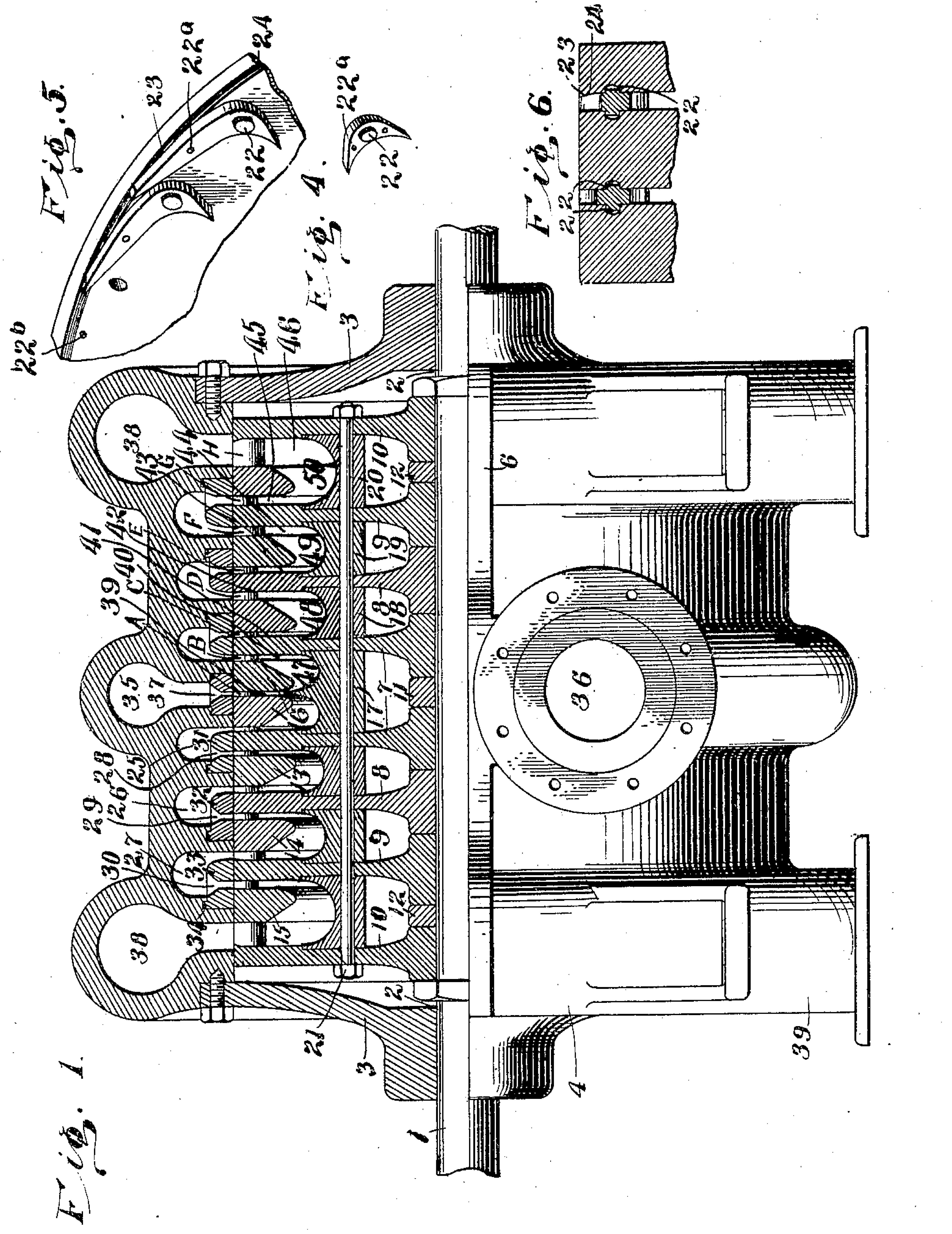
No. 794,614. PATENTED JULY 11, 1905.

R. H. GOLDSBOROUGH.

TURBINE.

APPLICATION FILED JAN. 9, 1905.

4 SHEETS—SHEET 1.



Witnesses
H. A. Robinette
E. L. Horn

Inventor
Richard H. Goldsborough

By G. Ayres.

Attorney

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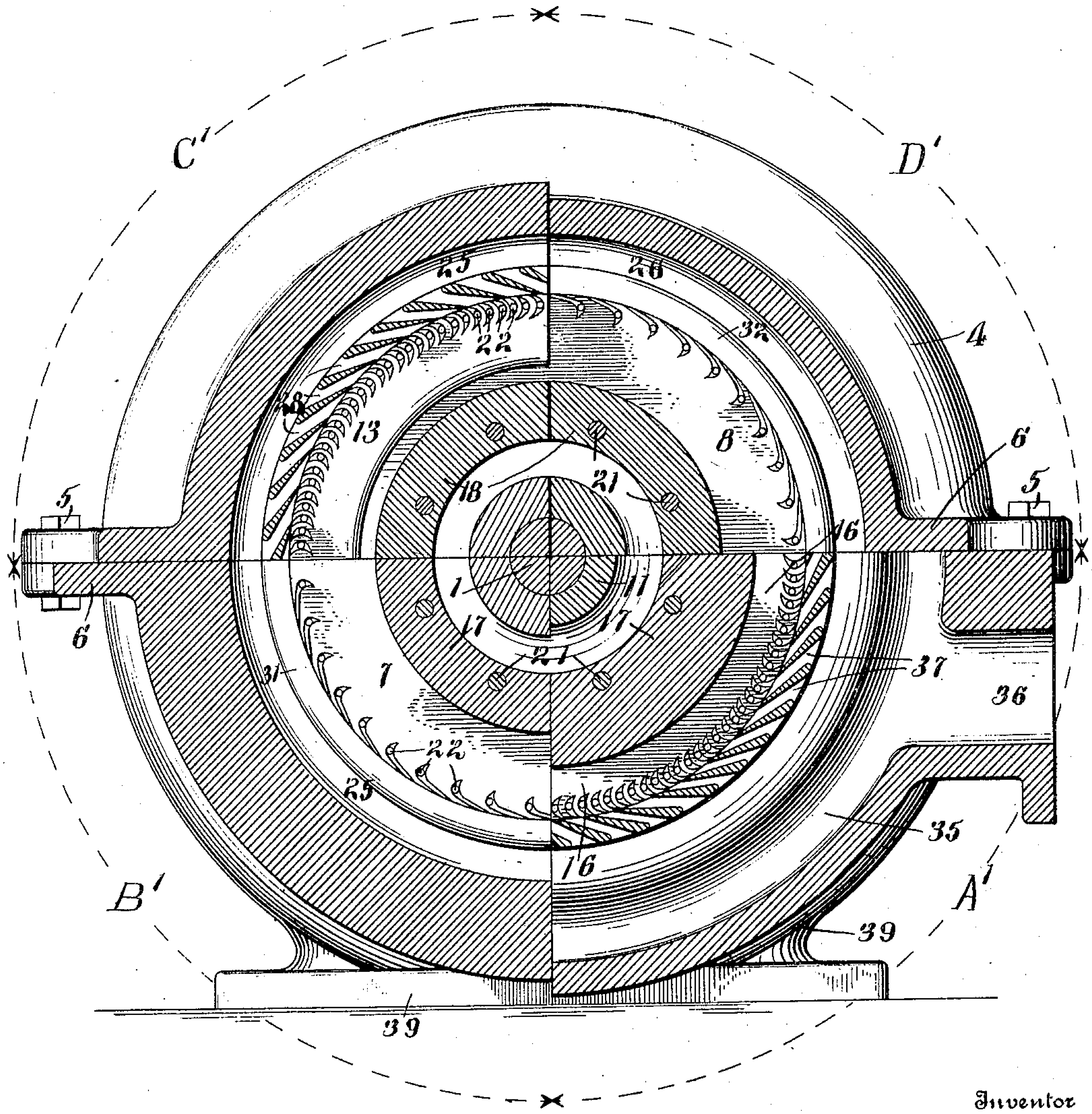
4 SHEETS—SHEET 2.

Fig. 2



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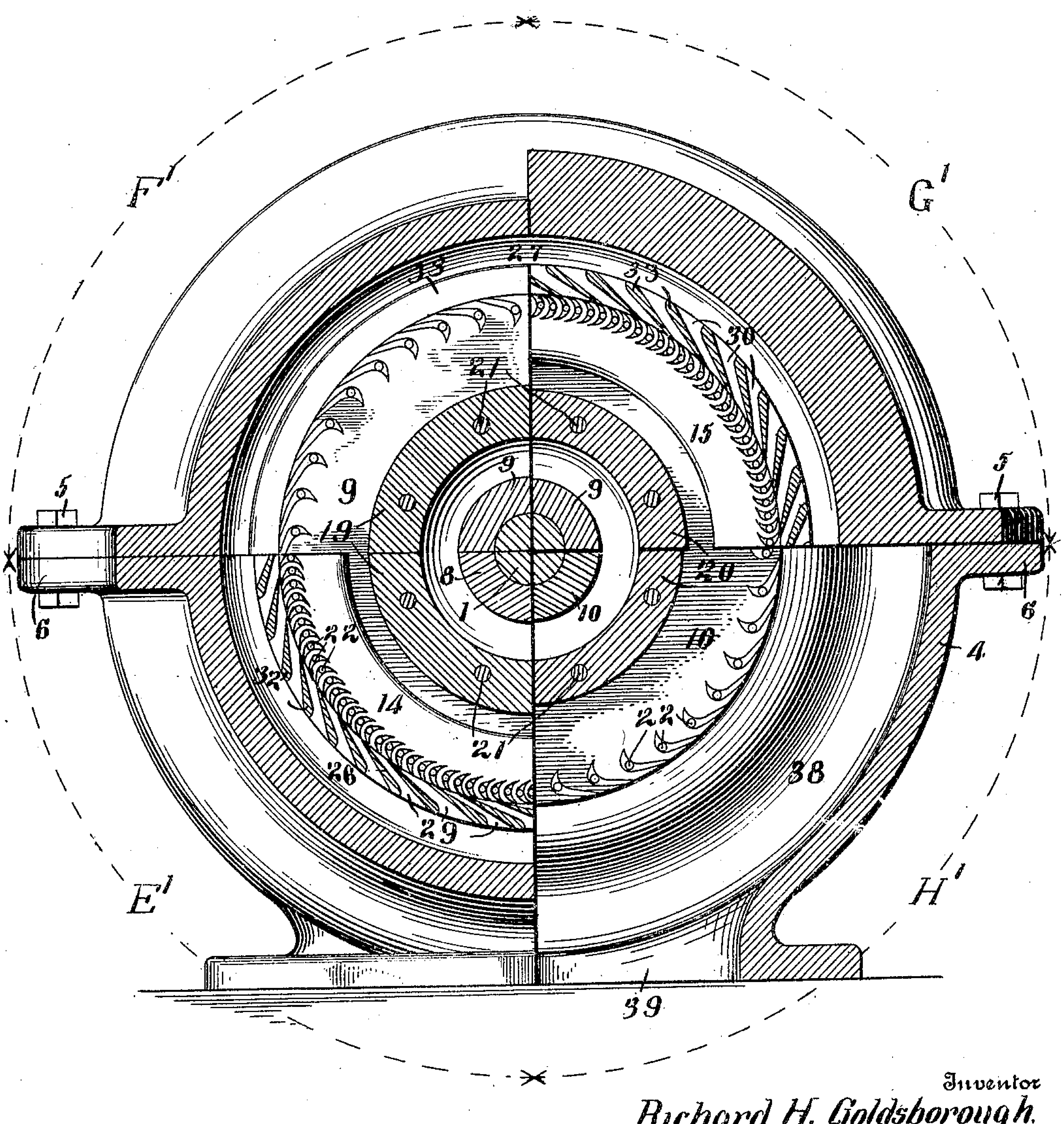
4 SHEETS—SHEET 3.

Fig. 3



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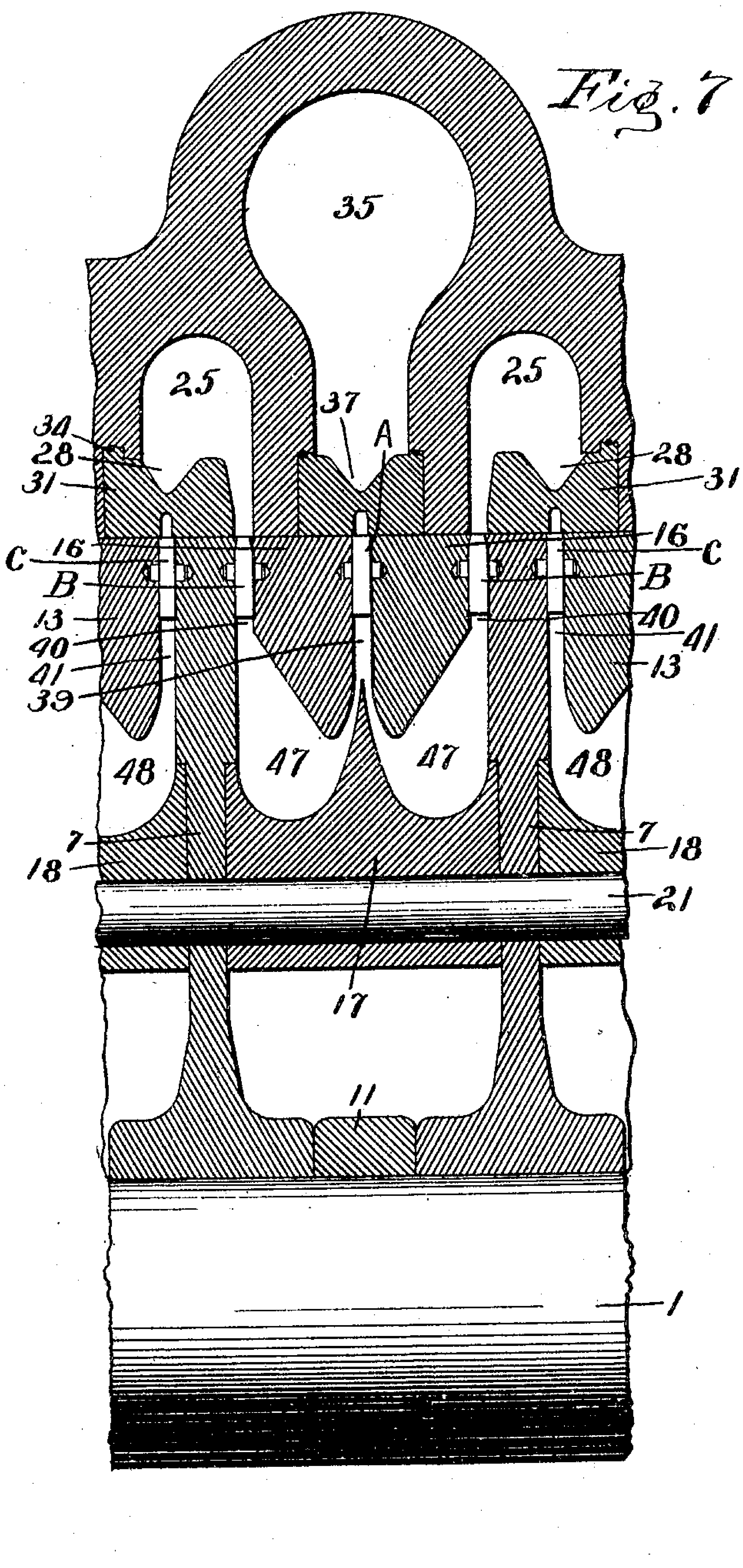
4 SHEETS—SHEET 4.

Fig. 7



Witnesses
H. A. Robinette
E. L. Horn.

Inventor
Richard H. Goldsborough.
By Attorney
G. Ayres

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UNITED STATES PATENT OFFICE.

RICHARD H. GOLDSBOROUGH, OF WASHINGTON, DISTRICT OF COLUMBIA.

TURBINE.

SPECIFICATION forming part of Letters Patent No. 794,614, dated July 11, 1905.

Application filed January 9, 1905. Serial No. 240,264.

To all whom it may concern:

Be it known that I, RICHARD H. GOLDSBOROUGH, a citizen of the United States, residing at Washington, in the District of Columbia, have invented certain new and useful Improvements in Turbines, of which the following is a specification.

My invention relates to compound types of turbines; and it consists in the constructions, combinations, and arrangements herein described and claimed.

The objects of my invention are to provide an improved form of compound turbine in which the energy of the steam or other actuating fluid is utilized in successive stages, partially in the form of pressure or static energy and partially in the form of *vis viva* or kinetic energy, with an avoidance of the large aggregate of losses occurring in existing types of multiple compound turbines.

A further object of my invention is to provide an improved multiple-stage turbine in which the steam from each stage is deflected for directing it in an efficient manner to the next succeeding stage with a minimum loss during such deflection.

A further object of my invention is to provide a compound turbine in which portions of the energy of the steam are successively imparted to alternate annular series of kinetic and pressure vanes, whereby the very material losses due to wasteful and inefficient expansion and regeneration in existing types of compound turbines are minimized and a highly-efficient utilization of the steam is obtained at a relatively low vane speed.

Referring to the accompanying drawings, forming a part of this application, in which similar reference-symbols indicate corresponding parts in the several views, Figure 1 is a side elevation illustrating one embodiment of my invention with the upper half shown in longitudinal section. Fig. 2 is a transverse sectional view, the successive quarters or quadrants A′, B′, C′, and D′ of said view being taken on planes passing, respectively, through the annular series of vanes A, B, C, and D in Fig. 1. Fig. 3 is a view similar to Fig. 2, its successive quarters or quadrants E′, F′, G′, and H′ being taken on the planes passing, respectively, through the annular series of vanes E, F, G, and H in Fig. 1. Fig. 4 is a detail perspective view, on an enlarged scale, of one of the kinetic vanes, showing the end lugs or pins for securing it in place. Fig. 5 is a similar view of two adjacent pressure-vanes, showing their securing-lugs and inclined end surfaces; and Fig. 6 is a detail sectional view showing the securing lugs or pins of the vanes fitting corresponding recesses in the abutting walls of adjacent disks and outer annular members. Fig. 7 is an enlarged view of a portion of Fig. 1, clearly illustrating the annular passages and chambers hereinafter described.

Referring especially to Figs. 1, 2, and 3 of the drawings, 1 indicates a turbine-shaft suitably journaled at 2 2 in the heads 3 3 of a turbine-casing 4, which latter is shown comprising two semicylindrical portions secured together by the bolts 5, engaging flanges 6 thereon. Two similar sets of disks 7, 8, 9, and 10 are carried by the turbine-shaft, spacing-collars 11 and 12 being shown positioned, respectively, between the pairs of disks 7 7 and 9 10. Outer annular members or rings 13, 14, and 15 are arranged, respectively, between the pairs 7 and 8, 8 and 9, and 9 and 10 of each set of disks, preferably with their outer peripheries lying in a common cylindrical plane with the peripheries of said disks. Annular series of vanes C, D, E, F, G, and H are securely clamped between the adjacent side faces of the disks 7 and rings 13, rings 13 and disks 8, disks 8 and rings 14, rings 14 and disks 9, disks 9 and rings 15, and rings 15 and disks 10, respectively, as clearly shown in Fig. 1. Two outer annular members 16 are arranged between the two disks 7, an initial annular series of vanes A being clamped between said two members, and a second annular series of vanes B being clamped between each member 16 and the adjacent disk 7. In the construction shown the vanes A, C, E, and G are of the kinetic type, while the alternate sets of vanes B, D, F, and H are of the pressure type. Inner annular members or rings 17, 18, 19, and 20 are arranged, respectively, within the outer rings 16, 13, 14, and 15 between the disks 7 and 7, 7 and 8, 8 and

9, and 9 and 10. Suitable clamping means, such as a plurality of bolts 21, passing through the several disks and inner rings, are provided for rigidly locking the parts together and securely clamping the several sets of vanes between the side faces of the disks and outer rings. The faces of the disks and inner and outer rings constitute the rotating walls of inner annular passages or channels for receiving the steam from the several series of kinetic vanes A, C, E, and G and conducting it to the respective succeeding series of pressure-vanes B, D, F, and H. This construction and arrangement provides a plurality of pairs of inner annular passages 39 and 40, 41 and 42, 43 and 44, and 45 and 46, which are circumscribed, respectively, by the pairs of annular series of vanes A and B, C and D, E and F, and G and H, as clearly shown in Fig. 1, the inner portions of the annular passages of said several pairs being arranged in free communication by connecting chambers 47, 48, 49, and 50. This construction constitutes an important part of my invention and insures a zone of relatively high pressure adjacent the inner edges of both the kinetic and pressure annular series of vanes and also produces a third area of high pressure, with corresponding low steam velocity, in the connecting-chambers, which are constructed to receive the steam from one annular passage and efficiently direct it into the other annular passage of the same pair. The steam in flowing inwardly through the annular passages passes successively through portions thereof, the annular cross-sections of which progressively decrease, owing to the diminishing radii, thereby producing a consolidation of the independent steam-discharges from the passages between the several vanes of the series.

The kinetic and pressure vanes are provided with end lugs or pins 22, constructed to fit corresponding recesses in the abutting walls of the disks and outer rings, as shown especially in Figs. 4, 5, and 6. Said lugs are preferably formed integral with the vanes; but obviously this is not essential. The vanes are shown provided with recesses 22^a to receive pins 22^b, secured to the disks and outer annular members for properly positioning and securing the vanes in place. Each pressure-vane preferably has a portion 23 of one end surface inclined and constructed to fit a corresponding inclined surface 24 on the abutting disk, as clearly shown in Figs. 21 and 22. These inclined portions 23 produce a comparatively rapid taper of the vanes contiguous to their discharge edges, thereby insuring an efficient diminution of cross-section in the discharge portions of the steam-passages between adjacent vanes. This construction is found to greatly excel existing types of pressure-vanes, which are tapered throughout, the improvement probably being due to the free entrance provided for the steam between adjacent vanes and also to the comparatively low steam velocity and corresponding small friction between the untapered portions of the vanes. The end tapered portions of the pressure-vanes are constructed to deflect the steam discharging therefrom at a proper angle to resist leakage or spill from the immediately preceding series of kinetic vanes and also to overcome any tendency of leakage into the next succeeding kinetic stage through the clearance-way between the rotor and casing. This construction further acts to maintain, by injector action, a partial vacuum between the periphery of the rotor disks and the casing. The inclined surfaces 23 and 24 further provide an efficient means for obviating any danger of the comparatively long pressure-vanes turning on their end lugs 22.

Outer annular channels 25, 26, and 27 are shown formed in the turbine-casing for conducting the exhaust from the several series of pressure-vanes B, D, and F to ports or nozzles 28, 29, and 30, constructed to direct the steam at an efficient angle against the respective series of kinetic vanes C, E, and G. The ports 28, 29, and 30 are shown formed in rings 31, 32, and 33, provided with peripheral shoulders 34, constructed to fit corresponding recesses in the turbine-casing for securely locking said rings in position when the two portions of the casing are assembled and secured together by the bolts 5. The casing is provided with a medial annular steam-chest 35, having one or more inlets 36, from which steam at any desired pressure is directed by admission-ports 37 at an efficient angle about the outer periphery of the medial series of kinetic vanes A. An annular exhaust-chamber 38 at each end of the casing is provided with a discharge-outlet 39, in communication with the atmosphere or a condenser.

In the operation of my invention the steam is maintained at any desired pressure within the annular chamber 35, from which it is directed by the ports 37 at an efficient angle against the outer periphery of the annular series of kinetic vanes A. The steam is discharged from the inner edges of these vanes into the circumscribed inner annular passage 39 and in flowing radially inward therethrough passes successively through portions of said passage of decreasing radius and correspondingly-reduced cross-section, thereby causing a material regeneration of the steam-pressure at the zone of maximum cross-section adjacent the inner edges of said vanes. Such zone of high pressure acts to produce a reaction in the steam discharged from the vanes, and thus tends to balance the force exerted by the impact of the steam entering the vanes and increases the rotative force imparted to said vanes by the steam. The steam flowing inwardly through the annular passage 39 impinges against a centrally-arranged annular partition 51, which deflects it laterally in both directions to annular chambers 47, which latter are constructed to direct it radially outward through the annular passages 40. The chambers 47 are constructed of considerably larger cross-section than that of the connected annular passages for the purpose of greatly reducing the velocity of the steam-flow therethrough. This construction provides a very low velocity of flow in the steam during the deflection necessary for directing the steam received from one stage at an efficient angle to the next succeeding stage, thereby eliminating the large aggregate of losses occurring in existing types of multiple compound turbines through the wasteful and injurious friction incident to deflecting the steam while flowing at high velocity between the numerous stages. The steam flowing radially outward through the annular passages 40 passes successively through portions thereof having increased cross-sections, thereby causing a material regeneration of the steam-pressure at the zone of maximum cross-section adjacent the inner edges of the annular series of pressure-vanes B. The zone of pressure maintained adjacent the inner edges of the pressure-vanes forces the steam through said vanes with a rapidly-increasing velocity, which reaches its maximum at the tapered discharge edges 23 thereof, thus producing an efficient difference of pressure between the inner and outer edges of the pressure-vanes.

It will be seen from the above description that the steam in passing from one series of kinetic vanes to the succeeding series of pressure-vanes flows through a continuous passage having an initial uniformly-converging portion, followed by a rapidly diverging and then converging portion, and finally a diverging portion, said final diverging portion being suddenly reduced in cross-section or dammed up by its circumscribing annular series of pressure-vanes. This construction provides an improved means for efficiently utilizing steam in compound turbines with minimum losses, and it will be noted that any friction of the steam against the rotating walls of the inner annular passages or their connecting-chambers tends to augment the regeneration of steam-pressure adjacent the inner edges of the annular series of vanes A and B, thereby utilizing such friction in a beneficial manner. The steam discharged from the outer periphery of the annular series of pressure-vanes B is directed by annular guide-channels 25 to the entrance-orifices of the annular series of ports 28. As shown especially in Fig. 1, each guide-channel is preferably constructed with an entrance-mouth having a width approximately that of the pressure-vanes, from which said channels first diverge gradually to maintain a low pressure adjacent the outer edges of the pressure-vanes and then diverge abruptly to produce a low velocity of flow during the deflection of the steam and an efficient regeneration of pressure adjacent the entrance-orifices of the ports 28. The steam is then directed by the ports 28 at an efficient angle against the outer periphery of the annular series of kinetic vanes C and passes successively through the alternately-arranged series of pressure-vanes D, F, and H and kinetic vanes E and G in a manner similar to that just described. A detailed description of the steps of this operation would be a mere repetition of the above description. The steam is discharged from the final series of pressure-vanes H into the annular exhaust-chambers 38, from which it is conducted by outlets 39 to the atmosphere, a condenser, or other desired point.

The apparatus herein specifically shown and described is of course merely one embodiment of my invention, which may be embodied in a great variety of forms. For example, I have shown a turbine with eight stages; but obviously a greater or less number may be used within the scope of my invention.

Having thus described my invention, what I claim as new, and desire to secure by Letters Patent, is—

1. In a turbine, the combination of annular series of vanes, annular passages circumscribed by the series of vanes, and an annular chamber extending radially inward from said passages and connecting the same, substantially as described.

2. In a turbine, the combination of a plurality of annular series of vanes, annular passages circumscribed by the series of vanes, and annular chambers extending radially inward from said passages and connecting the same in pairs, substantially as described.

3. In a turbine, the combination of annular series of vanes, inwardly-converging annular passages circumscribed by the series of vanes, and an annular chamber extending radially inward from said passages and connecting the same, substantially as described.

4. In a turbine, the combination of annular series of vanes, annular passages circumscribed by the series of vanes, and annular chambers of greater cross-section than said passages, said annular chambers extending radially inward from said passages and connecting the same in pairs, substantially as described.

5. In a turbine, the combination of annular series of vanes, inwardly-converging annular passages circumscribed by the series of vanes, and annular chambers of greater cross-section than said passages, said annular chambers extending radially inward from said passages and connecting the same in pairs, substantially as described.

6. In a turbine, the combination of annular series of vanes, an annular passage for conducting the actuating medium from one series of vanes, and a chamber for receiving the actuating medium from said annular passage

and deflecting it to the succeeding series of vanes, said chamber being provided with a reduced outlet, substantially as described.

7. In a turbine, the combination of annular series of vanes, an annular passage for conducting the actuating medium from one series of vanes, and a chamber for receiving the actuating medium from said annular passage and deflecting it to the succeeding series of vanes, said chamber being provided with a reduced outlet and inlet, substantially as described.

8. In a turbine, the combination of a plurality of annular series of vanes, chambers arranged intermediate of said several annular series of vanes for receiving the actuating medium discharged from the immediately-preceding series of vanes, said deflecting-chambers being constructed with reduced inlets and outlets, producing a substantial retardation of velocity and increase of pressure in the actuating medium during deflection, and passages of progressively-decreasing cross-section for conducting the discharge from each preceding series of vanes to said deflecting-chambers, whereby such discharge is consolidated, substantially as described.

9. In a turbine, the combination of a plurality of annular series of vanes, chambers arranged intermediate of said several annular series of vanes for receiving the actuating medium discharged from the immediately-preceding series of vanes, and deflecting it to the next succeeding series of vanes and constructed of greater cross-section perpendicular to the flow of the actuating medium than the aggregate cross-section of the passages between the several vanes of either of said series, to produce a substantial retardation of velocity in the actuating medium and increase of pressure during such deflection; and passages of progressively-decreasing cross-section, for conducting the discharge from each preceding series of vanes to said deflecting-chambers, whereby such discharge is consolidated, substantially as described.

10. In a turbine, the combination of rotating parts constituting walls of annular passages and connecting-chambers, each of said chambers constructed to diverge from the two connected passages, and a plurality of annular series of vanes carried by said rotating parts, substantially as described.

11. In a turbine, the combination of a rotor provided with annular passages, annular series of vanes carried by said rotor and circumscribing said annular passages, and an annular chamber in said rotor extending radially inward from said passages and connecting the same, substantially as described.

12. In a turbine, the combination of a rotor provided with annular passages, annular series of vanes carried thereby and circumscribing said annular passages, and annular chambers in said rotor extending radially inward from said passages and connecting the same in pairs, substantially as described.

13. In a turbine, the combination of alternately-arranged series of kinetic and pressure vanes circumscribing annular passages, and annular chambers connecting said passages in pairs, said chambers constructed to diverge from the two connected passages, substantially as described.

14. In a turbine, the combination of a plurality of alternately-arranged series of kinetic and pressure vanes, annular passages for conducting the actuating medium from each of said series of kinetic vanes, annular chambers for receiving the actuating medium from said annular passages and deflecting it to the succeeding series of pressure-vanes, said chambers being provided with reduced outlets, substantially as described.

15. In a turbine, the combination of a plurality of alternately-arranged series of kinetic and pressure vanes, annular passages for conducting the actuating medium from each of said series of kinetic vanes, annular chambers for receiving the actuating medium from said annular passages and deflecting it to the succeeding series of pressure-vanes, said chambers being provided with reduced outlets and inlets, substantially as described.

16. In a turbine, the combination of a plurality of alternately-arranged series of kinetic and pressure vanes, inwardly-converging annular passages for conducting the actuating medium from each of said series of kinetic vanes, annular chambers for receiving the actuating medium from said annular passages and deflecting it to the succeeding series of pressure-vanes, said chambers being provided with reduced outlets, substantially as described.

17. In a turbine, the combination of a plurality of disks, outer annular members arranged between said disks, annular series of vanes secured between said disks and members and circumscribing inwardly-converging annular passages therebetween, and annular chambers of greater cross-section than the passages connecting said passages in pairs, substantially as described.

18. In a turbine, the combination of a plurality of annular series of vanes, means for directing an actuating medium radially inward through an initial one of said annular series of vanes, and means for directing the discharge from such initial annular series of vanes simultaneously radially outward through the two adjacent annular series of vanes, substantially as described.

19. In a turbine, the combination of a plurality of alternately-arranged annular series of kinetic and pressure vanes, means constructed to direct an actuating medium radially inward through one of said annular series of kinetic vanes, and means constructed to direct the discharge from said series of kinetic

vanes simultaneously to the two adjacent annular series of pressure-vanes, substantially as described.

20. In a turbine, the combination of a plurality of alternately-arranged annular series of kinetic and pressure vanes circumscribing inner annular passages, means constructed to direct an actuating medium through one of said series of kinetic vanes into the circumscribed annular passage, and means constructed to direct the actuating medium from said passage to the annular passages circumscribed by the two adjacent annular series of pressure-vanes, substantially as described.

21. In a turbine, the combination of a plurality of alternately-arranged annular series of kinetic and pressure vanes circumscribing inwardly-converging annular passages, means constructed to direct an actuating medium through one of said series of kinetic vanes into the circumscribed annular passage, and means within said passage constructed to direct the actuating medium therefrom to the annular passages circumscribed by the two adjacent annular series of pressure-vanes, substantially as described.

22. In a turbine, the combination of an initial annular series of kinetic vanes, two groups of alternately-arranged series of pressure and kinetic vanes, means constructed to direct an actuating medium through the initial annular series of kinetic vanes, and means constructed to direct the discharge from the initial series simultaneously through the two groups of annular series of vanes, substantially as described.

23. In a turbine, the combination of an initial annular series of kinetic vanes circumscribing an annular passage, two groups of alternately-arranged annular series of pressure and kinetic vanes circumscribing annular passages, means constructed to direct an actuating medium through the initial annular series of kinetic vanes into the circumscribed annular passage, and means constructed to direct the discharge from said passage of the initial series simultaneously through said two groups of annular series of vanes, substantially as described.

24. In a turbine, the combination of a plurality of alternately-arranged series of kinetic and pressure vanes, annular passages for conducting the actuating medium from each of said series of kinetic vanes, annular chambers for receiving the actuating medium from said annular passages and deflecting it to the succeeding series of pressure-vanes, said chambers being provided with reduced outlets, and means for receiving the actuating medium from each of said series of pressure-vanes and deflecting it to the succeeding series of kinetic vanes, substantially as described.

In testimony whereof I affix my signature in presence of two witnesses.

RICHARD H. GOLDSBOROUGH.

Witnesses:

G. AYRES,

E. L. HORN.