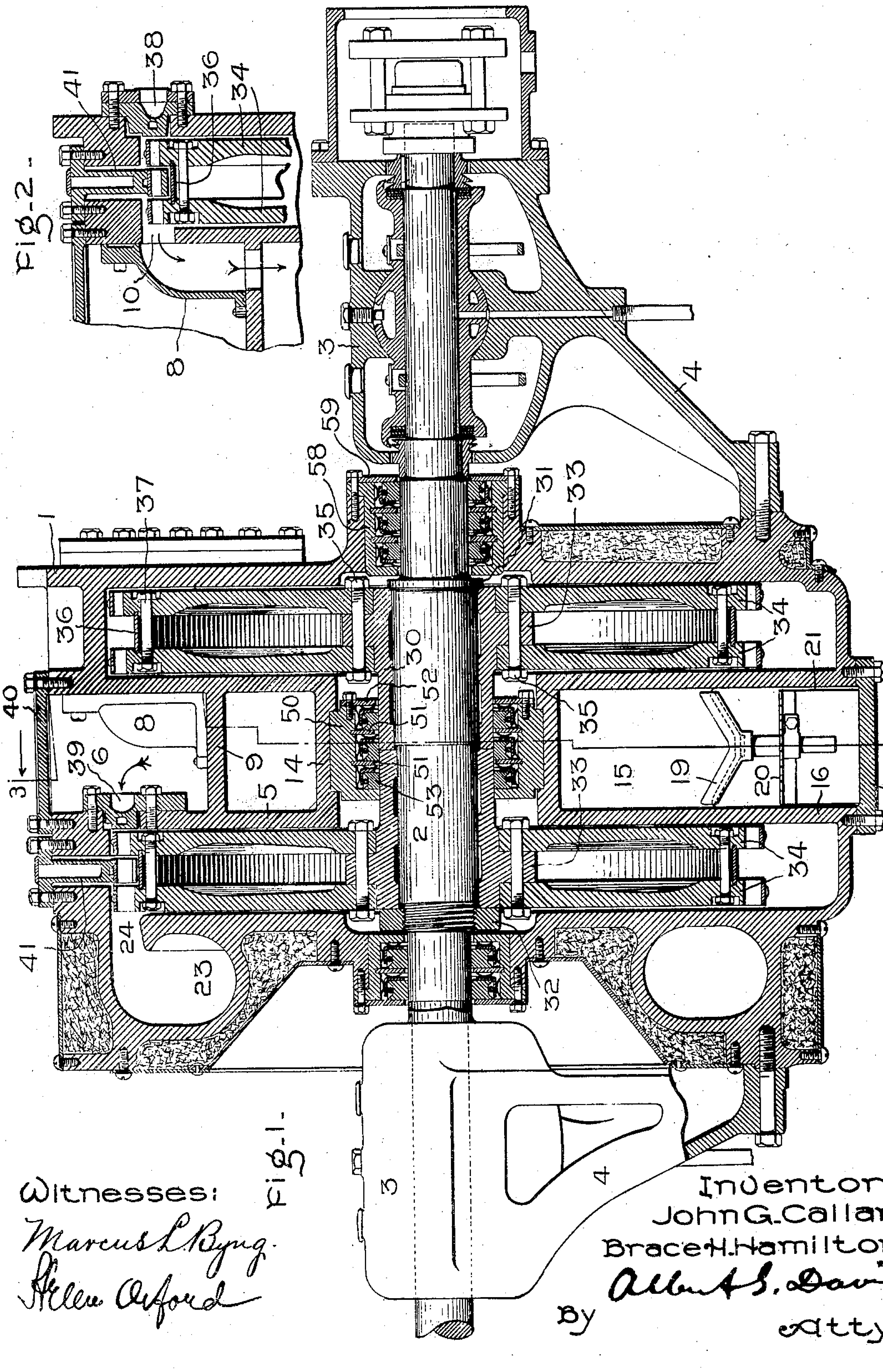
No. 822,247. PATENTED JUNE 5, 1906.

J. G. CALLAN & B. H. HAMILTON.

ELASTIC FLUID TURBINE.

APPLICATION FILED MAR. 12, 1904.

3 SHEETS—SHEET 1.



Witnesses:
Marcus L. Byng.
Helen Orford

Inventors,
John G. Callan,
Brace H. Hamilton,
by Albert G. Davis
Atty.

No. 822,247.

PATENTED JUNE 5, 1906.

J. G. CALLAN & B. H. HAMILTON.

ELASTIC FLUID TURBINE.

APPLICATION FILED MAR. 12, 1904.

3 SHEETS—SHEET 2.

Fig-3-

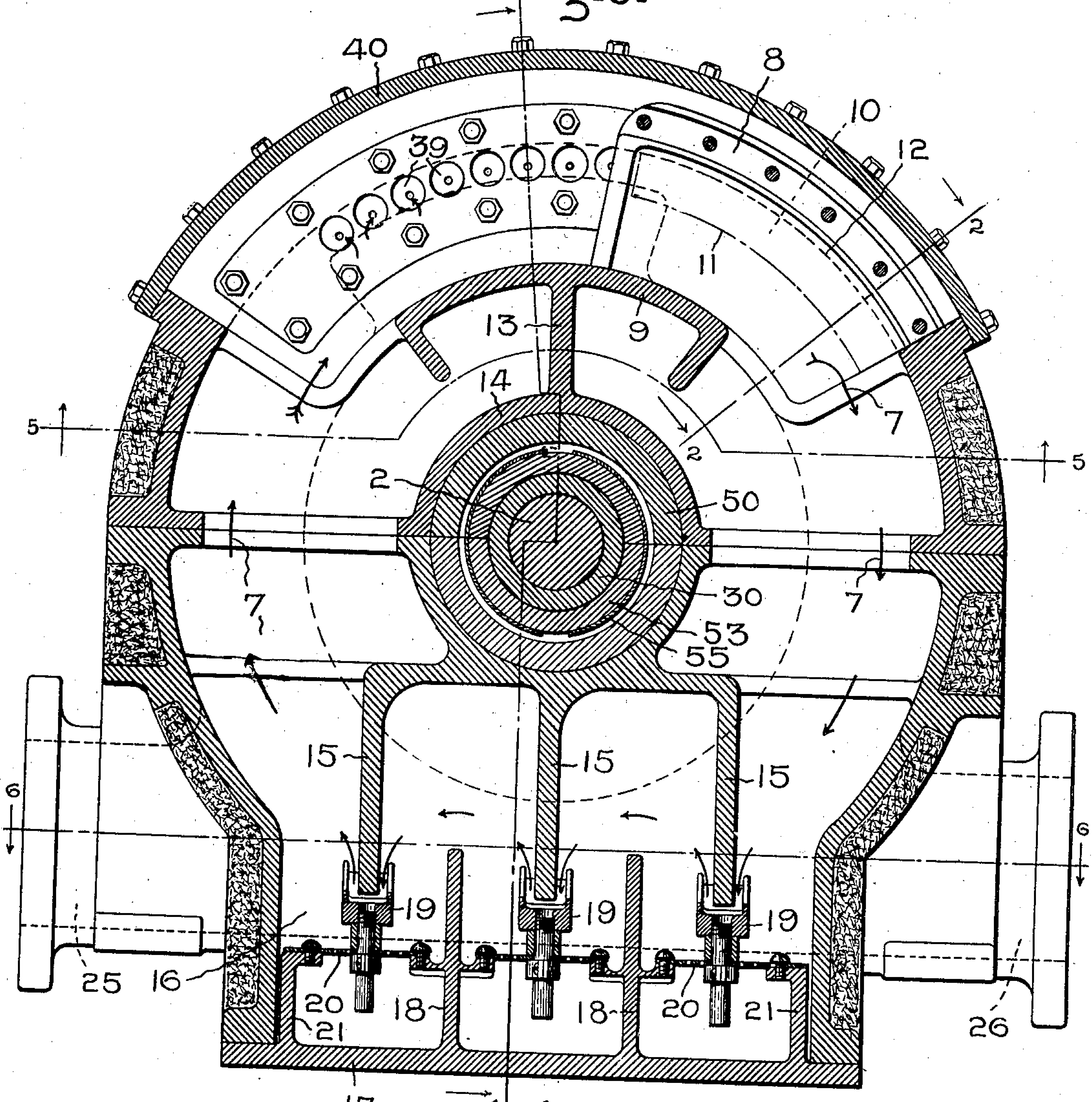
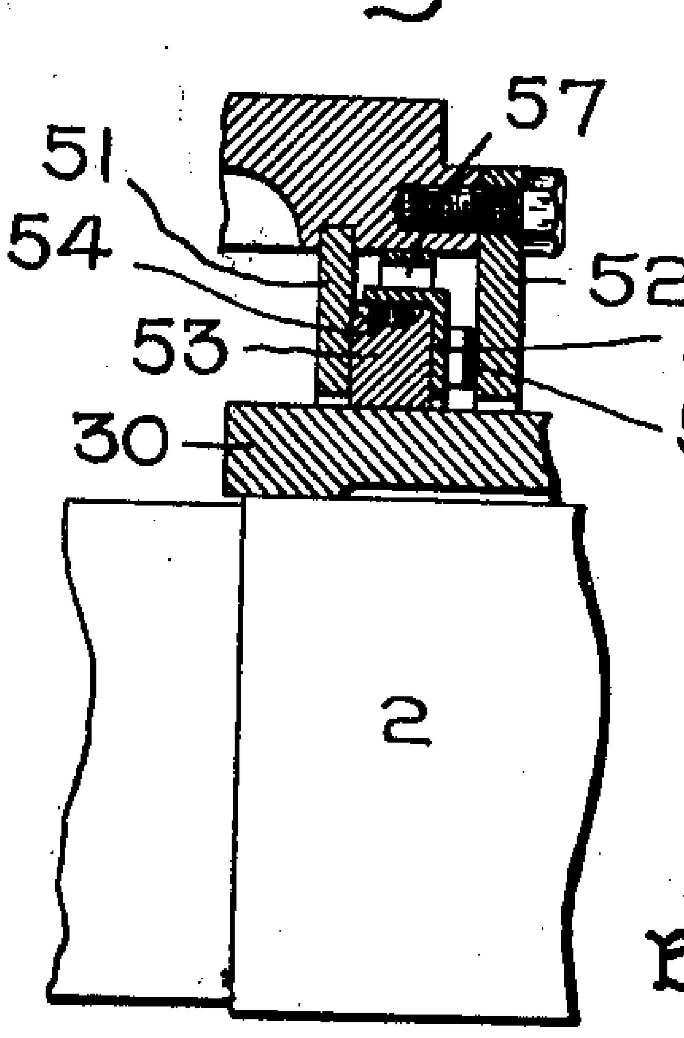


Fig-4-



Witnesses:
Marcus L. Byng.
Helen Orford

Inventors,
John G. Callan,
Brace H. Hamilton,
By Albert G. Davis
Atty.

No. 822,247.

PATENTED JUNE 5, 1906.

J. G. CALLAN & B. H. HAMILTON.

ELASTIC FLUID TURBINE.

APPLICATION FILED MAR. 12, 1904.

3 SHEETS—SHEET 3.

Fig. 5.

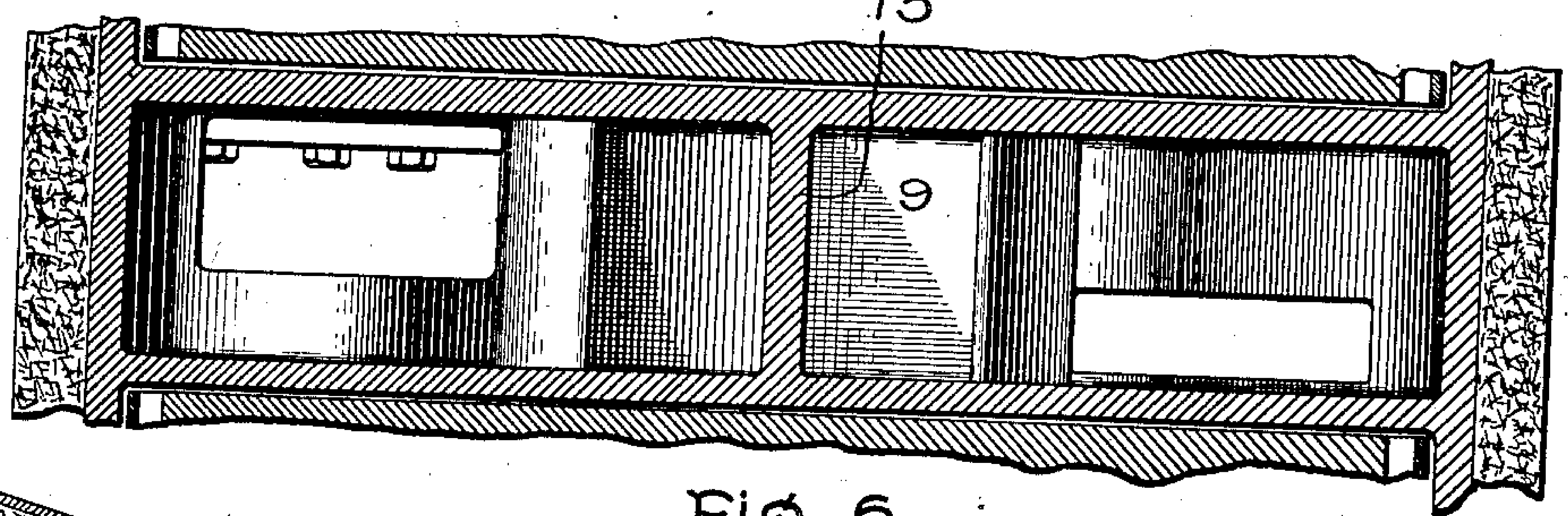


Fig. 6.

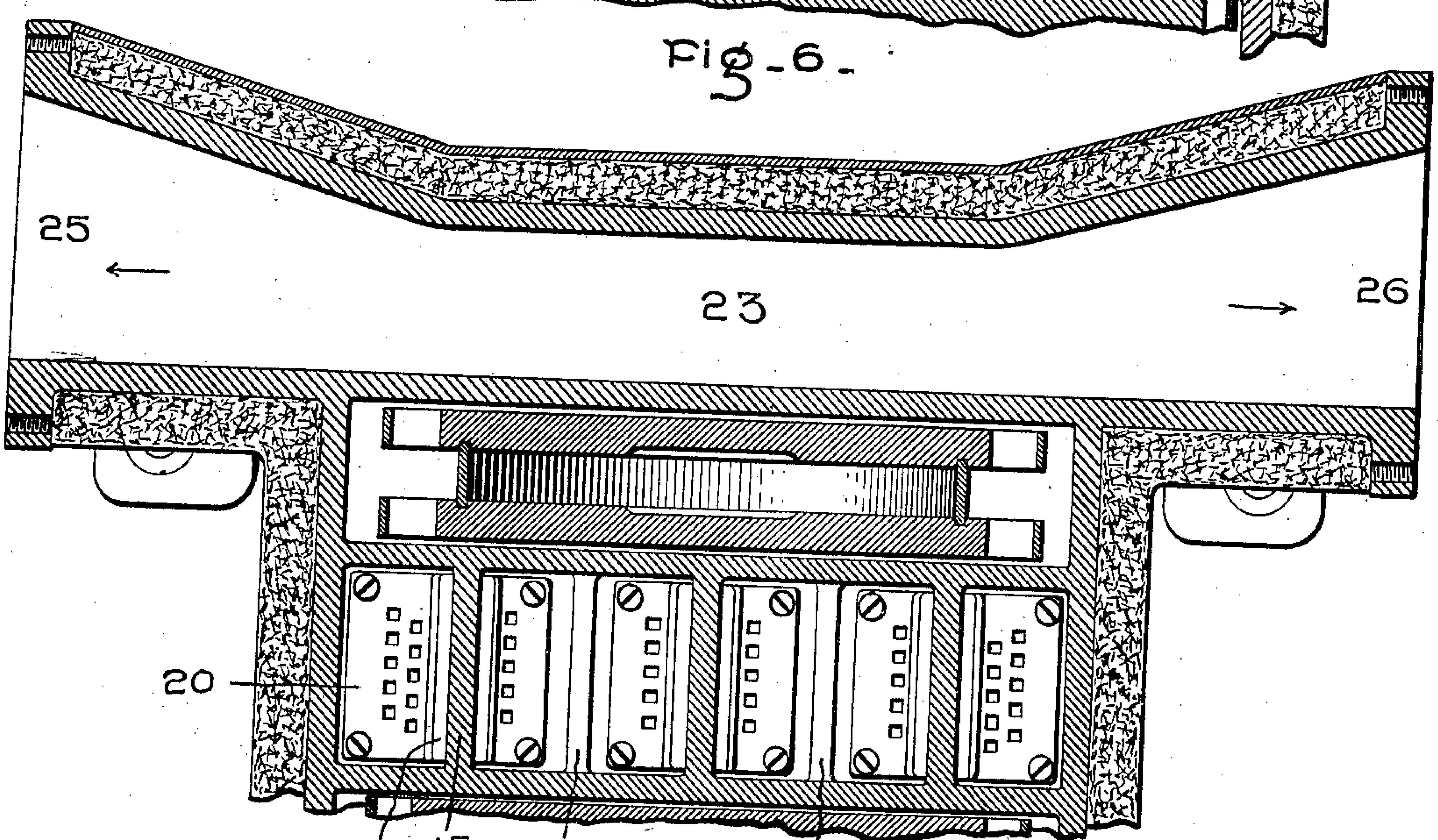


Fig. 7.

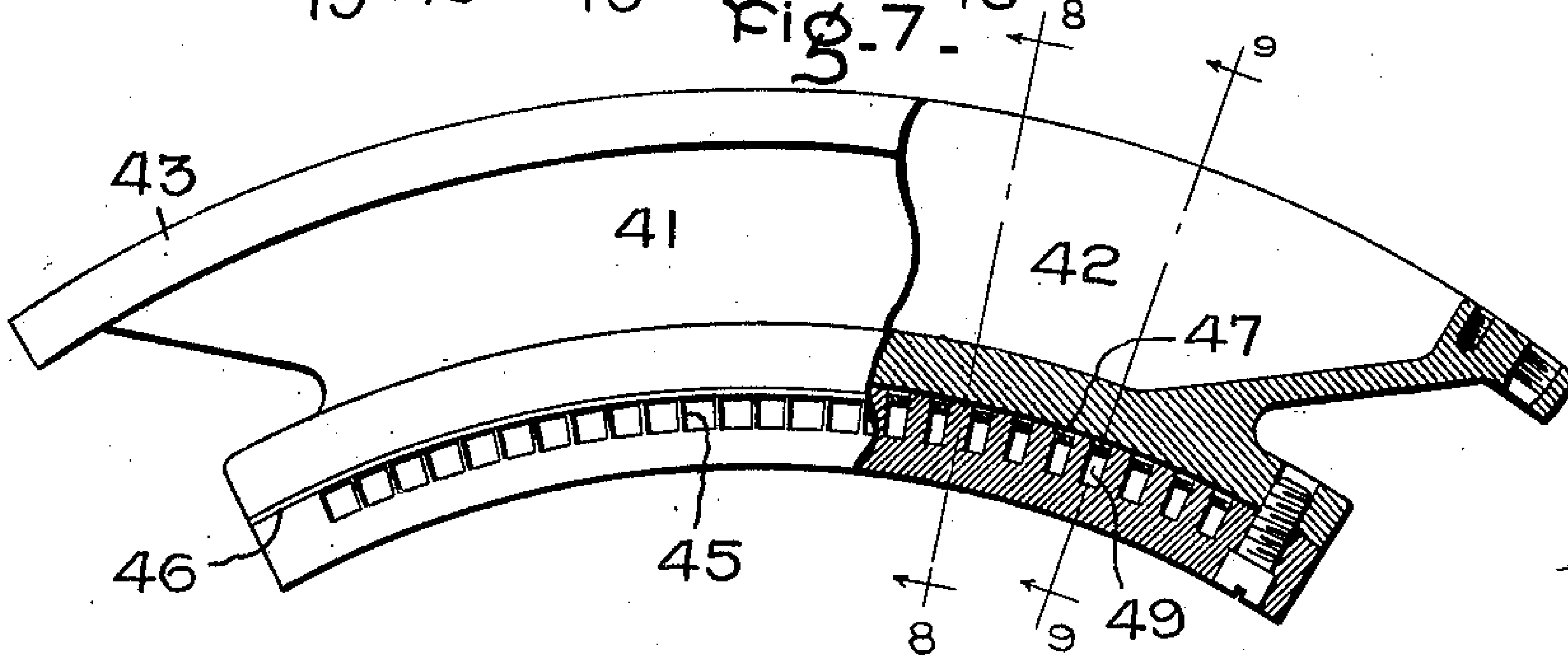


Fig. 8.

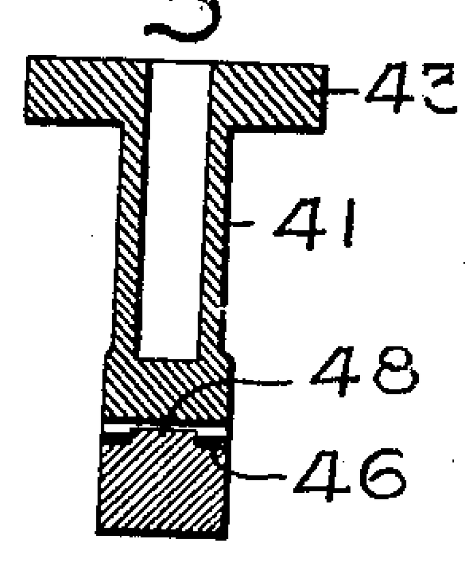
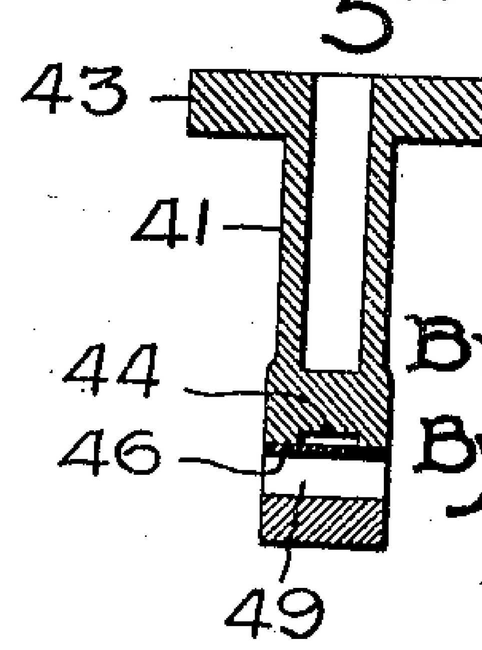


Fig. 9.



Witnesses:
Marcus L. Byng
Helen Orford

Inventors,
John G. Callan,
Brace H. Hamilton,
By Albert G. Davis
Att'y.

UNITED STATES PATENT OFFICE.

JOHN G. CALLAN AND BRACE H. HAMILTON, OF LYNN, MASSACHUSETTS, ASSIGNORS TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

ELASTIC-FLUID TURBINE.

No. 822,247. Specification of Letters Patent. Patented June 5, 1906.

Application filed March 12, 1904. Serial No. 197,789.

To all whom it may concern:

Be it known that we, JOHN G. CALLAN and BRACE H. HAMILTON, citizens of the United States, residing at Lynn, county of Essex, State of Massachusetts, have invented certain new and useful Improvements in Elastic-Fluid Turbines, of which the following is a specification.

The present invention relates to elastic-fluid turbines, and has for its object to increase their efficiency and to simplify and reduce the cost of construction.

In carrying out the invention a casing is provided, which is separable into pieces or sections, the line or lines of division being arranged in any desired manner. The interior of the casing has one or more wheel-compartments, and each compartment is provided with smooth walls to assist in decreasing the rotation losses of the bucket-wheels. The webs of the bucket-wheels are made with smooth exterior surfaces which run in close proximity to the side walls of each wheel-compartment, and the circumferential wall of the casing is in close proximity to the covers which close in the ends of the buckets. To state the matter in a different way, the wheel and wheel-compartment are so constructed and arranged that the former fills the latter as completely as possible, thereby reducing the dead space in the chamber to a minimum. When two or more separate wheels are provided in each chamber or compartment, it is advantageous to place a ring between the wheels at a point adjacent to the periphery, so as to cut off the space between them. This also has the advantage of decreasing the dead space within the chamber.

We find it desirable to employ a diaphragm for separating the casing into stages or compartments, which diaphragm contains a chamber wherein a separator may be located for separating the moisture from the steam as it passes from one stage or compartment to the other. Instead of a separator we may, however, employ a reheater and locate it in said chamber. In a broad sense a reheater and a separator serve the same purpose in that they both reduce the moisture carried by the motive fluid from one wheel-compartment to another. The diaphragm is preferably cast intergal with the parts of the casing, since this arrangement gives great strength with simplicity of construction. In addition to decreasing the number of parts it reduces the amount of machine-work. In the present embodiment of our invention we find it sufficient to divide the casing into two parts with the line of division in an axial plane; but the invention is not to be construed as so limited. The adjacent meeting surfaces of the diaphragm are faced off true, and when assembled a cylindrical or substantially cylindrical chamber is formed between wheel-compartments. This chamber is provided with one or more partitions or their equivalent, which instead of permitting the steam to pass directly from one stage to the next causes it to describe a substantially circular path in so doing. It is during the time that the steam is flowing through the substantially circular path that it either has moisture taken therefrom by a separator or is reheated. This arrangement lends itself very readily to the objects mentioned, since the direction of the steam may be suddenly changed and the path is relatively long, which gives the necessary time interval for the water to leave the steam or the latter to absorb heat. When a separator is employed, the length of the passage may be further increased by the use of partitions or bafflers, which may be stationary or adjustable, as desired.

In order to cause the steam to leave the last stage under a predetermined velocity and to divide equally, or substantially so, between two discharge-orifices arranged in multiple, the walls of the exhaust-port adjacent to the last wheel are made to diverge somewhat after the manner of an expansion-nozzle. In order that the exhaust may leave the discharge-orifices without choking, the walls of the casing adjacent to the orifices are divergent in the direction of the exhaust.

Other features of our invention, owing to their somewhat detailed and complex character, will be referred to hereinafter.

In the accompanying drawings, which illustrate one embodiment of our invention, Figure 1 is an axial section of a two-stage two-wheels-per-stage elastic-fluid turbine of the jet type, the said section being taken on line 1 1 of Fig. 3 and looking in the direction of the arrows. Fig. 2 is a partial longitudinal section through the first stage, taken on line 2 2 of Fig. 3 and looking in the direction of the arrows. Fig. 3 is a transverse section taken on line 3 3, Fig. 1, and looking in the direction of the arrows. Fig. 4 is an enlarged detail view showing one of the packing-rings. Fig. 5 is a partial inverted section taken on the line 5 5 of Fig. 3 and looking in the direction of the arrows. Fig. 6 is a partial longitudinal section taken on line 6 6 of Fig. 3 and looking in the direction of the arrows. Fig. 7 is an enlarged detail view, partially broken away, to show the support for the intermediate buckets. Fig. 8 is a section taken on the line 8 8 of Fig. 7, and Fig. 9 is a section taken on line 9 9 of Fig. 7.

1 represents the casing of the machine, which is divided into an upper and a lower section on a horizontal axial plane. Extending through the casing is a shaft 2, which is supported in bearings 3, carried by brackets 4, that are bolted at their lower extremity to the end walls of the casing. The casing is divided into compartments by a diaphragm 5, which contains a chamber 6, which receives steam or other elastic fluid from the first wheel and after causing it to pass downward and around the wheel-shaft in the direction of the arrows 7, Fig. 3, is discharged into the bowls of the second-stage nozzles. The chamber 6 extends circumferentially, and in order to prevent steam from the first stage from being discharged directly against the second-stage nozzles a hood or partition 8 is provided, which engages the right-hand vertical wall of the diaphragm and also the cylindrical wall 9. The wall adjacent to the buckets discharging steam from the first-stage nozzles is cut away to form an exhaust-port 10, which is covered by the hood 8. The size and arrangement of the exhaust-port 10 are best shown in Fig. 3, wherein the broken and dotted line 11 indicates the inner surface of the exhaust-port and the dotted line 12 the outer. The angular space occupied by the exhaust-port is substantially the same as that of the hood 8. In Fig. 5 the lower right-hand opening is the one through which the exhaust from the first-stage wheel and the hood 8 passes. In the same figure the upper left-hand opening is the one through which the steam passes to the second-stage nozzle after passing through the separator or reheater. The upper portions of the chamber 6 are separated from each other by the partition 13. (Best shown in Fig. 3.) This partition unites with a cylindrical wall 14, that surrounds the shaft and supports a packing. Attached to and forming a part of this cylindrical wall are one or more bafflers 15, which act as separators for separating the moisture from the steam and at the same time increase the length of its path. In the present illustration three of these bafflers are shown. The under side of the diaphragm-chamber 6 is provided with a neck 16, in which these bafflers are located. The lower end of the neck is provided with a detachable plate or cover 17, to which is attached one or more bafflers 18, that extend between the bafflers 15 and assist in separating moisture from the steam by causing it to change direction of flow.

In addition to the above we may provide means for further opposing the passage of the steam from one side of the chamber to the other and separating the moisture. Such a means is found in the V-shaped pieces 19, which are situated directly underneath the bafflers 15 and are adjustable toward and away from them. The closer the pieces are to the ends of the bafflers the greater will be the opposition offered to the passage of steam, and the sudden changing of the direction of flow will cause the water particles to be separated from the steam. These pieces are supported by perforated plates 20, which are carried by projections on the bafflers 18 and by projections 21 on the cover. Suitable means are provided for draining the chambers formed between the bafflers 18.

On the exhaust side of the machine an annular exhaust-passage 23 is provided, a part of which is formed in the upper section of the casing and a part in the lower. Formed in the wall adjacent to the buckets discharging steam or other motive fluid of the second stage is an exhaust-port 24, which is provided with walls that diverge in the direction of flow of the motive fluid, so as to impart additional velocity thereto, which is useful in that it prevents the choking of the passage and causes the exhaust to divide equally, or substantially so, between the two parts of the annular passage 23. Theoretically as the steam exhausts from the last wheel it should flow parallel to the wheel-axis; but in practice we have found that this is not always the case. Hence the arrangement of the walls of the exhaust-port. As the steam is discharged into the annular exhaust-passage 23 it flows downward and out through the discharge-orifices 25 and 26, Figs. 3 and 6. It is to be noted that the walls of the exhaust-passage 23 as they approach the discharge-orifices gradually diverge in the direction of flow of the steam, thereby imparting to it a certain amount of velocity, which tends to prevent the passages of the machine from choking and also assisting in causing the exhaust to flow in substantially equal amounts through said orifices.

We will now refer to the construction and arrangement of the wheels. Mounted on the shaft 2 is a cylindrical support or sleeve 30, which may be made in one or more pieces, as desired. This support engages a collar 31 at one end and a nut 32 at the other and is thereby prevented from moving longitudinally on the shaft. The support is provided with flanges 33, to opposite sides of which are bolted the bucket-wheels 34. These bucket-wheels or disks are secured in place by axiallyextending bolts 35, which pass through them and the flanges on the support. Near the periphery of the disks a ring 36, made in segments or otherwise, is provided, which is seated in grooves formed in the adjacent surfaces of the disks. Bolts 37 are employed to clamp the two disks together. The ring 36 cuts off steam from the space between the wheels, and since it presents a smooth surface to the exhaust-steam within the casing it assists in reducing the rotation losses of the wheel.

It is to be observed that the outer surfaces of the wheels are perfectly smooth and run in close proximity to the smooth flat walls of the casing. The object of this arrangement is to decrease the rotation losses to a minimum. This is accomplished chiefly by giving to all of the parts smooth or polished surfaces and causing the wheel to fill the chamber as nearly as possible. The superficial area of the interior of a wheel-compartment is approximately the same as the superficial area of the wheel therein. Hence there is little idle space between them wherein eddy-currents of any material consequence can be set up. In other words, there is just sufficient clearance between the surfaces of the wheel and the casing and the buckets to reduce rotation losses to a minimum. It is large enough, however, to prevent a water-braking effect being established between relatively movable surfaces by reason of the presence of moisture on the said surfaces. In this connection it is to be noted that the heads and nuts on the bolts are countersunk, so as to be below the exterior surfaces of the wheel. The heads of the inner bolts 35 may be countersunk or not, as desired. Being near the axis of rotation, their effect on the rotation losses can be disregarded.

In Fig. 2, 38 represents the sectionalized nozzle for discharging steam against the buckets of the first-stage wheel. These nozzles may be of the expanding type or not and are attached to the outer wall of the casing by bolts or other suitable means. Situated in line or substantially in line with the first-stage nozzle is a second-stage nozzle 39, Fig. 1, comprising a plurality of closely-associated fluid-discharging passages, which may or may not expand the motive fluid and which discharge it at the proper angle against the wheel-buckets of the second stage. Each of the nozzle-passages is provided with a bowl, a throat, and a discharge-orifice of suitable size and shape. The second-stage nozzle is secured to the inside wall of the diaphragm by bolts or other attaching means and can be inspected or removed by taking off the segmental cover 40, which forms a part of the chamber 6. We have found it desirable to mount the first and second stage nozzles in line or substantially in line with each other and at a point above the shaft, since by so doing we are able to obtain a passage for the steam between stages of sufficient length to enable the moisture to be removed during its passage. Between each row of bucket-wheels are mounted intermediate buckets, which extend over a greater or less arc, depending upon the arc covered by the nozzles. They cover a greater arc in the second stage than in the first, owing to the increased volume of steam.

Referring to Figs. 7, 8, and 9, the construction and arrangement of the intermediate buckets and their support will be described. 41 represents the segmental support, which is cored out at 42 to reduce its weight. It is provided with a flange 43, by means of which it can be attached to the wheel-casing. The inner surface of the support is finished on an arc struck from the axis of the wheel. In this surface is turned a longitudinally-extending groove 44, which receives the outer ends of the intermediate buckets 45, the latter being formed integral with a base-piece. In other words, the ends of the buckets form a tongue which enters the groove in the support and prevent the buckets as a whole from moving in an axial direction. Each bucket may have a tenon or some of the tenons can be omitted. With a groove extending longitudinally of the support it is evident that there will be a small portion of the groove that will remain unfilled between the ends of the buckets. Such a space would tend to create objectionable eddy-currents as the steam flows through them. In order to obviate this objection, we place a thin lining-strip of sheet metal 46 between the buckets and the support. This strip presents a smooth surface to the steam and is provided with openings which correspond in shape and size to the projections on the ends of the buckets and cover the small spaces 47, which would otherwise exist between the buckets and prevent eddy-currents.

In Figs. 7 and 8 it is clearly shown how the tongues or projections 48 on the buckets pass through openings in the lining-strip 46.

In Fig. 9 is shown one of the bucket spaces or passages 49, and it is to be noted that the upper and lower walls are perfectly smooth. The buckets themselves are given any suitable shape. The lining-strip is shown at the outer ends of the buckets; but it can be placed at the inner ends where desirable. It can also be used on rotary as well as stationary buckets.

In order to prevent the steam from leaking from one wheel-compartment to another and to the atmosphere, it is necessary to provide packing-rings, and it is particularly important to provide rings which do not require attention. Such a construction is shown in Figs. 1, 3, and 4. 50 represents a cylindrical casing which surrounds the shaft and is provided with a projection which is seated in a flat-sided groove formed in the cylindrical wall 14 of the diaphragm and is in this manner prevented from moving in an axial direction. The casing is grooved internally to receive one or more partitions 51, and between the partitions and the stationary end wall of the casing and the detachable plate 52 are carbon packing-rings 53, which are made up in segments and are held together by coil-springs 54, which surround them and are located in peripheral grooves. Outside of the carbon packing is a holder 55, which is L-shaped in cross-section and is mounted on the packing on the side away from the wall with which the packing engages. Situated on one side of the holder and extending between it and the adjacent stationary wall or partition is a spring 56, which tends at all times to move the packing in an axial direction. Extending circumferentially of the holder and engaging it and the surrounding casing is a spring 57, which tends at all times to force the carbon packing inward toward the axis of the shaft.

The packings located in the heads of the casing which prevent the escape of steam to the atmosphere each comprises a cylindrical flanged casing 58, containing one or more carbon packing-rings of the type previously described. They are retained in place by a plate 59, the latter being bolted to the casing by the same bolts which secure the latter to the head of the machine.

In accordance with the provisions of the patent statutes we have described the principle of operation of our invention, together with the apparatus which we now consider to represent the best embodiment thereof; but we desire to have it understood that the apparatus shown is only illustrative and that the invention can be carried out by other means.

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

1. An elastic-fluid turbine comprising a casing and wheel-buckets, the latter being arranged in rows, in combination with a diaphragm which divides the casing into compartments or stages for the rows of buckets, and a chamber formed within the diaphragm through which the motive fluid flows in passing from one stage to another for decreasing the amount of moisture contained therein.

2. An elastic-fluid turbine comprising a casing which is divided into wheel-compartments, in combination with a means for reducing the amount of moisture in the motive fluid which causes the fluid exhausting from one compartment to follow a circular or substantially circular path around the shaft of the turbine in passing to the adjacent compartment.

3. An elastic-fluid turbine comprising a divided casing, wheel-buckets in the compartments, and nozzles for discharging motive fluid against the buckets, which are substantially in alinement with each other, in combination with means for causing the motive fluid exhausting from one wheel-compartment to flow in a circular or substantially circular path before entering an adjacent compartment.

4. An elastic-fluid turbine comprising a casing which is divided into compartments, and wheel-buckets in each compartment, in combination with a chamber which surrounds the wheel-shaft, and a hood which receives motive fluid from one wheel and directs its passage into the chamber.

5. An elastic-fluid turbine of the axial-flow type comprising a casing, wheel-buckets in the casing, and a nozzle or device for discharging motive fluid against the buckets, in combination with a passage for the exhaust which is arranged in line with the nozzle and extends c rcumferentially around the casing and terminates in orifices arranged in multiple.

6. An elastic-fluid turbine comprising a casing, wheel-buckets in the casing, and a nozzle or device for discharging motive fluid against the buckets, in combination with an exhaust-passage, located on the same side of the axis of the turbine with the nozzle and discharge-orifices for the passage which are located at the point diametrically opposite from the passage and open in opposite directions.

7. An elastic-fluid turbine comprising a casing, wheel-buckets in the casing, and a nozzle or device for discharging motive fluid against the buckets, in combination with an exhaust-passage having discharge-orifices, and means for imparting additional velocity to the exhaust from the buckets to cause it to divide in substantially equal amounts between the said orifices.

8. An elastic-fluid turbine comprising a casing, wheel-buckets, and a nozzle or device for discharging motive fluid against the buckets, in combination with an exhaust-passage having discharge-orifices, and means adjacent to each orifice for imparting velocity to the escaping fluid.

9. An elastic-fluid turbine comprising a casing which is divided into compartments, and wheel-buckets in the compartments, in combination with a chamber which surrounds the shaft, receiving and discharge orifices for the chamber so arranged that the motive fluid follows a substantially circular path around the shaft in flowing from one to the other, and means acting on said fluid while passing through the chamber for decreasing the amount of moisture contained therein.

10. An elastic-fluid turbine, comprising a casing which is divided into compartments, and wheel-buckets in the compartments, in combination with means for causing the exhaust from one compartment to follow a circular or substantially circular path in flow-

ing from one wheel-compartment to the next, and one or more devices for increasing the length of said passages.

11. An elastic-fluid turbine comprising a casing which is divided into compartments, wheel-buckets in each compartment, and devices for discharging motive fluid against the buckets, in combination with a chamber independent of the wheel-compartment through which the motive fluid passes in flowing from one compartment to another, and an adjustable means for removing moisture from the motive fluid and varying the resistance opposed to its passage.

12. An elastic-fluid turbine comprising a casing divided into compartments, and nozzles or devices for discharging motive fluid against the buckets in the different compartments, which are situated at one side of the axis of the wheel, in combination with a chamber between compartments which receives the exhaust motive fluid from one wheel, directs it to the opposite side of the axis of the wheel and discharges it into a nozzle of lower pressure at a point on the other side of the axis of the wheel.

13. An elastic-fluid turbine comprising a casing, wheel-buckets, and nozzles or devices for discharging motive fluid against the wheel-buckets, a chambered diaphragm which divides the casing into compartments, and a partition in the chamber, which separates it into parts, one of said parts acting as a receiving and the other as a discharging device.

14. A casing for an elastic-fluid turbine, which is separable into sections, in combination with a wall for dividing the casing into compartments, which is also made in sections and formed integral with the casing-sections and a chamber formed wholly within the wall, one section of the wall forming one part of the chamber and another section a different part, the chamber being so arranged that the motive fluid passes through it as it flows from one compartment to another.

15. A casing for an elastic-fluid turbine of the axial-flow type, which is separable into sections in an axial plane, in combination with a divided and chambered diaphragm for separating the casing into wheel-compartments, which diaphragm is formed integral with the sections of the casing, the lines of division coinciding or substantially coinciding with those of the casing, and orifices in the chamber which receive and discharge the motive fluid.

16. An elastic-fluid turbine comprising sets of relatively movable buckets, compartments for the sets of wheel-buckets, and nozzles having a constant ratio of expansion, in combination with a means for decreasing the moisture entrained with the motive fluid, a conduit for conveying the exhaust from one set of wheel-buckets to the said means, and a second conduit for conveying the steam after it leaves the said means to the nozzle of a lower-pressure stage.

17. An elastic-fluid turbine comprising a casing, a diaphragm which divides the casing into compartments, and a separator located within the casing and between compartments for separating the water of condensation from the steam.

18. An elastic-fluid turbine comprising a casing, and a diaphragm which divides the casing into compartments, in combination with a separator comprising one or more plates or partitions which cause the steam to follow an irregular path in flowing from one compartment to another for separating the moisture from the steam.

19. An elastic-fluid turbine comprising a casing, and wheel-buckets, in combination with a chambered diaphragm for dividing the casing into compartments, and nozzles for discharging fluid against the wheel-buckets, which are located within the chamber.

20. An elastic-fluid turbine comprising a casing, and wheel-buckets, in combination with a chambered diaphragm for dividing the casing into compartments, nozzles which are attached to one wall of the chambered diaphragm, and a cover for the diaphragm which when removed exposes the nozzles.

21. An elastic-fluid turbine comprising a casing, and a diaphragm for dividing the casing into compartments which present smooth surfaces to the buckets, in combination with bucket-wheels for the compartments, which present smooth unbroken surfaces to the diaphragm and are located in close proximity thereto, the said diaphragm and wheels acting to reduce the fan-like action of the buckets to prevent eddy-currents.

22. An elastic-fluid turbine comprising a casing having smooth walls, wheels mounted therein which are spaced apart and on their peripheral and side surfaces run in close proximity to the walls of the casing for substantially their entire circumference to reduce rotation losses, and intermediate buckets which are located between the wheel-buckets.

23. In an elastic-fluid turbine, the combination of a shaft, a support sleeved thereon which is provided with flanges, bucket-carrying disks which are secured to opposite sides of the flanges, and bolts adjacent the wheel peripheries for securing each pair of wheels together and whose ends are disposed below the surfaces of the disks to decrease rotation losses.

24. In an elastic-fluid turbine, the combination of a shaft, a support sleeved thereon which is provided with flanges, bucket-carrying disks which are secured to opposite sides of the flanges, means adjacent the wheel peripheries for securing each pair of wheels together, and rings situated between each pair

of disks in corresponding annular grooves therein and which act as separators and also to prevent the motive fluid from contacting with the central part of the wheel.

25. In an elastic-fluid turbine, the combination of a shaft, flanged sleeves mounted thereon which abut and act as spacers, wheel-disks mounted on opposite sides of the flanges, and means for securing the disks in place.

26. In an elastic-fluid turbine, the combination of a shaft having a collar thereon; flanged sleeves mounted thereon which abut and form spacers, a nut for pressing the sleeves against each other and the collar, and bucket-carrying disks which are bolted to opposite sides of the flanges.

27. In an elastic-fluid turbine, the combination of one or more buckets, a support therefor, and a lining-strip situated between the buckets and the support and forming a wall of each of the bucket spaces or passages.

28. In an elastic-fluid turbine, the combination of a plurality of buckets, a base-piece which is formed integral with the buckets, a support, and a lining-strip between the ends of the buckets and the support.

29. In an elastic-fluid turbine, the combination of a plurality of buckets, a base-piece which is formed integral with the buckets, a support, a lining-strip between the ends of the buckets and the support, and attaching means which extend through the base-piece into the support.

30. In an elastic-fluid turbine, the combination of a plurality of buckets, a lining-strip through which one or more of the bucket ends extend, and a support to which the buckets are attached, and which is provided with a groove to receive the bucket ends projecting through said strip.

31. In an elastic-fluid turbine, the combination of a plurality of buckets, some or all of which are provided with end projections, a lining-strip through which the projections extend, a support, and means for attaching the buckets and lining-strip to the support.

32. In an elastic-fluid turbine, the combination of a plurality of buckets, a base-piece to which the buckets are attached, a support, a smooth lining-strip located between the buckets and the support, and retaining devices which hold the base-piece and lining-strip in place.

33. In an elastic-fluid turbine, the combination of a casing-wall, a shaft, and a packing carried by the wall, which surrounds the shaft and comprises a sleeve, partitions located within the sleeve which form grooves or compartments around the shaft, carbon packing-rings situated within the grooves and adjacent to the partitions and shaft, and spring-pressed holders for the rings also situated in the grooves.

34. In an elastic-fluid turbine, the combination of a casing-wall, a shaft, and a packing carried by the wall, which surrounds the shaft and comprises a sleeve, partitions located within the sleeve, carbon packing-rings situated within the sleeve and adjacent to the partitions and shaft, a holder for each packing, and a spring for holding each packing in place.

35. An elastic-fluid turbine comprising a casing, and bucket-wheels therein, in combination with a separator located within the casing through which the entire volume of motive fluid passes for decreasing the amount of moisture carried from one wheel to another by the motive fluid, and a support for the means, which is detachably secured to the casing.

36. An elastic-fluid turbine comprising a casing, and bucket-wheels therein, in combination with one or more partitions permanently located within the casing, another partition or partitions adjacent to the first, and a detachable cover or plate for the casing, which supports the last-mentioned partition.

37. In an elastic-fluid turbine, the combination of a casing, a wheel-carrying shaft therein, a diaphragm which divides the casing into wheel-compartments and is provided with a cylindrical wall surrounding the shaft, and a packing between the wall of the diaphragm and the shaft, said packing comprising a sleeve, partitions therein which divide it into grooves, packing-rings in the grooves, and springs for urging the rings against the shaft and the partitions.

38. In an elastic-fluid turbine, the combination of a casing, a wheel-carrying shaft therein, a cylindrical wall surrounding the shaft which is provided with a groove, a packing between the wall and the shaft, said packing comprising a sleeve arranged in the groove of the wall to prevent axial movement thereof, packing-rings in the sleeve, and springs which urge the rings against the shaft.

39. In an elastic-fluid turbine, the combination of a casing, a wheel-carrying shaft therein, a cylindrical wall surrounding the shaft which is provided with a groove, a packing comprising a sleeve arranged in the groove of the wall to prevent axial movement thereof, partitions which divide the sleeve into grooves, a packing-ring in each groove, a holder for the ring, and means between the holder and the wall of the groove for urging the rings against the shaft and adjacent partitions of the sleeve.

40. In an elastic-fluid turbine, the combination of a casing, a wheel-carrying shaft therein, a wall surrounding the shaft, a sleeve around the shaft which is divisible on an axial plane, means on the said wall for preventing axial movement of the sleeve, partitions in

the sleeve, packing-rings between the partitions, and means for urging the rings against the shaft and the partitions.

41. In an elastic-fluid turbine, the combination of a casing comprising a wheel-compartment, a bucket-wheel mounted therein comprising bucket-carrying disks whose outer surfaces conform in shape to the walls of the compartment and are disposed in close proximity to the latter to reduce rotation losses but separated sufficiently therefrom to prevent a braking effect due to the presence of moisture, and a means for securing the disks adjacent to their peripheries whose outer ends are disposed below the surfaces of the disks to permit the said surfaces to be disposed in close proximity to the walls of the compartment and contributing to reduce rotation losses.

42. An elastic-fluid turbine comprising a compound bucket-wheel, and an inclosing casing therefor whose walls are located in close proximity to the buckets to reduce rotation losses, and means carried by the wheel and forming a part thereof which contributes to reduce rotation losses.

43. An elastic-fluid turbine comprising a compound bucket-wheel formed of bucket-carrying disks and a peripheral ring between the disks, and a casing for the wheel whose walls are arranged in close proximity to the buckets to contribute with the said ring to reduce rotation losses.

44. An elastic-fluid turbine comprising a casing having smooth interior walls, wheel-buckets mounted within the casing and arranged in rows, the said buckets running in close proximity to the walls of the casing to reduce their fan-like action, a support for the buckets which with the latter substantially fills the casing to reduce eddy-currents of the motive fluid, and a nozzle or device for discharging motive fluid against a portion of the wheel-buckets.

45. An elastic-fluid turbine comprising a casing and bucket-wheels, in combination with a diaphragm the walls of which are located in close proximity to the buckets to reduce rotation losses, and a chamber within the diaphragm through which the motive fluid passes in flowing from one row of wheel-buckets to another for decreasing the amount of moisture contained therein.

46. An elastic-fluid turbine comprising stage-compartments, a bucket-wheel for each stage-compartment, and fluid-discharging devices, in combination with a chamber located between stage-compartments which receives the exhaust from one stage, prevents it from reacting on the wheel that discharged it, and delivers it into another stage.

47. An elastic-fluid turbine comprising stage-compartments, a bucket-wheel for each stage-compartment, and fluid-discharging devices, in combination with an internal annular chamber which receives fluid from a given wheel, and after permitting the same to circulate without interfering with said wheel supplies it to the discharging devices of the adjacent stage of lower pressure.

48. An elastic-fluid turbine comprising stage-compartments, a bucket-wheel for each stage-compartment, and fluid-discharging devices, in combination with an annular chamber which receives fluid from a given wheel, and supplies it to one or more discharging devices of a lower-pressure stage, and a throat or orifice for the chamber which conforms in shape to the entering column of motive fluid.

49. An elastic-fluid turbine comprising stage-compartments, a bucket-wheel for each stage-compartment, and fluid-discharging devices, in combination with a chamber located within the casing of the machine and between the stage-compartments which receives fluid from one wheel and delivers it to another, and walls for the chamber which extend into close proximity with the idle wheel-buckets and cut down the rotation losses.

In witness whereof we have hereunto set our hands this 5th day of March, 1904.

JOHN G. CALLAN.
BRACE H. HAMILTON.

Witnesses:
DUGALD McK. McKILLOP,
WILLIAM G. FISHER.