No. 780,790. PATENTED JAN. 24, 1905.

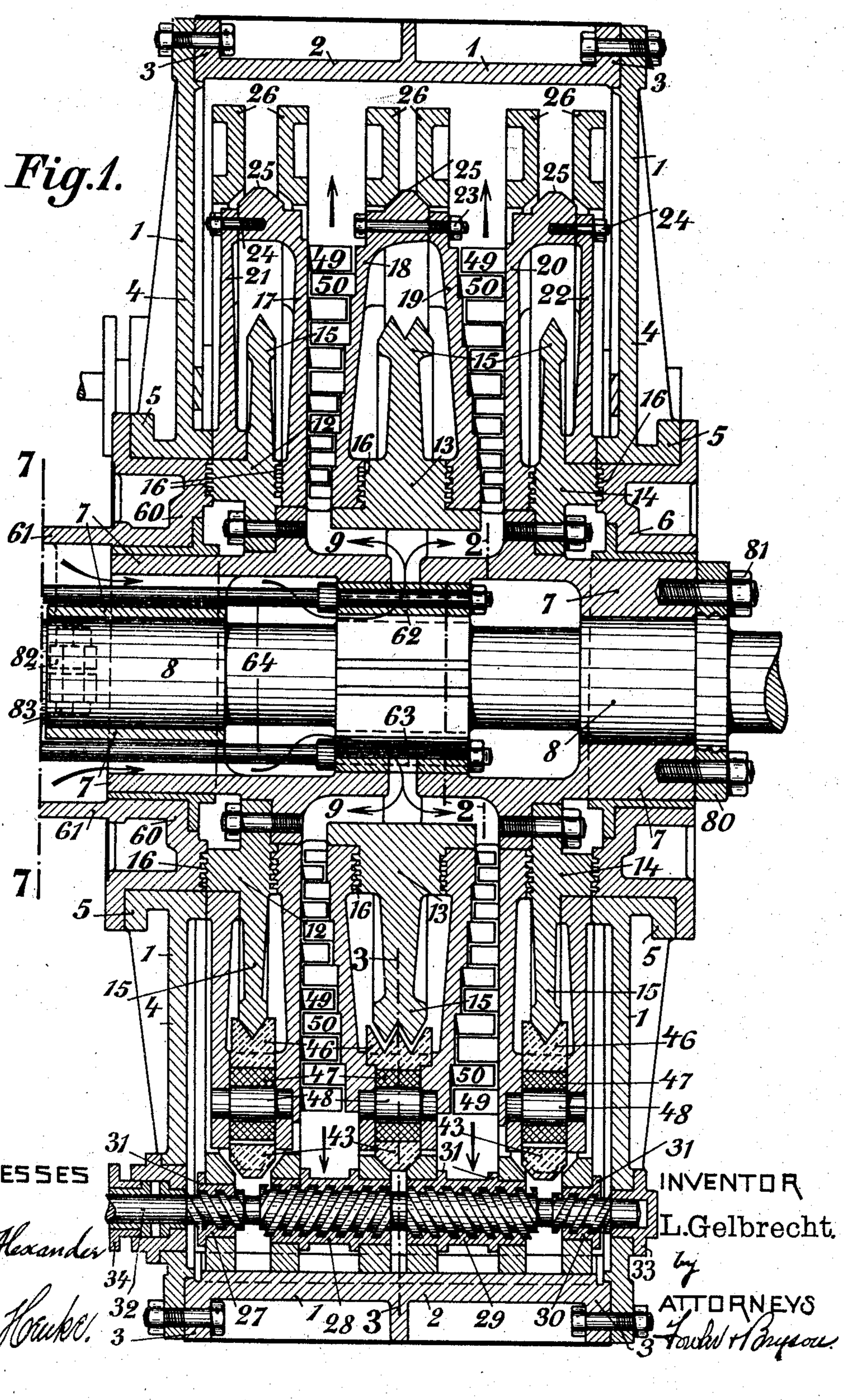
L. GELBRECHT.

REVERSIBLE TURBINE.

APPLICATION FILED JUNE 20, 1904.

5 SHEETS—SHEET 1.

Fig. 1.



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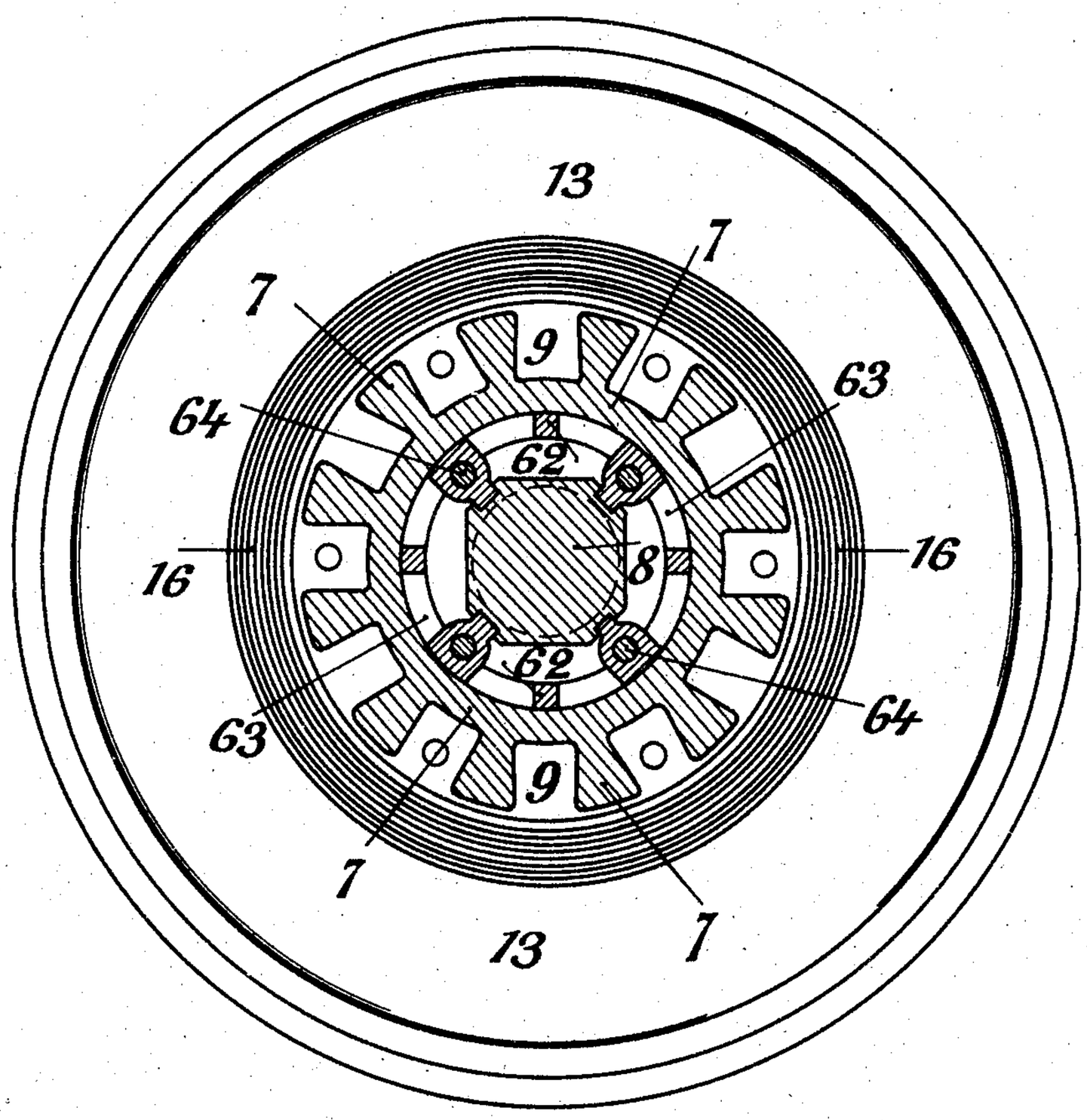
5 SHEETS—SHEET 2.

Fig. 2.



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5 SHEETS—SHEET 3.

Fig. 4.

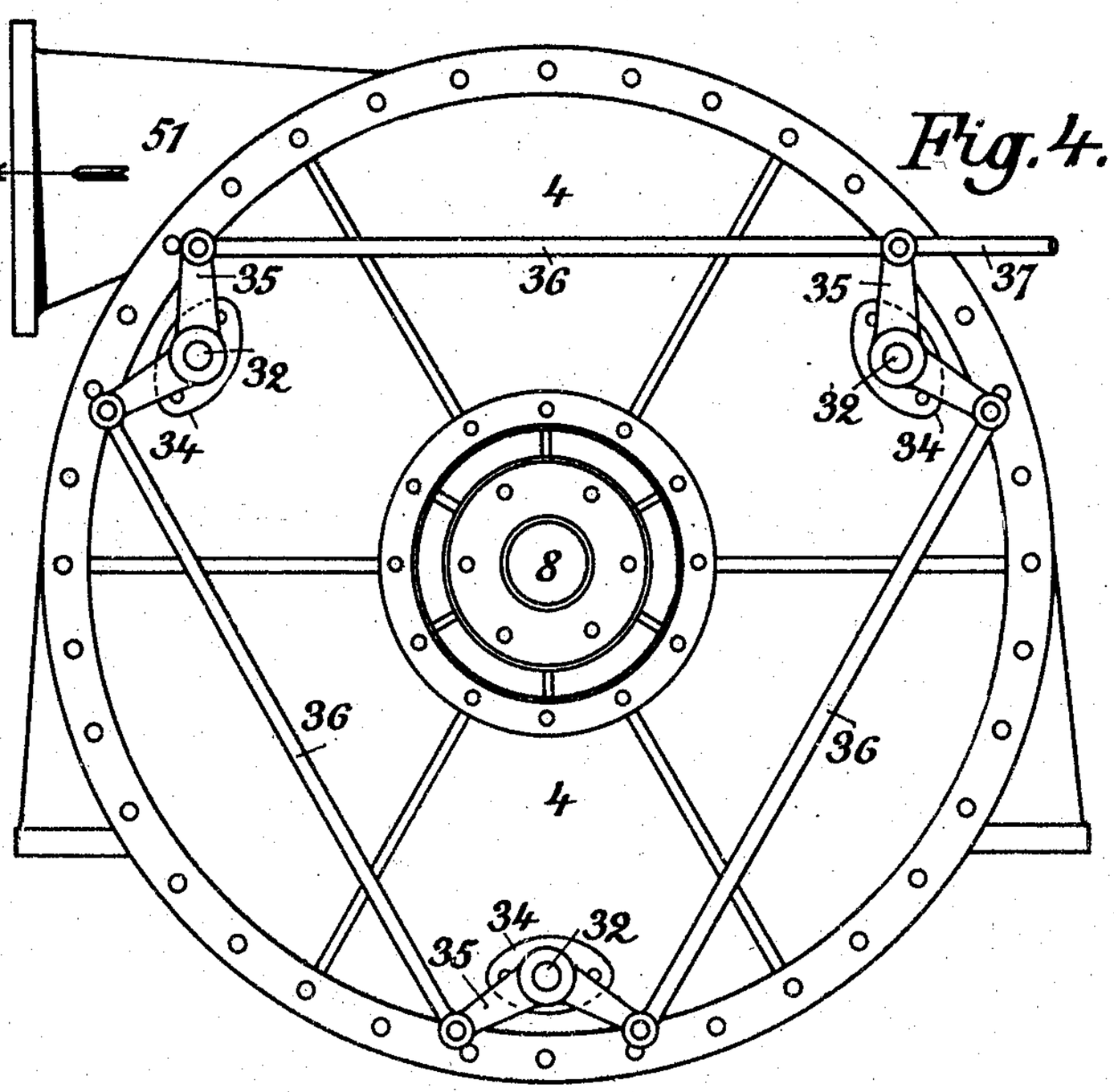
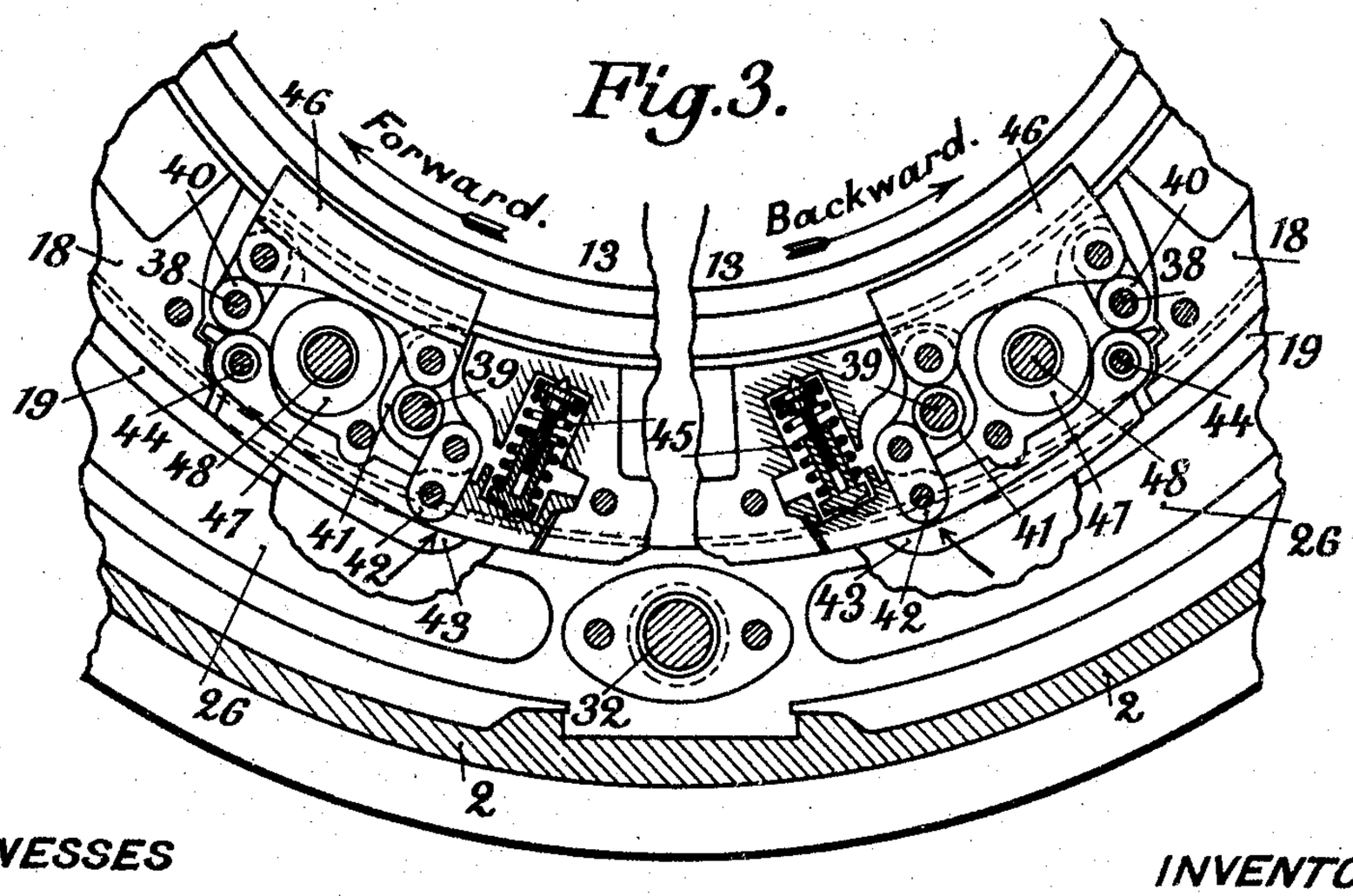


Fig. 3.



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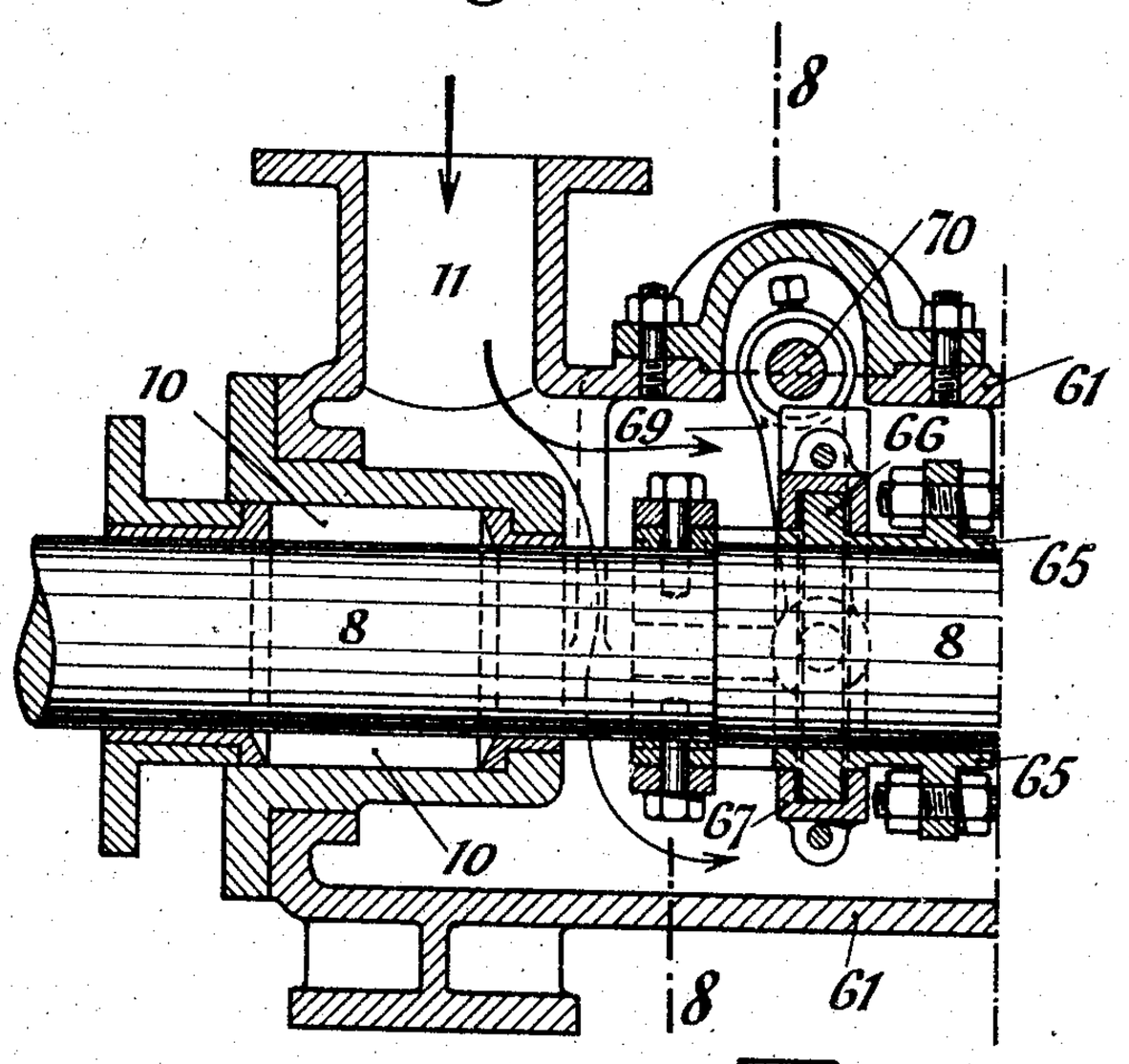
5 SHEETS—SHEET 4.

Fig. 5.



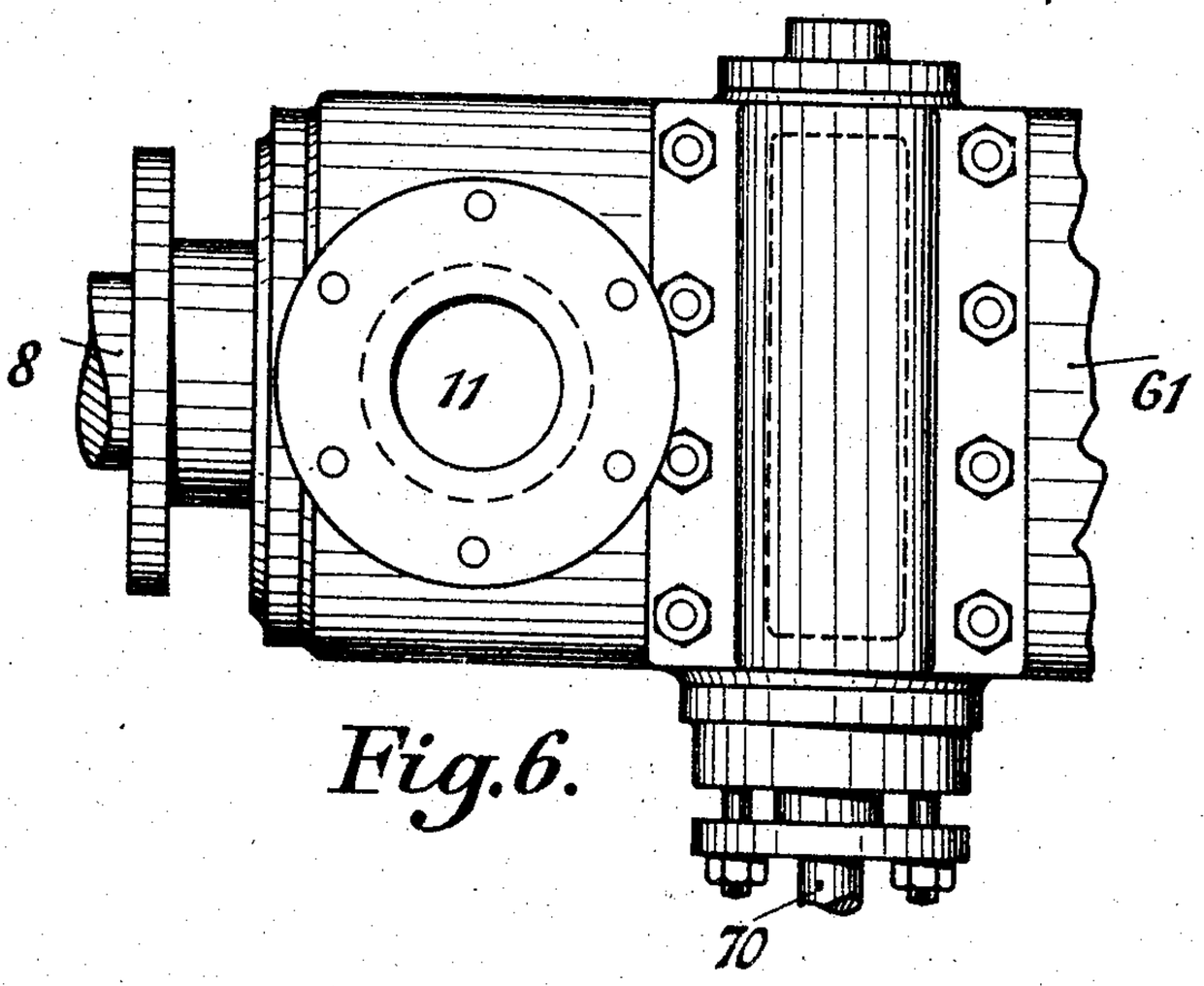


Fig. 6.

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5 SHEETS—SHEET 5.

Fig. 8.

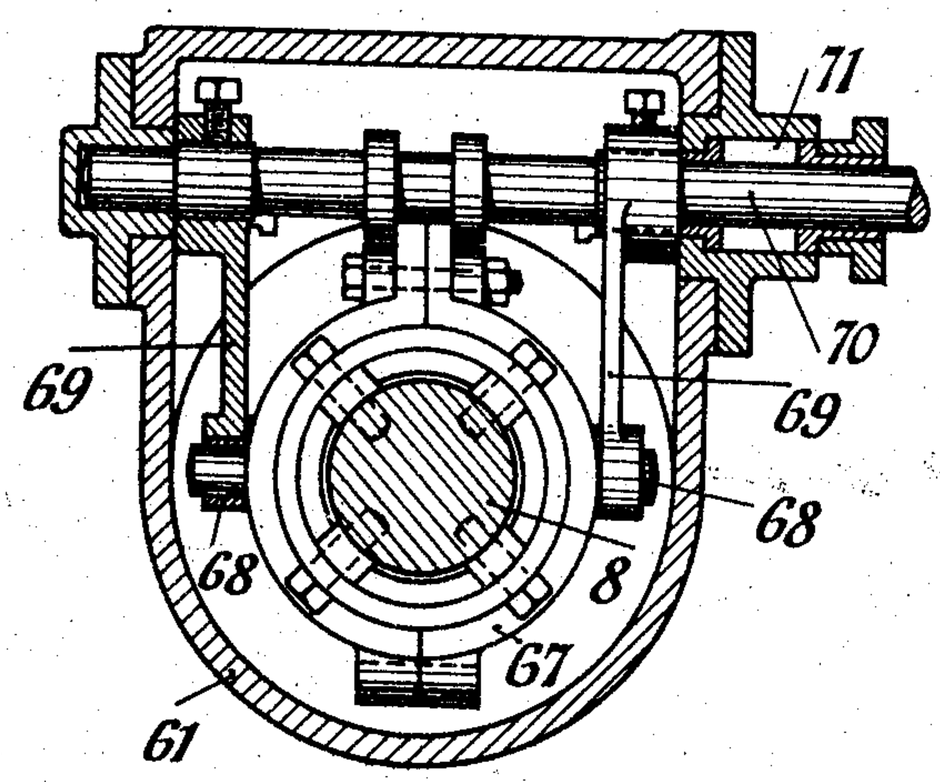
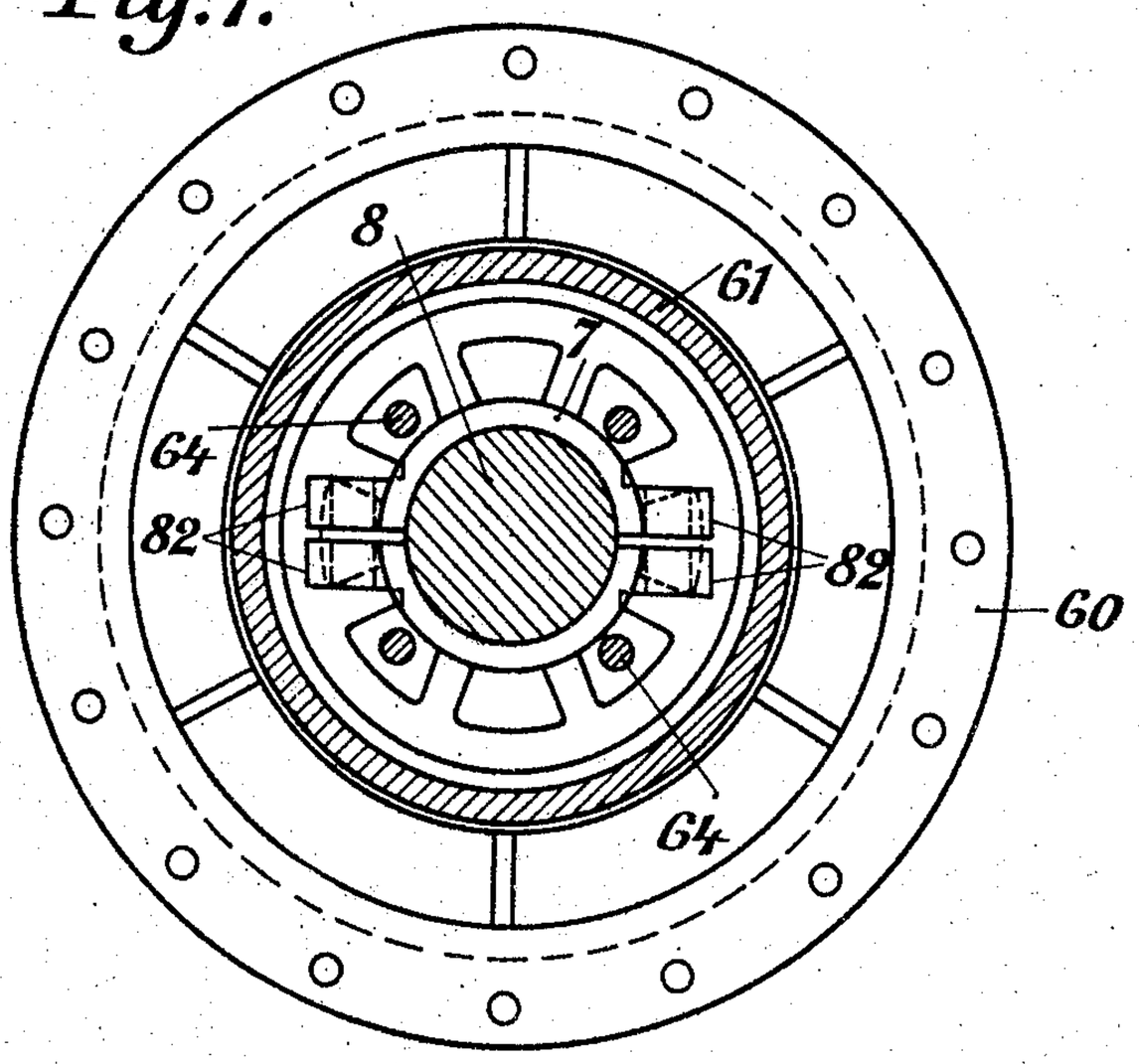


Fig. 7.



WITNESSES

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No. 780,790. Patented January 24, 1905.

UNITED STATES PATENT OFFICE.

LUDWIG GELBRECHT, OF BREMEN, GERMANY.

REVERSIBLE TURBINE.

SPECIFICATION forming part of Letters Patent No. 780,790, dated January 24, 1905.

Application filed June 20, 1904. Serial No. 213,246.

To all whom it may concern:

Be it known that I, LUDWIG GELBRECHT, engineer, a subject of the German Emperor, residing at 28 Moltkestrasse, Bremen, Germany, have invented certain new and useful Improvements in Reversible 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.

My invention refers to steam-turbines, and has for its object to make such turbines reversible, thus adapting them for the use as ships' engines and similar purposes.

The usual steam-turbine consists of sets of stationary and movable vanes forming a passage for the steam or gaseous fluid jet which thus is forced to pass a stationary and a movable set of vanes alternately. The stationary vanes operate to give the steam issuing from the preceding set of movable vanes the same direction which it had when entering that set of movable vanes, thereby making it available for entering and propelling a successive set of movable vanes. For this purpose the curvature of both sets of vanes, stationary and movable, may be practically the same, differing only in this, that while the one set of vanes appears convex with reference to any tangent the other set will appear concave with reference to the same tangent. It will therefore be theoretically irrelevant which of the two sets is made stationary and which movable; but accordingly as the one or the other set or series of sets is made movable the engine will be propelled in one or the other sense of rotation. According to my present invention this property of the steam-turbine is made use of for the purpose indicated.

The invention consists in supplying means for coupling either drum or disk carrying a set of or a series of alternate sets of vanes with the stationary parts of the machine, preferably the casing surrounding it and forming its support, and at the same time for coupling the drum or disk carrying the other set of vanes or series of alternate sets of vanes with the driving-shaft of the engine. Thus accordingly as the driving-shaft is coupled with either set or series of sets it will be propelled in one or the other sense of rotation, or, with other words, the engine will be reversed.

My invention also comprises means for effecting these couplings during the operation of the engine and other means for gradually and softly reducing the *vis viva* accumulated in the mass of revolving parts and transmitting the energy required for starting the stationary parts.

Of the accompanying drawings, Figure 1 is a vertical section through the preferred form of my improved turbine. Fig. 2 is a section on line 2 2 in Fig. 1, certain parts being omitted for the sake of clearness. Fig. 3 is part of a section on line 3 3 in Fig. 1, showing preferred means for coupling the drums or disks carrying the operating-vanes with the driving-shaft. Fig. 4 is an end view, on a reduced scale, showing means for operating the coupling of the drums or disks carrying the working vanes either with the driving-shaft or with the stationary part of the engine. Fig. 5 is a vertical section through part of the machine, completing the section shown in Fig. 1. Fig. 6 is a plan view of the part shown in section in Fig. 5. Fig. 7 is a section on line 7 7 in Fig. 1, and Fig. 8 is a section on line 8 8 in Fig. 5.

The same numerals of reference are used in all the figures to indicate the same parts.

Referring to Fig. 1, 1 is the stationary casing surrounding the whole machine and forming its frame or support. The casing consists of the cylindrical part 2, provided with flanges 3, to which are fixed by bolts or in any other way approved in the art the two flat lids or covers 4, thus constituting a closed box. At their centers the covers 4 are provided with flanges 5, forming cylindrical recesses into which the bearings 6 and 60 are tightly fitted and secured by bolts around their circumferences, so that they form a practically integral piece with the said covers 4. In these bearings the hollow shaft or axle-box 7 is journaled so as to turn freely therein. Into this axle-box is fitted a driving-shaft 8, which at one end is provided with a flange or shoulder 80, secured to the end of the axle-box 7 by means of screws 81. The opposite end of the axle-box 7 is slotted and provided with later-

ally-projecting eyes 82, which are compressed by bolts 83. Thus it will be understood that the axle-box 7 and driving-shaft 8 are rigidly locked together and may for purposes of explanation be assumed to be integral.

Integral with the bearing 60 is a projecting casing 61, (see Figs. 5 to 8,) ending in a stuffing-box 10 or other approved means for forming a steam-tight joint, through which the driving-shaft 8 passes out. The latter is shown broken off in Figs. 1 and 5; but it is assumed to be connected in any approved way with such machinery that is to be driven by the turbine—as, for instance, the propeller of a vessel. The projecting casing 61 is provided with a stud 11, which is supposed to be connected with the boiler or other source of compressed fluid employed in driving the engine. Through this stud 11 the driving agent is admitted. It traverses the interior of the casing 61 and enters the axle-box 7, from whence it issues through a series of ports 9, the outer openings of which register with the inner circumferences of the working passages containing the vanes.

Between the inner ends of the ports 9 and the driving-shaft 8 a sleeve 62 is inserted and is likewise provided with a number of ports 63, which in the normal position of the sleeve register with the inner ends of the ports 9. The sleeve 62 is secured to four rods 64, passing outward into the casing 61 and secured at their outer ends to another sleeve, 65. Both sleeves 62 and 65 are fitted onto the shaft 8 in such a way as to slide freely lengthwise upon it, and the fit of the sleeve 62 is made so close that it is practically steam-tight. The sleeve 65 is provided with a shoulder 66, upon which rides loosely a ring 67, having studs or journals 68 on opposite sides. These journals cooperate with a pair of cranks 69, keyed to shaft 70, which passes out of the casing 61 through a stuffing-box or steam-tight joint 71. The shaft 70 is shown broken off in Fig. 8; but it is supposed to be connected in any approved way with a governor, (not shown in the drawings, since its application will readily be understood by anybody who is conversant with the art.) It will be understood from the foregoing that if the shaft 70 is rocked the sleeves 65 and 62 will be shifted lengthwise with relation to the axle-box 7 and the ports 9 will thereby be partially or completely closed, thus regulating the steam-supply to the working passages containing the vanes.

Rigidly secured to the axle-box 7 by suitable means are three disks 12, 13, and 14, having beveled rims 15. The boss of each of these disks is made somewhat thicker than the rest of the disk and is provided on its front or flat side with a number of ring-shaped flanges 16. The outer sets of these flanges on the disks 12 and 14 register with a corresponding number of concentric grooves formed in the abutting fronts of the bearing-pieces 6 and 60. The flanges and grooves are fitted loosely, so that no appreciable friction is caused thereby when the axle-box 7, with the disks, revolves; but nevertheless a practically steam-tight joint is formed. The inner faces of disks 12 and 14 and both faces of disk 13 are provided with similar sets of concentric flanges, which coöperate in the same way with grooves fashioned in the abutting fronts of disks 17, 18, 19, and 20, loosely mounted on the hollow shaft 7.

The disks 18 and 19 are rigidly connected together by bolts 23, arranged around their circumference, so that they constitute a hollow casing or drum surrounding the disk 13. Other disks 21 and 22 are also provided outside the disks 12 and 14 and likewise loosely mounted on the axle-box 7 and similarly connected at their circumference by means of bolts 24 with disks 17 and 20, so as to form hollow casings or drums surrounding the disks 12 and 14.

The disks 17, 18, and 20 are provided with projecting rims 25, having beveled edges adapted to coöperate with corresponding beveled surfaces fashioned on the inner sides of a series of rings 26, a pair of which is provided for every drum 21 17, 18 19, and 20 22. These rings 26 are supported on three sets of sleeves 27, 28, 29, and 30, one of which only appears in the section represented in Fig. 1, since they are distributed at equal distances round the circumference of the engine. The sleeves are rigidly secured to the rings 26 and are provided with projecting shoulders 31, adapted to prevent any longitudinal displacement of the rings with relation to the sleeves. In the interior of each of these sleeves threads are cut so that the sleeves really constitute so many nuts coöperating with and supported by correspondingly-threaded spindles 32. The spindles 32 are rotatably journaled in bearings 33 and 34, secured to the covers 4. The bearing 33 is closed, and the bearing 34 is made after the fashion of a stuffing-box or in any other approved way, so as to allow the spindle 32 to pass through it out of the cover 4 and to form a steam-tight joint. The threads on the spindles 32 and in the sleeves 27 to 30 are alternately left and right hand threads. If, therefore, the spindles 32 are turned one way, the result will be that the pair of rings 26 surrounding the drum 18 19 are approached and the pairs of rings 26 surrounding the drums 21 17 and 20 22 are separated, and vice versa if they are turned the opposite way.

Means for simultaneously rocking the three spindles 32 either one way or the other are separately illustrated in Fig. 4. Keyed to the projecting end of each of the spindles is a bell-crank lever 35, and the free ends of these cranks are connected by means of links 36. It will be seen that thus if one of the cranks is rocked the other two will be obliged

to rock through the same angle and in the same sense of rotation. One of the cranks is controlled by a rod 37. If therefore this rod 37 is advanced or withdrawn, the rings 26 will be either closed upon the outer drums 21 17 and 20 22 and separated from the inner drum 18 19, or vice versa.

The drums 17 to 22 are rotatable either simultaneously with or independently of the axle-box 7; but the rings 26 are not rotatable, since they are supported upon the spindles 32, which pass through them. If therefore one or more of the drums are revolved and the corresponding rings 26 are closed upon it slowly, they will gradually consume by friction the *vis viva* accumulated in the mass of the drum until they are tightly locked upon it and have thus coupled it with the main casing of the machine and transformed it from a rotatable into a stationary part of the engine.

I wish it to be understood that the illustrated means for simultaneously rocking the three shafts 32 are not the only means available for this purpose, since any person expert in the art will be able to substitute equivalent means without thereby altering the nature of my present invention.

Referring to Fig. 3, it will be seen that on the inside of the drums 17 to 22 a number of brake-shoes are provided, adapted to effect a coupling between the respective drum and the inclosed disk 12 to 14. Two pins or bolts 38 and 39 are fixed in the circumference of the drum. On bolt 38 is pivoted a link 40 and on bolt 39 is pivoted a bell-crank lever 41. The link 40 and the corresponding arm of the bell-crank lever 41 are both pivotally connected with either end of a brake-shoe 46, adapted to bear against the beveled rim 15 of the disk 13. The fixed pivots 38 and 39 and the pivots in the brake-shoe are arranged to form a parallelogram. It will be seen that this arrangement will act to press the brake-shoe 46 against the circumference of the disk 13 whenever the bell-crank lever 41 is swung outward. The free arm of the bell-crank lever 41 is connected by a link 42 to a lever 43, having a fixed pivot at 44. The free end of lever 43 is provided with a recess which registers with a similar recess fashioned in the opposite surface of the disk 18. The cylindrical space formed by these two recesses is filled up by a spring 45, which tends to push the lever 43 away from the circumference of the disk 18. This spring therefore tends to swing the bell-crank lever 41 outward, and thereby to press the brake-shoe 46 against the beveled rim of the disk 13. The action of the spring 45 is backed up by the centrifugal force, which likewise tends to throw the lever 43 outward when the disk 18 is rotating. When the lever 43 is swung out, so as to bring the brake-shoe to bear upon the rim, its back projects beyond the rim of disk 18. This projecting curved back of the levers 46 is intended to coöperate with the rings 26. It will be seen that when the rings 26 are approached by means of the spindles 32 their beveled inner edges in closing upon the rim of the drum 18 19 or either of the other two drums will force the levers 43 inward, thus withdrawing the brake-shoes 46 from the rims of the inner disks 12, 13, or 14. Since the full torque generated by the impact of the steam-jet upon the vanes is transmitted through these brake-shoes 46 upon the disks 12 and 14 or the disk 13, the pressure of the springs 45, though aided by the centrifugal force, would not be sufficient to effect a secure and reliable coupling between the driving and driven parts. Therefore special means are provided for automatically increasing the pressure of the brake-shoes when they have been advanced so as to contact the rim of the inner disk by the action of spring 45 and the centrifugal force. Such means may, for instance, consist in the rollers 47, journaled on fixed pins or bolts 48, secured in the circumference of the casing. The back of the brake-shoe is made concave, so as to taper from the point of contact, with the circumference of the roller 47 toward the point of connection with the link 40. Therefore the surface facing the rim of the inner disk 12, 13, or 14 and the surface facing the roller 47 constitute together a wedge. When the bell-crank lever 41 is swung outward, its arm connected with the brake-shoe performs a tangential movement with relation to the drum, and thereby draws in the wedge-shaped part of the brake-shoe between the roller 47 and the circumference of the disk 13. At the time when this coupling action takes place it is to be understood that the disk 18 is at rest, while the inner disk 13 is revolving. The sense of rotation is such that the friction of the rim of the inner disk upon the inner surface of the brake-shoe tends, further, to draw the latter in between the rim of the inner disk and the roller 47. Thus by the action of the machine itself the brake-shoe is jammed as tight as is necessary to transmit the torque, and the more the torque increases the tighter the brake-shoes will be jammed.

The vanes 49 and 50 are secured to the inside faces of the disks 17 and 20 and to the outside faces of the disks 18 and 19, respectively. They are disposed in the usual manner in concentric circles, and thus constitute the working passage for the propelling agent. A discharge-port 51 is provided near the periphery of the main casing, as shown in Fig. 3.

The operation of the described turbine is as follows: In the position shown in Fig. 1 the rings 26 are closed on the drum 18 19, and this drum is therefore held stationary. At the same time the rings 26 by closing have depressed the levers 43 and have thereby retracted the brake-shoes 46 against the force of the springs 45. Therefore the inner disk 13, and with it the axle-box 7 and the driving-shaft 8,

is free to revolve. On the other hand, the rings 26, surrounding the two outer drums 17 21 and 20 22, are separated, and therefore these drums are free to revolve; but they are coupled, by means of the brake-shoes 46, with the inner disks 12 and 14 and will therefore in revolving propel those disks, and thereby transmit their motion to the axle-box 7 and to the driving-shaft 8. The sets of vanes 50, secured to the inner drum, will act as stationary vanes and the vanes 49 on the two outer drums as movable vanes. The steam will enter at the inlet-port 11, pass through the ports 9 in the axle-box 7, will then make its way through the working passage, propelling the movable vanes, and thereby the driving-shaft, and will finally issue at the discharge-pipe 51. The engine will revolve in the sense indicated by the arrow marked "forward" in Fig. 3. When it is desired to reverse the engine, the rod 37 is advanced. The bell-crank levers 35 are rocked, and thus the spindles 32 turned sufficiently to separate the nuts 28 and 29 and approach the nuts 27 and 30, thus locking the drums 17 21 and 20 22 to the outer casing of the machine and depressing the levers 46, belonging to these two outer drums, and thereby liberating the inner disks 12 and 14 and at the same time liberating the drum 18 19 and the levers 43, belonging to that drum. By this latter action the respective brake-shoes 46 are brought to bear upon the rim of the disk 13. The result is that the sets of vanes 49 now become stationary and the sets of vanes 50 movable, and the machine will in consequence revolve in the sense of the arrow marked "backward" in Fig. 3. Since the coupling and uncoupling of the sets of vanes or of the drums supporting them takes place gradually and by means of friction devices, it will be possible with the help of my improved reversing-gear to reverse the engine without allowing it to come to rest beforehand. The *vis viva* stored in the revolving masses will be consumed by the friction between the rings 26 and the beveled rims of the drum supporting the vanes and the brake-shoes 46 and the rims of the inner disks, respectively.

I desire it to be understood that various parts of the described machine could be replaced by other equivalent devices without altering the nature of my invention.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is—

1. In a reversible steam-turbine, the combination with a stationary part, of a rotary part, two sets of vanes, means for coupling either of said sets of vanes to said stationary part, and means for coupling either of said sets of vanes to said rotary part, said latter coupling means being controlled by the first-named coupling means.

2. In a reversible steam-turbine, the combination with a stationary part, of a rotary part, two sets of vanes, means for frictionally coupling either of said sets of vanes to said stationary part, and means for frictionally coupling either of said sets of vanes to said rotary part, said latter coupling means being controlled by the first-named coupling means.

3. In a reversible steam-turbine, the combination with a stationary part, of a rotary part, two sets of vanes, positively-actuated means for coupling either of said sets of vanes to one of said parts, and spring-actuated means for coupling either of said sets to the other of said parts.

4. In a reversible steam-turbine, the combination with a stationary part, of a rotary part, two sets of vanes, positively-actuated means for coupling either of said sets of vanes to one of said parts, and spring-actuated means for coupling either of said sets of vanes to the other of said parts, said latter coupling means being controlled by said first coupling means.

5. In a reversible steam-turbine, the combination with a stationary part, of a rotary part, two sets of vanes, positively-actuated means for frictionally coupling either of said sets of vanes to one of said parts, and spring-actuated means for frictionally coupling either of said sets of vanes to the other of said parts.

6. In a reversible steam-turbine, the combination with a stationary part, of a rotary part, two sets of vanes, positively-actuated means for frictionally coupling either of said sets of vanes to one of said parts, and spring-actuated means for frictionally coupling either of said sets of vanes to the other of said parts, said latter-named coupling means being controlled by said first-named coupling means.

7. In a reversible steam-turbine, the combination with a stationary part, of a rotary part, two sets of vanes, positively-controlled means for coupling either of said sets of vanes to one of said parts, coupling devices for coupling either of said sets of vanes to the other of said parts, springs for actuating said coupling devices, and auxiliary means in addition to said spring for actuating said coupling devices.

8. In a reversible steam-turbine, the combination with a stationary part, of a rotary part, two sets of vanes, positively-controlled means for frictionally coupling either of said sets of vanes to one of said parts, frictional coupling devices for coupling either of said sets of vanes to the other of said parts, springs for actuating said coupling devices, and auxiliary means in addition to said springs for actuating said coupling devices.

9. In reversible steam-turbines the combination with two sets of vanes both rotatably mounted upon a hollow driving-shaft of means for coupling either of the said sets of vanes with the stationary part of the machine and of other means for coupling the other set of

vanes with the driving-shaft, such latter means being controlled by the first-mentioned coupling means.

10. In reversible steam-turbines the combination of the following instrumentalities, to wit: a stationary casing surrounding the engine, a hollow driving-shaft journaled in said casing and provided with ports adapted to admit steam to the interior, two sets of vanes both rotatably mounted on said shaft, two sets of frictional coupling devices the one being adapted to couple either of the sets of vanes with the casing and the other being adapted to couple either of the sets of vanes with the driving-shaft and means for automatically counteracting the action of the latter set of coupling devices when the former is actuated.

11. In a reversible steam-turbine the combination of the following instrumentalities, to wit: two sets of vanes both rotatably mounted on a shaft rotatably mounted in the stationary casing of the engine, a spring-actuated frictional coupling device tending to couple the said sets of vanes with the said shaft and a hand-actuated frictional coupling device adapted to couple either of the said sets of vanes with the stationary casing and means for automatically preventing the action of the former coupling device with regard to that set of vanes which is coupled to the stationary casing by means of the latter coupling device.

12. In a reversible steam-turbine the combination of the following instrumentalities to wit: a hollow driving-shaft rotatably journaled in a stationary casing, disks secured to said shaft, hollow drums rotatably mounted upon said shaft and surrounding said disks and supporting alternate sets of vanes, ports provided in said shaft and adapted to admit steam to said vanes, spring-pressed frictional means for coupling said drums with said disks, other frictional means for coupling said drums with the said stationary casing and means for automatically preventing the action of the said spring-pressed means in such of the said drums which are coupled to the stationary casing.

13. In a reversible steam-turbine the combination of the following instrumentalities, to wit: a hollow shaft provided with ports to admit steam to the vanes, such hollow shaft being rotatably journaled within a stationary casing, disks rigidly mounted upon said shaft, hollow drums rotatably mounted upon said shaft and surrounding said disks such drums supporting alternate sets of vanes, spring-pressed brakes bearing upon said disks and thereby tending to couple said drums to said disks, means for frictionally coupling said drums to the stationary casing and other means for retracting said spring-pressed brakes when said drums are coupled to the casing and means for automatically increasing the frictional pressure of said brakes.

14. In a reversible steam-turbine the combination of the following instrumentalities, to wit: a hollow shaft journaled in a stationary casing, disks rigidly mounted on said shaft, hollow drums rotatably mounted on said shaft and surrounding said disks, said drums supporting alternate sets of vanes, ports provided in said hollow shaft and adapted to admit steam to said vanes, spring-pressed means for frictionally coupling said drums to said disks, pairs of friction-rings surrounding said drums, means for closing said pairs of rings on the drums supporting either of the said sets of vanes and separating the pairs surrounding the drums supporting the other set of vanes and means for counteracting the said spring-pressed means when the respective pair of said friction-rings is closed.

15. In a reversible steam-turbine the combination of the following instrumentalities, to wit: a hollow shaft journaled in a stationary casing, disks rigidly secured to said shaft, hollow drums surrounding said disks and rotatably mounted upon said shaft, alternate sets of vanes supported by said drums, ports provided in said hollow shaft and adapted to admit steam to said vanes, spring-pressed brake-shoes provided in the circumference of said drums and adapted to bear upon the rims of said disks, levers normally projecting beyond the rims of said drums and adapted to control said brake-shoes, pairs of friction-rings surrounding said drums, means for closing said pairs of rings upon the rims of said drums, and thus simultaneously coupling said drums to the stationary casing and depressing said projecting levers.

16. In a reversible steam-turbine the combination of the following instrumentalities, to wit: a hollow shaft journaled rotatably in a stationary casing, disks rigidly keyed to said shaft, hollow drums rotatably mounted on said shaft and surrounding said disks, alternate sets of vanes supported by said drums, ports provided in said shaft and adapted to supply steam to said vanes, spring-pressed brakes provided in the circumference of said drums and adapted to bear upon the rims of said disks, levers normally projecting beyond the rims of said drums and arranged to control said brakes, pairs of friction-rings adapted to close upon the rims of said drums and thereby to depress said levers and retract said brakes, left and right hand threaded spindles journaled in said casing and passing through nuts rigidly connected with said rings and means for simultaneously rocking said spindles through equal angles of rotation.

In testimony whereof I have hereunto set my hand and affixed my seal in the presence of the two subscribing witnesses.

LUDWIG GELBRECHT. [L. S.]

Witnesses:
HENRY HASPER,
WOLDEMAR HAUPT.