction. Secured to the casting 36 is a hood 40, Fig. 2, which covers all the nozzle-sections, and connected with this hood is a pipe 41 for supplying elastic fluid to the reversing-nozzle.

The sets of stationary intermediate direct vanes 42 for the second stage of the turbine are constructed in the same manner as the stationary reversing-vanes except that they are turned in the opposite direction, being made integral with a band 43 and covered by a curved plate 44, which is secured to the vanes 42. These sets of direct stationary vanes are located in the upper part of the turbine, being secured to the shell by bolts 45 and spacing-blocks 46, so as to be located in line with the direct moving vanes, with which they coöperate. The nozzle G for the second stage of the turbine and its coöperating valve mechanism are so similar in construction to the nozzle of the first stage of the turbine that a description of it will be deferred until after the nozzle of the first stage of the turbine, which is more fully illustrated, is described.

The wheel D of the first stage of the turbine is built up like the wheel E, except that it may have a smaller number of disks, and the sets of moving vanes 47 of the wheel D may be cut upon two rings 48 49 instead of upon four rings. The moving vanes 47 have their outer ends encircled by bands 50 secured thereto. The intermediate stationary vanes 51 are constructed in all respects like the stationary reversing-vanes 30 except that they are turned in the opposite direction and are secured in a similar manner to a pad 52, bolted in an opening in the top of the shell A.

The nozzle H of the first stage of the turbine is composed of a casting 39, already referred to, Fig. 11, which is secured in an opening in the upper half of the outside head of the shell A, opposite the stationary intermediate vanes 51, which carry the elastic-fluid jet from one set of moving vanes 47 to another set. The casting 39 is provided with a series of nozzle-sections 53 and bowls 54, such nozzle-sections terminating at their discharge ends in thin partitions, so that the separate streams of elastic fluid combine at the delivery end of the nozzle into a substantially single stream, as described in my application before referred to. Upon the casting 39 is bolted another casting 55, covering the bowls of all the nozzle-sections, and in the casting 55 are partitions 56, extending back from the partitions between the bowls 54 to ports 57, over which slides a valve 58, having an area sufficient to cover all of said ports. I have not found it necessary to provide as many valve ports and conduits leading to the sections of the nozzle as there are sections in the nozzle itself in order to secure an efficient governing of the turbine. In the case of the nozzle H for the first stage of the turbine I have shown one such port and conduit for every two nozzle-sections; but it is evident that if the nozzle-sections were smaller and greater in number there might be more than two of such nozzle-sections for each port and conduit. Upon the casting 55 is secured the valve-case 59, in which the valve 58 slides. The valve-case 59 is connected with a supply-pipe 60 for supplying the elastic fluid thereto. To operate the valve 58, I provide a rod 61, having a screw-threaded inner end working in a nut 62 in the valve 58. This rod passes through a stuffing-box 63 in the valve-case 59, and outside thereof it passes through a bearing 64, on opposite sides of which bearing it is provided with thrust-collars 65 to prevent longitudinal movement. The outer end of the rod 61 has mounted loosely upon it a beveled gear 66, which is locked to the rod by a hand-operated clutch 67. Another beveled gear 68, carried by a shaft 69, meshes with the gear 66. The shaft 69 may be turned by a handle 70 or by connection with a speed-governor, and by its movement the rod 61 will be turned and will open more or less of the ports 57, thus varying the number of the nozzle-sections through which the elastic fluid will pass and maintaining an efficient operation of the turbine under variations of load. The elastic-fluid jet after passing from the nozzle H through the compound series of moving and stationary vanes 47 and 51 is discharged from the last set of moving vanes 47, opposite the exhaust-opening I of the first shell.

Between the exhaust-opening I and the direct nozzle G of the second shell is located a connecting-box 71, which is similar to the casting 55 of the nozzle H, being divided by partitions 72, which extend back from the partitions separating the bowls of the sections of the nozzle G to ports 73 at the other end of the partitions 72. The nozzle G is formed of a casting 74 similar to the casting 39 of the nozzle H, but having a much greater length, so as to provide for the greater cross-sectional area of the nozzle for the low-pressure stage of the turbine, and in this casting 74 are formed the nozzle-sections 75 and bowls 76, which correspond with the similar parts 53 and 54 of the nozzle H. The partitions 72 form four conduits leading from the nozzle-sections back to the ports 73, which are four in number, each one of these conduits embracing three of the nozzle-sections. (See Figs. 1 and 9.) Valves 77 78 covers the ports 73 and slide in guides formed between the casting 71 and the exhaust-opening I. The valve 78 has approximately twice the length of the valve 77, and is so placed with relation to the ports which it covers that where all the ports are covered by both valves and the valves are moved to the left to uncover the ports the valve 77 will first uncover its ports and the valve 78 will then uncover its ports, while if the ports are all open and the valves are moved at the same speed to the right to cover the ports the valve 78 will first close its ports and then the valve 77 will close its ports. This relation of the valves is illustrated in Fig. 9. To move the two valves, they are connected together by a rod 79, from which extends a link 80 to a nut 81, which nut is moved by a screw-rod 82. This screw-rod is held against longitudinal movement by a bearing 83 at its inner end. It passes through a stuffing-box 84 out through the side of the shell A surrounding the exhaust-opening I and is provided on its end with a beveled gear 85, which meshes with a beveled gear 86 on the end of the shaft 69. The beveled gear 86 is larger than the gear 85, so that the speed of rotation of the screw-rod 82 is greater than that of the shaft 69. On the other hand, the screw-rod 61, which moves the valve of the nozzle H, has a less speed than the shaft 69, its gear-wheel 66 being larger than the gear-wheel 68 on the shaft 69. The different speeds imparted to the screw-rods 61 and 82 by the shaft 69 are such that the movements of the valve 58 and the valves 77 and 78 will be coordinated, so that the valves controlling the two nozzles will be moved proportionately.

The function of the clutch 67, which permits the valve-rod 61 to be disconnected from the operating-shaft 69, is to allow of adjustment of the valves of the second-stage nozzle independent of the movement of the valves of the first-stage nozzle, so that the intermediate pressure of the elastic fluid, or that pressure which exists at the exhaust-opening I of the first shell, may be varied sufficiently to secure the most effective working of the turbine as an entirety. The casting 71, which is placed between the two shells and is bolted to both of them, serves additionally to hold the shells in a fixed relative position and to produce a rigid construction.

The supply-pipes 41 and 60 for the elastic fluid are connected with a pipe 87, leading to the steam-boiler or other source of elastic fluid, and a two-way valve 88 is located at the junction of the pipes 41, 60, and 87, so that the elastic fluid can be directed into either pipe 41 or 60 and can be throttled more or less, if desired.

K is the exhaust for the second stage of the turbine, which will be connected with the condenser and through which the elastic fluid from the direct vanes, as well as from the reverse vanes, is discharged.

What I claim is—

1. The combination, in an elastic-fluid turbine, of a delivery-nozzle and moving vanes for producing forward motion; and an expansion sectional nozzle and moving vanes, upon which the elastic fluid delivered by said expansion sectional nozzle acts two or more times in succession, for producing backward motion, substantially as set forth.

2. The combination, in an elastic-fluid turbine, of an expansion sectional nozzle and moving vanes, upon which the elastic fluid delivered by said expansion sectional nozzle acts two or more times in succession, for producing forward motion; and an expansion sectional nozzle and moving vanes, upon which the elastic fluid delivered by said expansion sectional nozzle acts two or more times in succession, for producing backward motion, substantially as set forth.

3. In an elastic-fluid turbine, the combination with an inclosing shell and a wheel therein, of two or more sets of moving vanes mounted on said wheel for producing the forward rotation of the turbine, and a corresponding number of sets of moving vanes mounted on said wheel at a different distance from the center for producing reverse rotation of the turbine, one or more sets of stationary intermediate vanes for each class of moving vanes, the two classes of intermediate vanes being supported by the shell at different portions of its circumference, and independent nozzles coöperating with the two classes of moving and stationary vanes and entering the shell in line with the two classes of stationary vanes, substantially as set forth.

4. In an elastic-fluid turbine, the combination with the shell and wheel, of two series of compound moving vanes mounted on the wheel at different distances from the center and having their vanes reversed to produce rotation of the turbine in opposite directions, two series of stationary intermediate vanes mounted on different circumferential portions of the shell and supported at different distances from the center so as to coöperate with the two series of moving vanes, and independent sectional nozzles coöperating with the two classes of moving and stationary vanes and entering the shell in line with the two classes of stationary vanes, substantially as set forth.

5. In an elastic-fluid turbine, the combination with an annular set of direct vanes formed integral with a wrought-metal wheel-rim, of an annular set of reverse vanes formed integral with a wrought-metal ring surrounding the direct vanes and secured thereto, substantially as set forth.

6. In an elastic-fluid turbine, the combination with an annular set of direct vanes formed integral with a wrought-metal wheel-rim, of an annular set of reverse vanes formed integral with a wrought-metal ring surrounding the direct vanes and secured thereto, and a band encircling the ends of the reverse vanes, substantially as set forth.

7. In an elastic-fluid turbine, the combination with an annular set of direct vanes formed integral with a wrought-metal wheel-rim, of an annular set of reverse vanes formed integral with a wrought-metal ring surrounding

the direct vanes, the centers of the direct and reverse vanes registering, a band encircling the ends of the reverse vanes, and bolts passing through the said band and the reverse vanes into the direct vanes, substantially as set forth.

8. In an elastic-fluid turbine, the combination with movable vanes and coöperating nozzles operating by stage expansion for producing forward motion, of means for producing backward motion consisting in an expansion-nozzle and movable reverse vanes located in one stage only, upon which movable reverse vanes the fluid jet delivered by said expansion-nozzle at high velocity acts two or more times in succession at a single stage of expansion, substantially as set forth.

9. In an elastic-fluid turbine, the combination with movable vanes and coöperating nozzles operating by stage expansion for producing forward motion, of means for producing backward motion consisting in an expansion-nozzle and movable reverse vanes located in the low-pressure stage only, upon which movable reverse vanes the fluid jet delivered by said expansion-nozzle at high velocity acts two or more times in succession at a single stage of expansion, substantially as set forth.

10. In an elastic-fluid turbine, the combination with movable vanes and coöperating expansion-nozzles operating by stage expansion for producing forward motion, of means for producing backward motion consisting in an expansion-nozzle and movable reverse vanes located in the low-pressure stage only, upon which movable reverse vanes the fluid jet delivered by said expansion-nozzle at high velocity acts two or more times in succession at a single stage of expansion, substantially as set forth.

11. In an elastic-fluid turbine constructed in sections inclosed in separate fluid-tight shells connected in succession, the combination with compound moving and stationary vanes in each of the two or more shells, and coöperating nozzles for producing the direct rotation of the turbine, of compound moving and stationary vanes in the low-pressure shell, and a coöperating nozzle for producing the reverse rotation of the turbine, substantially as set forth.

12. In an elastic-fluid turbine, a turbine-wheel composed of two or more wrought-metal disks clamped together, two or more wrought-metal rings secured to such disks at their peripheries, and vanes formed integral with said rings, substantially as set forth.

13. In an elastic-fluid turbine, a turbine-wheel composed of two or more wrought-metal disks clamped together, two or more wrought-metal rings secured to such disks at their peripheries, vanes formed integral with said rings, and wrought-metal bands encircling said vanes and secured thereto, substantially as set forth.

14. In an elastic-fluid turbine, a turbine-wheel composed of two or more wrought-metal disks and intermediate radial stiffening-bars clamped together, two or more wrought-metal rings secured to such disks at their peripheries, vanes formed integral with said rings, and wrought-metal bands encircling said vanes and secured thereto, substantially as set forth.

15. In an elastic-fluid turbine, a moving-vane wheel having its rim formed of two or more abutting wrought-metal rings, each having one or more annular rows of vanes formed integral therewith, substantially as set forth.

16. In an elastic-fluid turbine, the combination of two or more wrought-metal rings each having one or more annular rows of vanes formed integral therewith, such rings being rabbeted together, substantially as set forth.

17. In an elastic-fluid turbine, the combination with a sectional nozzle, of conduits for supplying the elastic fluid to such sections, each embracing a plurality of nozzle-sections, substantially as set forth.

18. In an elastic-fluid turbine, the combination with a sectional nozzle, of conduits less in number than the nozzle-sections extending back to valve-ports, and valve mechanism for opening and closing such ports, substantially as set forth.

19. In an elastic-fluid turbine, the combination with a sectional nozzle and conduits leading back to two sets of valve-ports, of two valves connected together and moved simultaneously, one having a greater width than the ports it covers, so as to open said ports only after the other valve has opened its ports, substantially as set forth.

20. In an elastic-fluid turbine, the combination with two turbine-sections connected in succession, each section having a delivery-nozzle and controlling-valve mechanism, of means for adjusting the valves of the second section independent of those of the first section to vary the intermediate pressure independent of variations in the terminal pressures, substantially as set forth.

21. In an elastic-fluid turbine, the combination with two or more turbine-sections connected in succession, each section having a delivery-nozzle and controlling-valve mechanism, of means connecting such valve mechanisms for simultaneous and proportional movement, and means for adjusting the connection with either or both valve mechanisms to vary the intermediate pressure independent of variations in the terminal pressures, substantially of set forth.

This specification signed and witnessed this 29th day of October, 1901.

CHARLES G. CURTIS.

Witnesses:

JNO. ROBT. TAYLOR,
JOHN LOUIS LOTSCH.