No. 868,438. PATENTED OCT. 15, 1907.

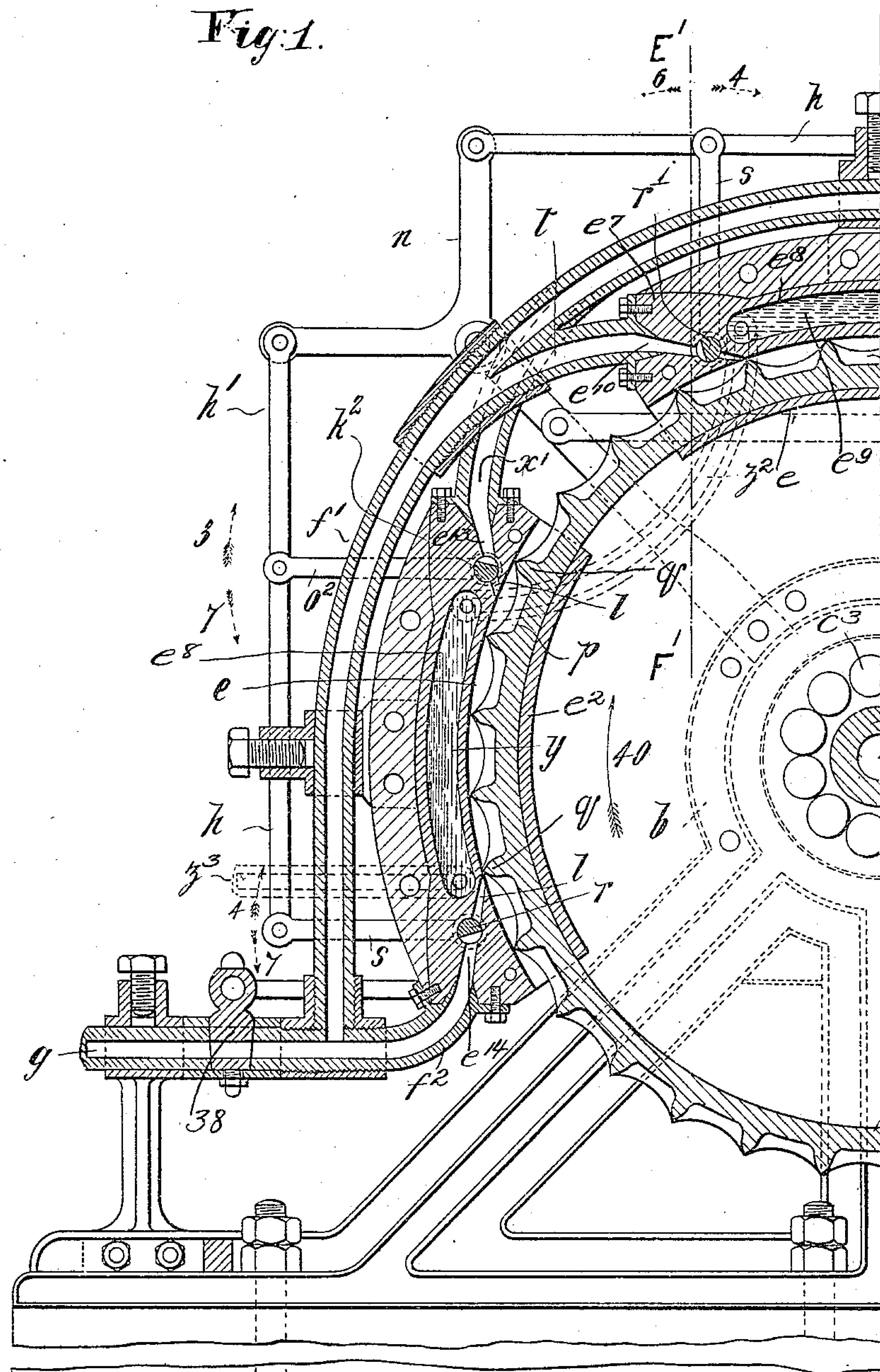
J. HUTCHINGS.

TURBINE.

APPLICATION FILED JAN. 30, 1905.

5 SHEETS—SHEET 1.

Fig. 1.

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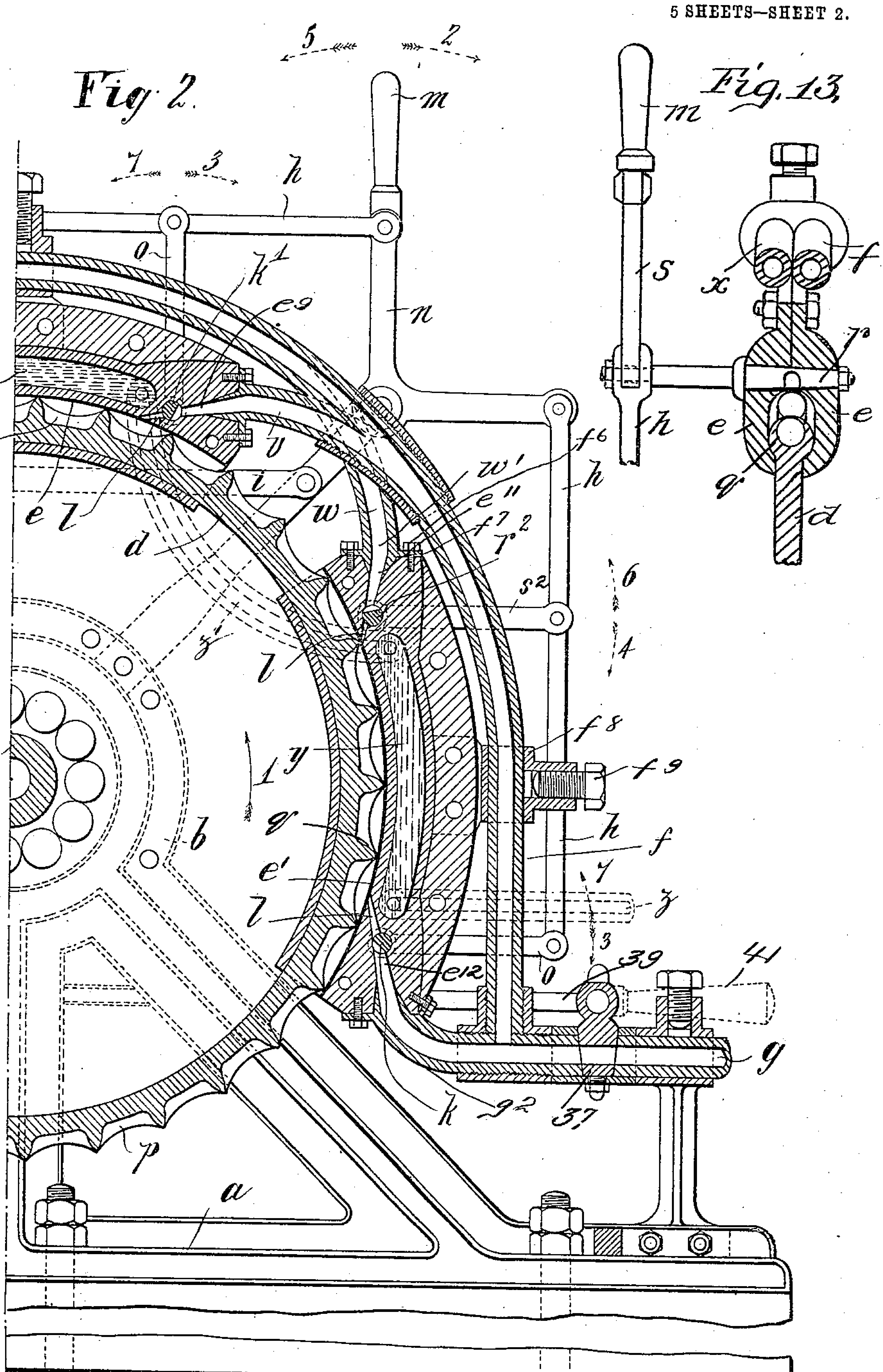
5 SHEETS—SHEET 2.

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5 SHEETS—SHEET 3.

Fig: 5.

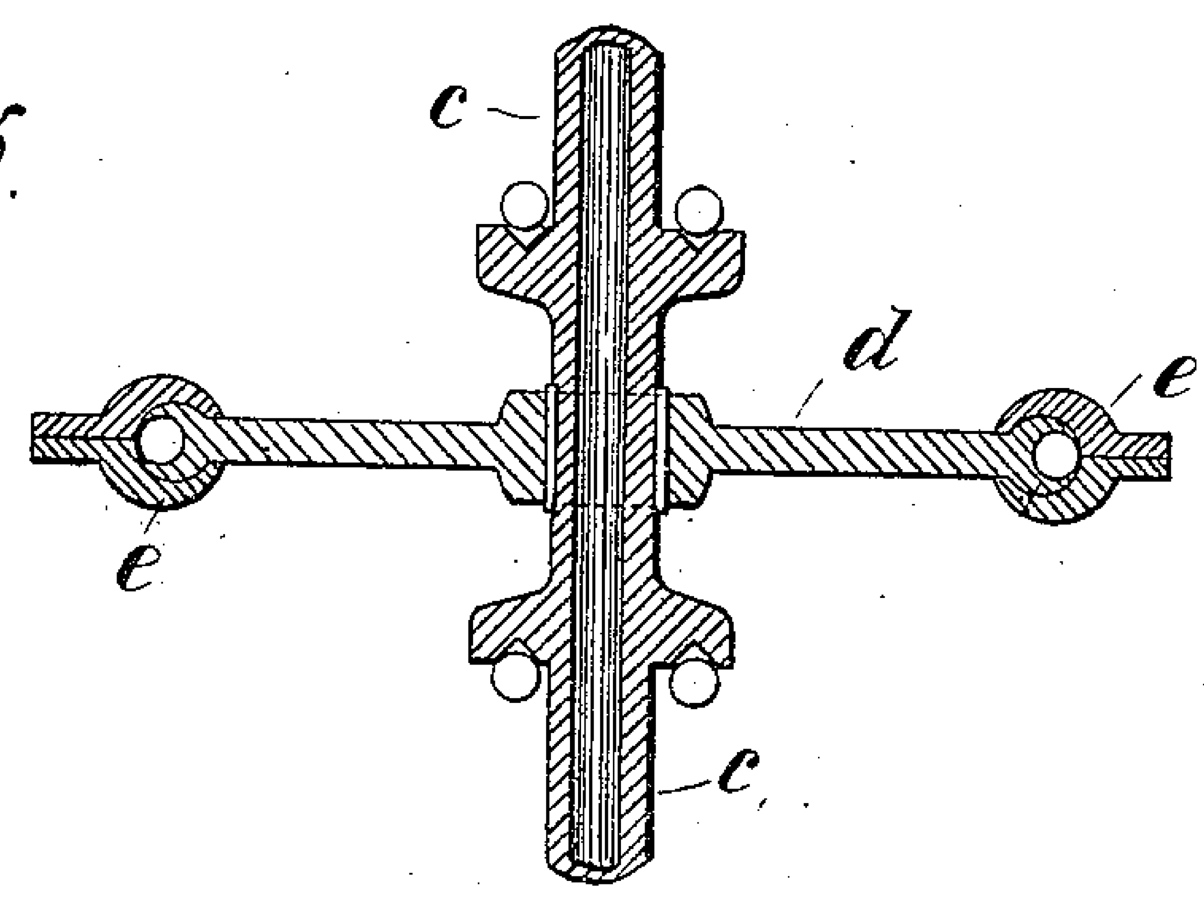



Fig: 3.

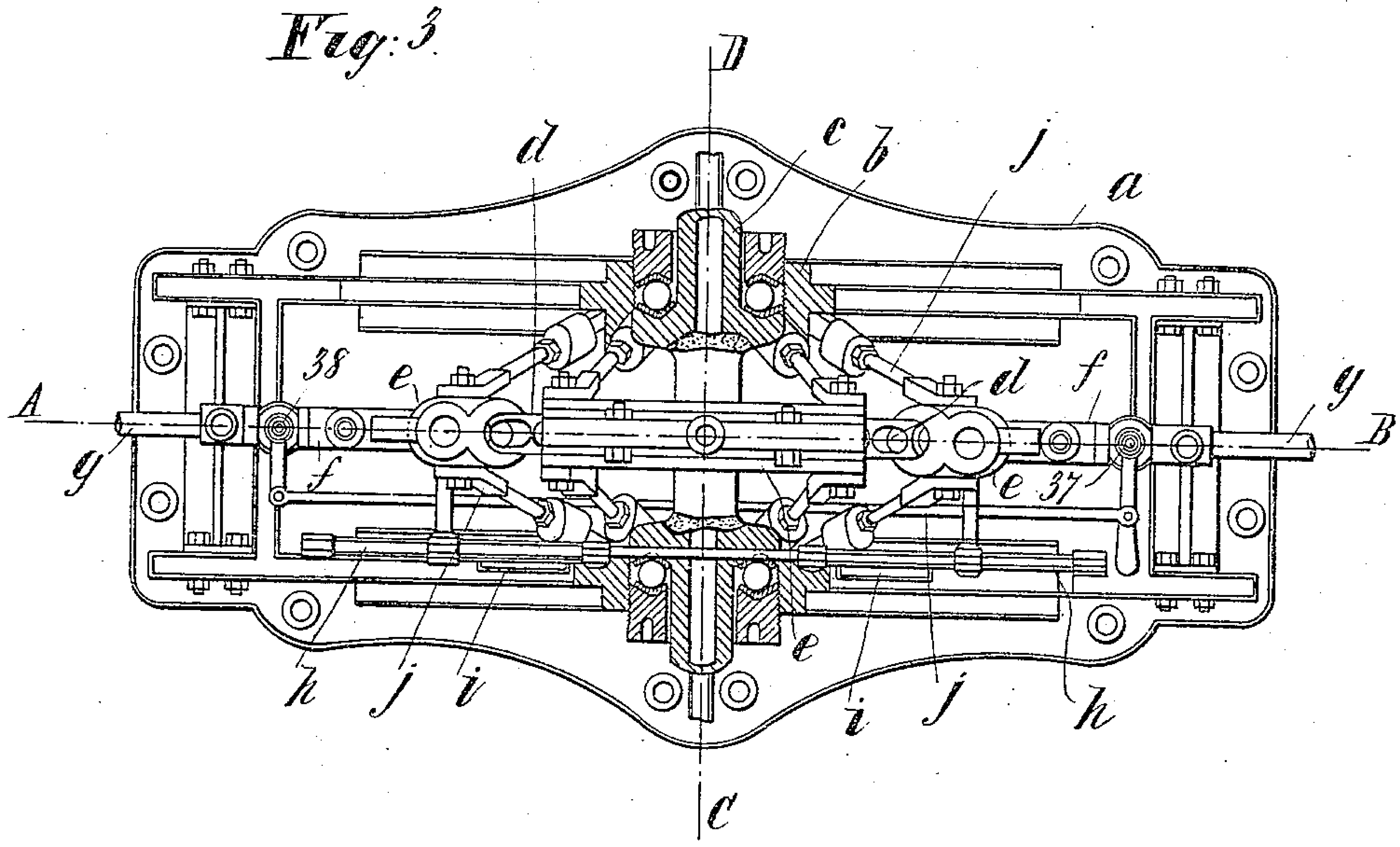
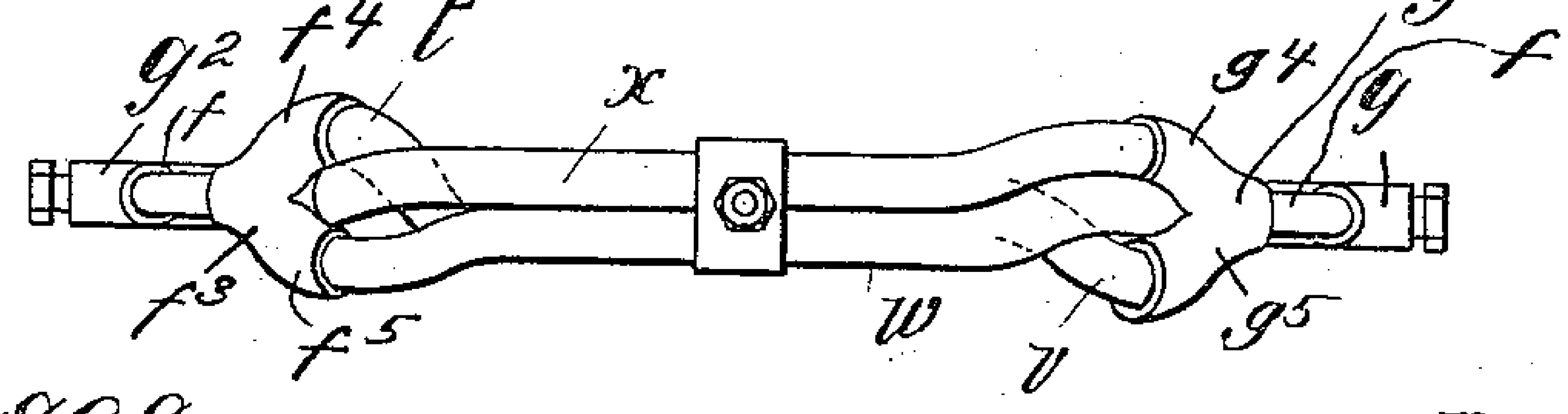



Fig: 4.

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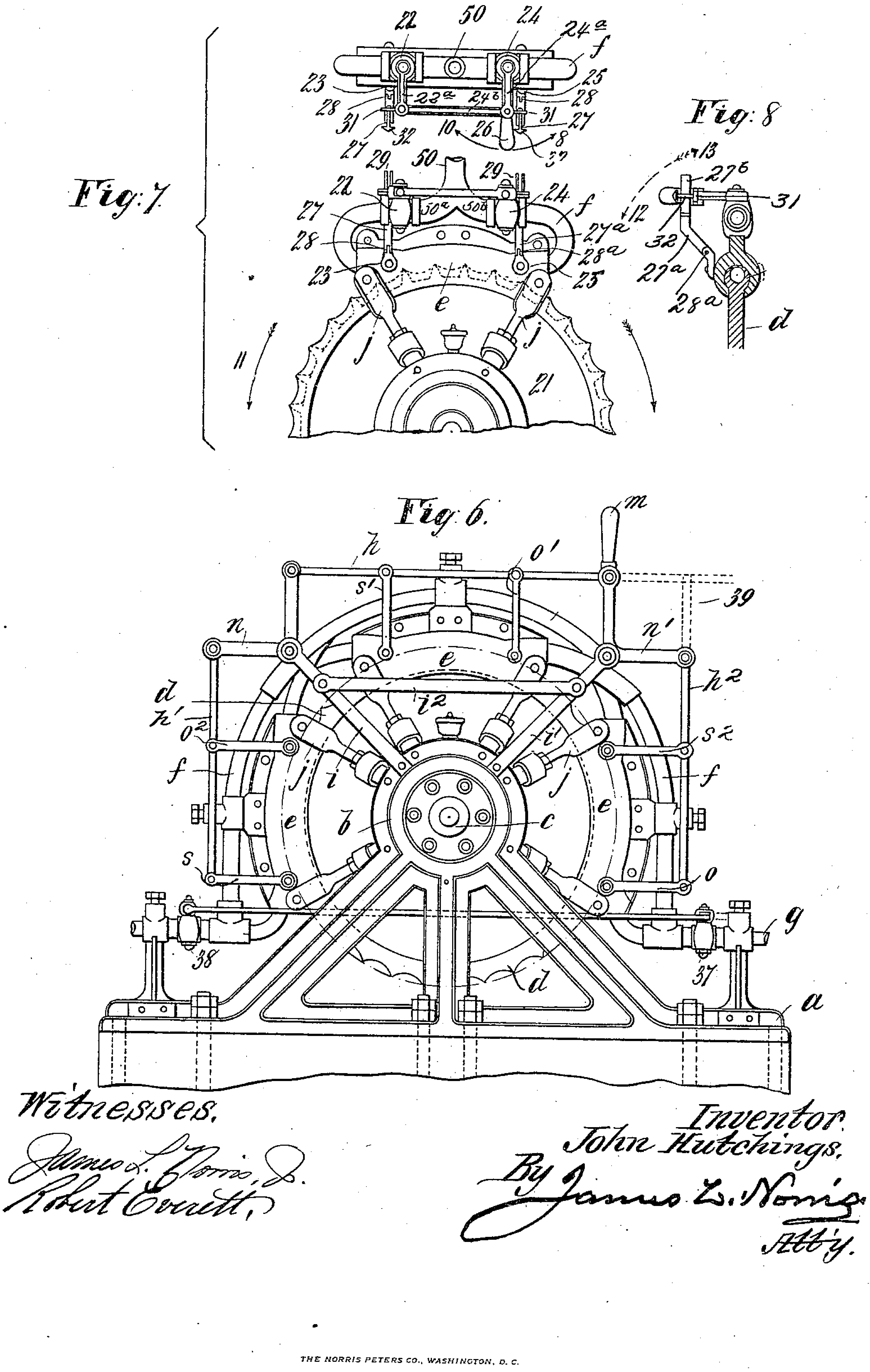
5 SHEETS—SHEET 4.



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5 SHEETS—SHEET 5.

Fig:9.

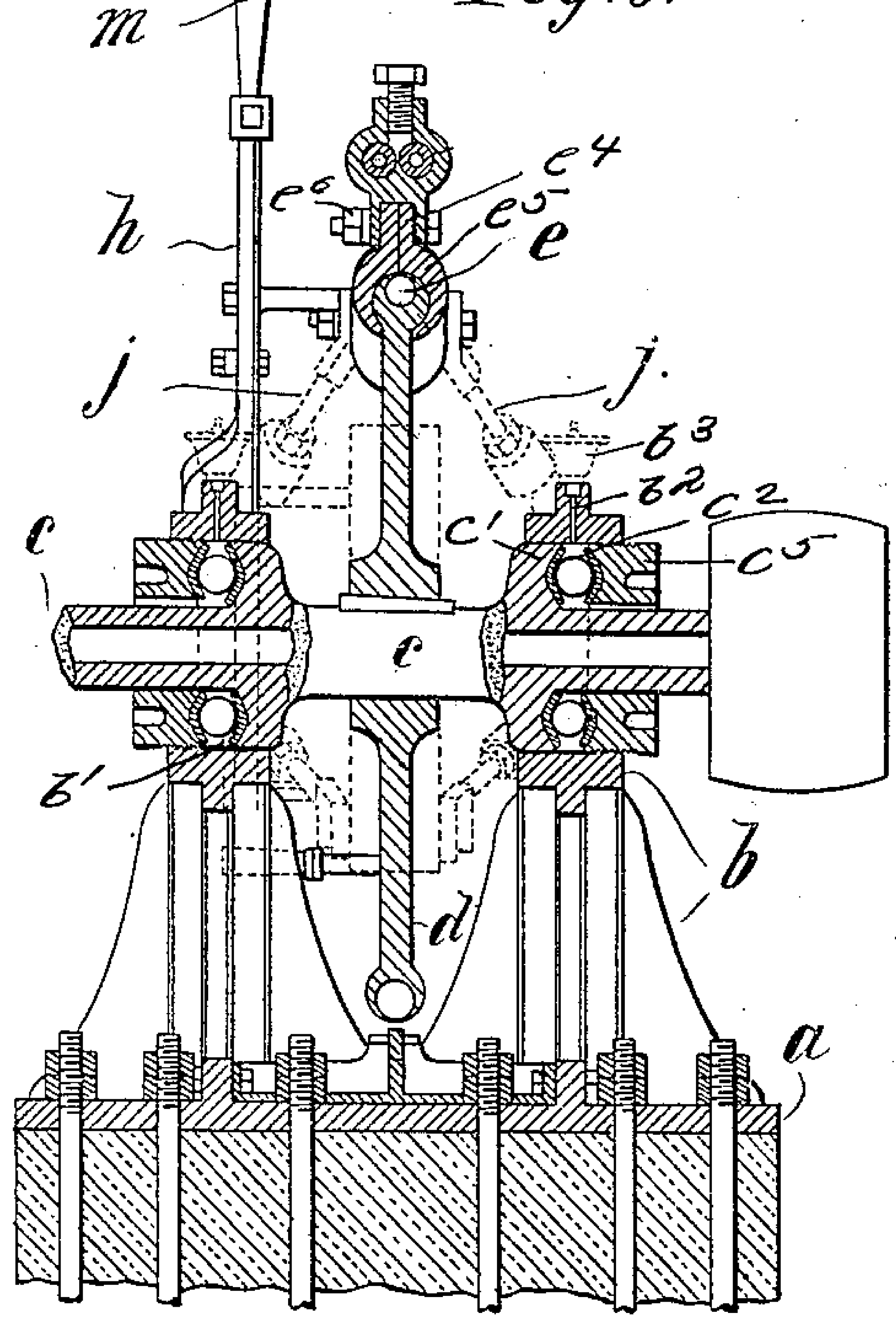



Fig:10.

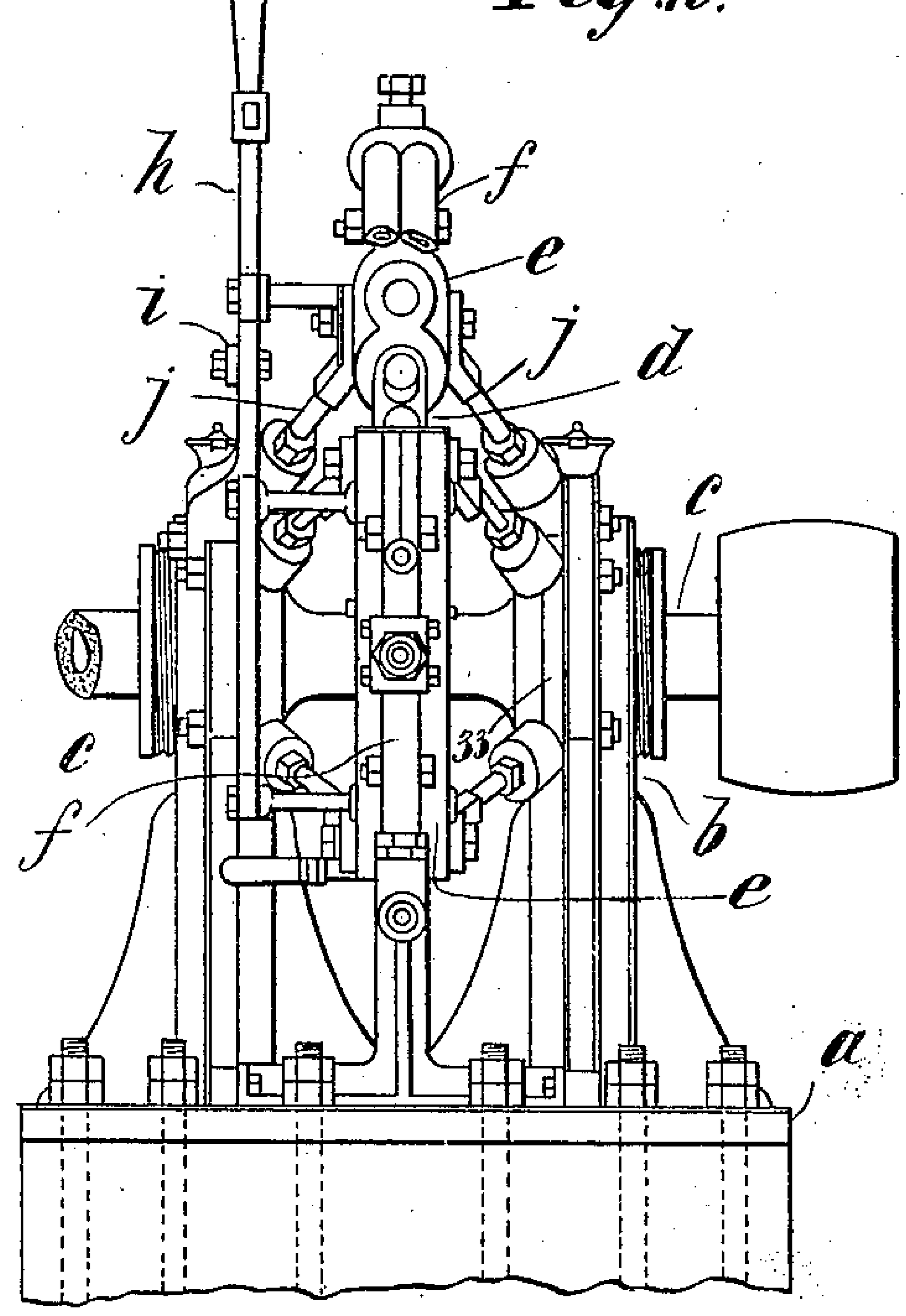



Fig:11.

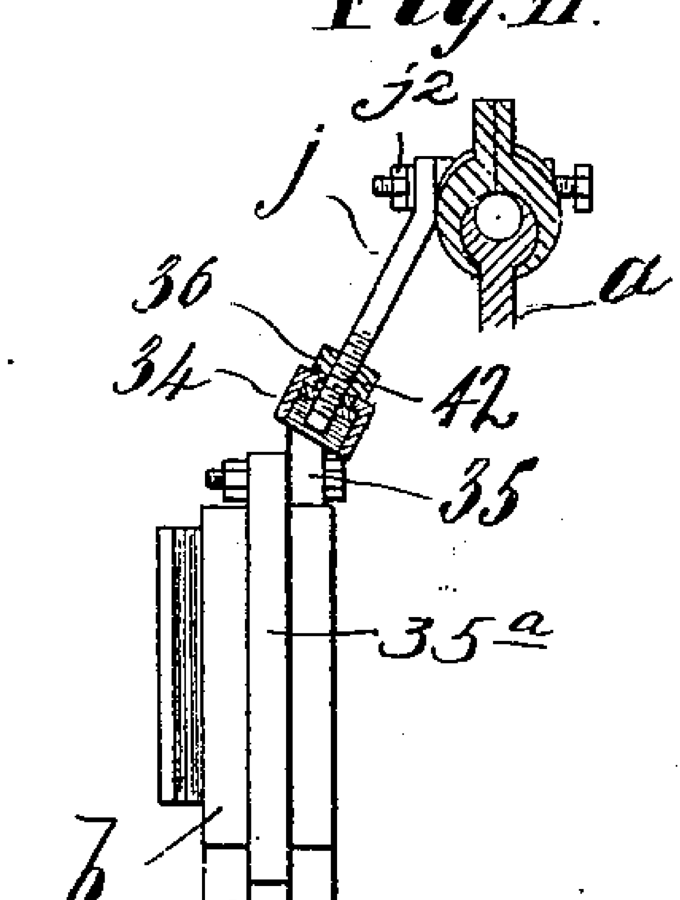
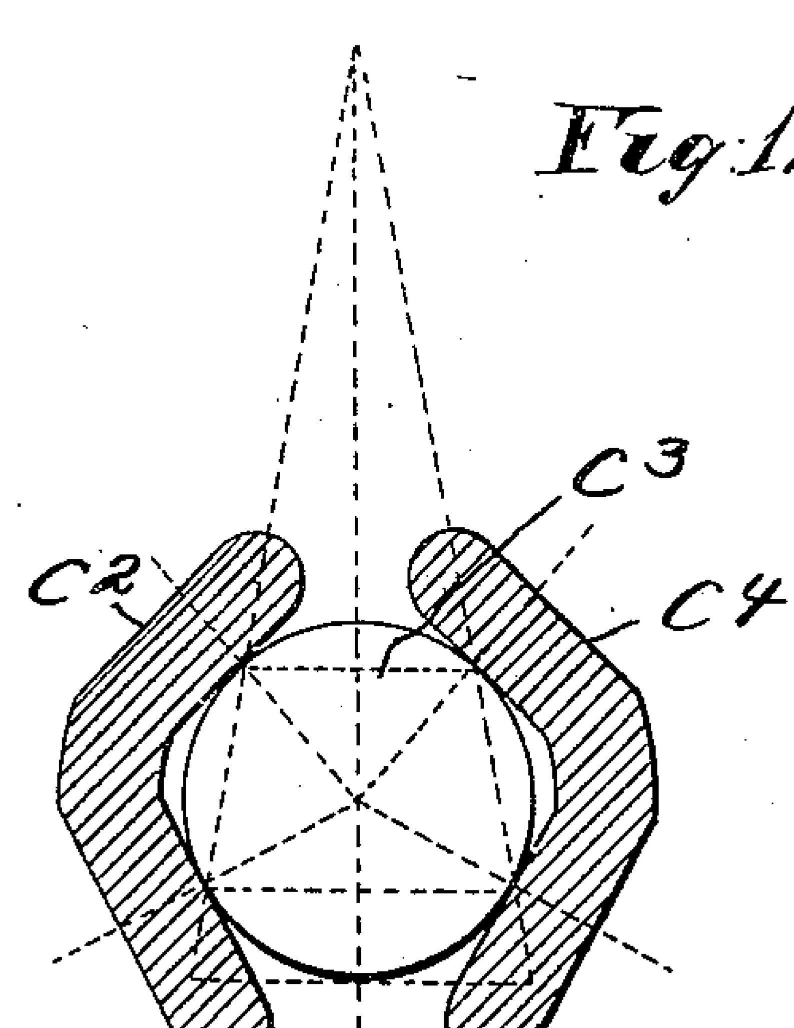



Fig:12.

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# UNITED STATES PATENT OFFICE.

JOHN HUTCHINGS, OF LONDON, ENGLAND.

## TURBINE.

No. 868,438. Specification of Letters Patent. Patented Oct. 15, 1907.

Application filed January 30, 1905. Serial No. 243,360.

*To all whom it may concern:*

Be it known that I, JOHN HUTCHINGS, a subject of the King of Great Britain, residing at 210 Moorgate Station Chambers, in the city of London, England, engineer, have invented certain new and useful Improvements in and Relating to Turbines, of which the following is a specification.

This invention relates to "elastic fluid turbines," and the object thereof is to provide a turbine in a manner as hereinafter set forth which has a continuous direction of rotation, driven by the expansion of air, steam or other fluid, and capable of being suddenly reversed so as to revolve in the opposite direction.

A further object of the invention is to provide the turbine with a driving disk having a circumferentially-extending series of peripheral recesses so as to form a series of vanes adapted to be impacted by the incoming motive fluid, the surfaces against which the fluid impacts being substantially at right angles to the line of force and each of such surfaces being composed of an epicycloidal curve in order that each surface may adjust itself during the revolution of the disk so that such force is received upon the curvilinear surface substantially in a succession of such planes as to in fact form a continuous direct abutment to oppose and take up the impelling impulse with the maximum economy.

A further object of the invention is to provide a turbine of such class with motive fluid conducting pipes in a manner as hereinafter set forth whereby the fluid is conducted to impact at different points of the driving disk to facilitate the operation thereof, whether the disk is driven in one direction or the other.

A further object of the invention is to provide the turbine in a manner as hereinafter set forth with a plurality of independent compression chambers arranged in operative relation with respect to the vanes formed on the driving disk, and to further provide means in a manner as hereinafter set forth for adjustably supporting the said independent compression chambers.

Further objects of the invention are to provide an elastic fluid turbine which shall be comparatively simple in its construction, strong, durable efficient in its operation, having the direction of movement of its driving disk readily reversed when occasion so requires, and conveniently set up.

With the foregoing and other objects in view, the invention consists in the novel construction, combination and arrangement of parts hereinafter more specifically described and illustrated in the accompanying drawings wherein is shown the preferred embodiment of the invention, but it is to be understood that changes, variations and modifications can be resorted to which come within the scope of the claims hereunto appended.

In describing the invention in detail reference is had to the accompanying drawings wherein like characters denote corresponding parts throughout the several views, and in which—

Figures 1 and 2 are longitudinal, sectional views, showing, respectively, the left and right halves of an elastic fluid turbine in accordance with this invention, the section being taken upon line A—B of Fig. 3; Fig. 3 is a plan, partly in section; Fig. 4 is a detail showing in plan the motive fluid supply or conducting pipes; Fig. 5 is a horizontal section of the turbine shaft and driving disk; Fig. 6 is a side elevation of the turbine; Fig. 7 is a plan and elevation of the motive fluid supply or conducting pipes for a single-acting type of turbine; Fig. 8 is a detail in vertical section of the single-acting turbine reversible driving fittings; Fig. 9 is a section on line C—D of Fig. 3; Fig. 10 is an end elevation of the turbine with certain of the parts removed; Fig. 11 is a sectional detail showing the adjustable supporting means for the pressure chambers; Fig. 12 shows, diagrammatically in cross section drawn to a larger scale, one of the balls and its races, the dotted lines indicating the positions of the axis or center of the turbine shaft, the radius and the theoretical bearing cone of each ball, and, Fig. 13 is a section on line E′—F′ of Fig. 1.

Referring to the drawings by reference characters, $a$ denotes a bed plate having secured thereto supporting standards $b$, which at their upper ends are provided with openings $b'$ to allow of the turbine shaft $c$ being journaled in the standards $b$. The opening $b'$ is of much greater diameter than the turbine shaft $c$, but the latter is formed with annular flanges $c'$ of a diameter substantially equal to the diameter of the opening $b'$, but the diameter of the flanges $c'$ is such as not to retard the operation of the shaft $c$. Against one face of each of the flanges $c'$ is positioned a bearing ring $c^2$ which is angular in cross section and constitutes one-half of a ball race for the bearing balls $c^3$. The other half of the ball race is formed by a bearing ring $c^4$ which is of the same contour as the ring $c^2$, and the said rings $c^4$ are retained in position by the cap pieces $c^5$ which are screw-threaded and engage with the screw-threads formed on the walls of the openings $b'$. Each of the standards $b$ at its top is formed with a lubricant passage $b^2$ communicating at one end with a lubricant supply $b^3$ and at its other end communicating with the opening $b'$. The function of the passage $b^2$ is to supply a lubricating material to the bearing rings $c^2$, $c^4$ and bearing balls $c^3$.

Fixed upon the shaft $c$ is a driving disk $d$ having its periphery formed with a circumferentially-extending series of recesses $p$ substantially circular in transverse section, forming thereby the periphery of the disk *d* with a circumferentially-extending series of vanes *q*. The vanes *q* in cross section are each formed of two epicycloidal curves intersecting each other at a point at the original peripheral line of the disk *d*. The vanes *q* constitute surfaces upon which the fluid impacts so as to cause the rotation of the disk *d*, thereby revolving the shaft *c*. The surfaces of the vanes *q* are so disposed that the abutment formed thereby for the impelling fluid is substantially at right angles to the line of force and as each surface of each vane is formed upon an epicycloidal curve, such surface adjusts itself during the revolution of the disk so that such force is received upon the curvilinear surface substantially in a succession of such planes as to in fact form a direct abutment to oppose and take up the impelling impulse with the maximum economy.

The disk *d* as it rotates is adapted to travel through a plurality of independent expansion chambers, as shown, three in number, and which are indicated by the reference characters *e*, *e′*, $e^3$. As the elements which form each of the expansion chambers are the same the construction of one chamber will be described, the same reference characters being applied thereto, with the exception of the reference characters which designate the inlet ports for the motive fluid. Each of the expansion chambers is formed from a pair of segment-shaped plates having a flattened and a curvilinear portion $e^4$, $e^5$, respectively. The flattened portions are adapted to abut and are secured together by the hold-fast devices $e^6$. The curvilinear portions $e^5$ are adapted to straddle the rim of the disk *d* and between said curvilinear portions $e^5$ the vanes *q* travel during the rotation of the disk *d*. The segment-shaped plates are hollowed out so as to receive a casting $e^7$ formed with a hollow chamber $e^8$ which receives a heating or cooling medium $e^9$ depending upon the character of the motive force employed. The lower face of the casting $e^7$ constitutes the outer wall of the expansion chamber. The chamber $e^8$ which receives the heating or cooling medium for the expansion chamber *e′* communicates at its lower end with a heating or cooling medium supply pipe *z*, while at its other end is connected with the chamber $e^8$ which receives the heating or cooling medium for the expansion chamber *e* by the branch-conducting pipe *z′*. This last-mentioned chamber $e^8$ communicates with the chamber $e^8$ which receives a heating or cooling medium for the expansion chamber $e^2$ by the branch-conducting pipe $z^2$. The last-mentioned chamber $e^8$ is provided with a discharge pipe $z^3$. The elements which form the expansion chambers *e*, *e′*, $e^2$ also act as a means to guide the disk *d* to prevent lateral movement thereof when it is rotating. This is evident owing to the fact that the curvilinear portions $e^5$ straddle the enlarged rim of the disk *d* as clearly shown in Fig. 9.

The expansion chamber *e* has the motive fluid inlets $e^9$, $e^{10}$ communicating therewith, the inlet $e^9$ communicating with the chamber *e* near one end, while the inlet $e^{10}$ communicates with the chamber at the opposite end. The expansion chamber *e′* has the motive fluid inlets $e^{11}$ and $e^{12}$ communicating therewith, the inlet $e^{11}$ communicating with the chamber *e′* near one end, while the inlet $e^{12}$ communicates with the chamber at the opposite end. The expansion chamber $e^2$ has the motive fluid inlets $e^{13}$ and $e^{14}$ communicating therewith, the inlet $e^{13}$ communicating with the chamber $e^2$ near one end, while the inlet $e^{14}$ communicates with the chamber at the opposite end.

Within the inlet $e^9$ is positioned the valve *k′*, while in the inlet $e^{10}$ the valve *r′* is positioned. Within the inlet $e^{11}$ a valve $r^2$ is positioned, while in the inlet $e^{12}$ a valve *k* is arranged, and within the inlet $e^{13}$ a valve $k^2$ is positioned, while in the inlet $e^{14}$ a valve *r* is arranged. The valves *k*, *k′* and $k^2$ are operated simultaneously and a like action is had in connection with the valves *r*, *r′* and $r^2$. The manner of operating the valves *k*, *k′*, $k^2$, *r*, *r′* and $r^2$ will be hereinafter referred to. The inlets of the various expansion chambers are so disposed with respect to the vanes *q*, and the latter so constructed, that the abutment formed by the vanes for the impelling fluid is substantially at right angles to the line of force.

The turbine as shown in Fig. 1 is provided with a pair of motive fluid supply pipes *g* and *g′*, the former communicating with a motive fluid conducting pipe *f* and the latter with a motive fluid conducting pipe *f′*. The supply pipe *g* terminates in an upwardly-curved nipple $g^2$ which opens into the upwardly-extending port $e^{12}$. The conducting pipe *f* which communicates with the supply pipe *g* opens into a coupling $g^3$ having two branches $g^4$, $g^5$. From the branch $g^5$ extends a nipple *v* which opens into the downwardly-inclined port $e^9$. From the branch $g^4$ extends a conducting pipe *x* having its end terminating in a nipple *x′* which communicates with the downwardly-inclined port $e^{13}$. When the valves *k*, *k′*, $k^2$ are opened the motive fluid impacts against the vanes *q* so as to rotate the disk *d* in the direction of the arrow 1. When the valves *k*, *k′*, $k^2$ are opened the valves *r*, *r′*, $r^2$ are closed. The motive fluid supply pipe *g′* terminates at its upper end in an upwardly-curved nipple $f^2$ which opens into the upwardly inclined port $e^{14}$. The motive fluid conducting pipe *f′* which communicates with the motive fluid supply pipe *g′* opens into a coupling $f^3$ having two branches $f^4$, $f^5$. Extending from the branch $f^4$ is a nipple *t* which communicates with the downwardly-inclined port $e^{10}$. Extending from the branch $f^5$ is a motive fluid-conducting pipe *w* which terminates in a nipple *w′* opening into the downwardly-inclined port $e^{11}$. When the valves *r*, *r′*, $r^2$ are opened and the valves *k*, *k′* and $k^2$ closed the motive fluid will be caused to impact against the vanes *q* so as to drive the disk in the direction of the arrow 40—that is to say, in an opposite direction from that indicated by the arrow 1. The nipples $g^2$, *v*, *x′*, $f^2$, *t* and *w′* are connected to the castings $e^7$ by the hold-fast devices $f^6$ which extend through the flanges $f^7$ formed on the nipples and which bear against the castings $e^7$. The motive fluid conducting pipes *f*, *f′*, *x* and *w* are retained in position through the medium of the coupling sleeves $f^8$ and set-screws $f^9$. The coupling sleeves $f^8$ are secured to the segment-shaped plates by the hold-fast devices $e^6$.

The valves *k*, *k′*, $k^2$ are operated alternately with respect to the valves *r*, *r′*, $r^2$ through the medium of the following mechanism: To the stem of the valve *k* is attached the link *o*; a link *o′* is attached to the stem of the valve *k′* and a link $o^2$ is attached to the stem of the valve $k^2$. To the stem of the valve *r* a link *s* is attached; a link *s′* is attached to the stem of the valve *r′* and a link $s^2$ is attached to the stem of the valve $r^2$. A rod *h* is attached to the outer ends of the links $o'$, $s'$; a rod $h'$ is attached to the outer ends of the links $s$, $o^2$ and a rod $h^2$ is attached to the outer ends of the links $o$, $s^2$. The upper end of the rod $h'$ is articulated to one arm of a bell crank lever $n$, the other arm of said bell crank lever being articulated to one end of the rod $h$. The latter has its other end attached to one arm of the bell crank lever $n'$, while the other end of said bell crank lever is articulated to the upper end of the rod $h^2$. The bell crank lever $n$ is pivotally connected to a support $i$, the lever $n'$ being pivotally connected to a support $i'$. The supports $i$, $i'$ are braced by the cross bar $i^2$. A handle $m$ is attached to the bell crank lever $n$ to enable the mechanism for actuating the valves to be shifted in the directions as indicated by the arrows 2 and 5. If the handle $m$ is moved in the direction of the arrow 2 the valves $k$, $k'$, $k^2$ are shifted in the direction indicated by the arrows 3. The links, $s$, $s'$, $s^2$ will then be moved in the direction of the arrows 4 causing an automatic closing of the valves, $r$, $r'$, $r^2$ so that the motive fluid will be caused to impact against one side of the vanes $q$ and rotate the disk $d$ in the direction as indicated by the arrow 1. To reverse the direction of movement of the disk $d$, the handle $m$ is moved in the direction of the arrow 5. Such action will move the links $s$, $s'$, $s^2$ in the direction of the arrows 6, thus opening the valves $r$, $r'$, $r^2$ and automatically closing the valves $k$, $k'$, $k^2$ for the reason that the links $o$, $o'$, $o^2$ will be moved in the direction of the arrows 7. When the valves $k$, $k'$, $k^2$ are closed and the valves $r$, $r'$, $r^2$ opened the motive fluid will impact against the opposite side of the vanes $q$ and cause the disk $d$ to rotate in the direction of the arrow 40.

Within the supply pipe $g$ is arranged a cut-off 37 and a cut-off 38 is arranged within the supply pipe $g'$. These cut-offs 37, 38 are connected by the rod 39. A handle 41 is provided for operating the rod 39. When the rod 39 is shifted in one direction it will open the cut-off 37 and close the cut-off 38 and a reverse operation of the cut-offs 37, 38 is had when the rod 39 is shifted in the opposite direction.

In Fig. 7 is shown a turbine of single-acting type and reversely driven. In such form of turbine 21 denotes a drive wheel which is constructed in the same manner as the disk $d$. But one compression chamber $e$ is employed and its construction is similar to that hereinafter referred to. The supply pipe is indicated by the reference character 50 and which terminates in the branches $50^a$, $50^b$. In the branch $50^a$ is arranged a cut-off 22 and in the branch $50^b$ is arranged a cut-off 24. The branch $50^a$ communicates with an inlet port (not shown) at one end of the compression chamber $e$ and the branch $50^b$ communicates with an inlet port (not shown) at the opposite end of the chamber $e$. The cut-offs 23 and 25 are provided for the inlet ports. To the stem of the cut-off 22 is attached a link $22^a$ and to the stem of the cut-off 24 is attached a link $24^a$. The links $22^a$ and $24^a$ are connected together by the rod $24^b$. A handle 26 is attached to the rod $24^b$. The cut-offs 22 and 24 are so disposed that when the handle 26 is shifted in the direction of the arrow 8 the cut-off 22 will be opened and the cut-off 24 closed and when the handle 26 is shifted in the direction of the arrow 10 the cut-off 24 will be opened and the cut-off 22 closed. To the stem of the valve 23 is hinged a link 27, as at 28 and to the stem of the valve 25 is hinged a link $27^a$ as at $28^a$. The lower portions of the links 27, $27^a$ are inclined, while the upper portions extend in a vertical manner and are bifurcated, as at $27^b$. Each of the links $22^a$, $24^a$ is formed with a protuberance 31 which carries a T-shaped pin 32 extending in the bifurcation $27^b$. From such construction it is evident that when the cut-off 22 is opened a like movement will be imparted to the cut-off 23 and the cut-offs 24 and 25 will be closed. When these latter cut-offs are opened the cut-offs 22 and 23 will be closed. The dotted arrows 12 and 13 indicate the curve described by the levers 27, $27^a$ when disconnected from the links $22^a$, $24^a$. In Fig. 7 the links 27, $27^a$ are shown connected up in working position.

The large cut-offs or valves 22, 24 are made strong so as to secure a perfect closure and thus break the pressure that would otherwise bear against the cut-offs 23 and 25 when the turbine is not in use, but with the full pressure of working fluid in the branches $50^a$, $50^b$. The cut-offs 22 and 24 are provided with a port equal to the internal diameter of the branch pipes $50^a$, $50^b$, thus minimizing the construction offered to the working fluid required upon the disk 21 when rotating. The cut-offs 23 and 25 are finely made and graduated for the purpose of regulating the speed at which the disk 21 is to be driven.

The segment-shaped plates which constitute two of the elements for forming the compression chambers $e$ are supported through the medium of the inclined bars $j$ which are adjustably connected to the top of the supporting standards $b$. The bars $j$ are secured at their upper ends to the segment-shaped members by the holdfast devices $j^2$. The bars $j$ are arranged in pairs, a pair being positioned at each side of each segment-shaped member, the bars of each pair being attached to near the end of each of said segment-shaped members. The lower end of each of the bars $j$ is screw-threaded, as at 42 and extends through a ferrule 34 attached to a cradle-lug 35 which is secured to a flange $35^a$ upon the top of the standard $b$, there being a ferrule 34 at each end of a cradle-lug 35 so that the cradle-lug 35 will be used in connection with a pair of rods $j$. Upon the screw-threaded end of the rod $j$ and exterior of the ferrule 34 is an adjusting nut 36.

By the manner of setting up the bars $j$ with respect to the segment-shaped members it is evident that the compression chambers $e$, $e'$, $e^2$ can be adjusted and in this connection it will be stated that when the rod $j$ and cradle-lug 35 have been adjusted the adjustment of the pressure chambers minutely in their working position is effected by turning the nut 36 upwardly or downwardly upon its bar. By the adjustment of the nuts 36 upon their bars $j$ the pressure chambers can be raised or lowered so that the necessary regulation thereof will be had.

What I claim is—

1. An elastic fluid turbine comprising a driving disk having its periphery formed with a circumferentially-extending series of vanes with each of the faces thereof of epicycloidal curvature, thereby forming a continuous direct abutment for the motive fluid.

2. An elastic fluid turbine comprising a driving disk having its periphery formed with a circumferentially-extending series of vanes with each of the faces thereof of epicycloidal curvature, thereby forming a continuous di-

rect abutment for the motive fluid, and a plurality of independent expansion chambers communicating with a motive fluid supply and through which said vanes travel to receive the impact of the motive fluid, said expansion chambers opening into the atmosphere and suitably spaced from each other.

3. An elastic fluid turbine comprising a driving disk having its periphery formed with a circumferentially-extending series of vanes with each of the faces thereof of epicycloidal curvature, thereby forming a continuous direct abutment for the motive fluid, a plurality of independent expansion chambers communicating with a motive fluid supply and through which said vanes travel to receive the impact of the motive fluid, said expansion chambers opening into the atmosphere and suitably spaced from each other, and means for adjustably supporting said chambers.

4. An elastic fluid turbine comprising a driving disk having its periphery formed with a circumferentially-extending series of vanes with each of the faces thereof of epicycloidal curvature thereby forming a continuous direct abutment for the motive fluid, and a plurality of jacketed expansion chambers arranged independent of each other, communicating with a motive fluid supply and through which said vanes travel to receive the impact of the incoming motive fluid, said expansion chambers opening into the atmosphere and suitably spaced from each other.

5. An elastic fluid turbine comprising a driving disk having its periphery formed with a circumferentially-extending series of vanes with each of the faces thereof of epicycloidal curvature thereby forming a continuous direct abutment for the motive fluid, a plurality of jacketed expansion chambers arranged independent of each other, communicating with a motive fluid supply and through which said vanes travel to receive the impact of the incoming motive fluid, said expansion chambers opening into the atmosphere and suitably spaced from each other, and means for adjustably supporting said chambers.

6. An elastic fluid turbine comprising a driving disk having its periphery formed with a circumferentially-extending series of vanes with each of the faces thereof of epicycloidal curvature thereby forming a continuous direct abutment for the motive fluid, a plurality of independent expansion chambers through which said vanes travel for receiving the impact of the motive fluid, said chambers opening into the atmosphere and suitably spaced from each other, each of said chambers provided at each end with an inlet port, cut-offs arranged in each of said ports, the cut-offs in the ports at one end for each of said chambers alternately operating with respect to the cut-offs in the ports for the other end of said chambers, and means for operating the cut-offs.

7. An elastic fluid turbine comprising a driving disk having its periphery formed with a circumferentially-extending series of vanes with each of the faces thereof of epicycloidal curvature thereby forming a continuous direct abutment for the motive fluid, a plurality of independent expansion chambers through which said vanes travel for receiving the impact of the motive fluid, said chambers opening into the atmosphere and suitably spaced from each other, each of said chambers provided at each end with an inlet port, cut-offs arranged in each of said ports, the cut-offs in the ports at one end for each of said chambers alternately operating with respect to the cut-offs in the ports for the other end of said chambers, means for operating the cut-offs, and means for adjustably supporting the expansion chambers.

8. An elastic fluid turbine comprising a driving disk having its periphery formed with a circumferentially-extending series of vanes with each of the faces thereof of epicycloidal curvature thereby forming a continuous direct abutment for the motive fluid, a pair of segment-shaped plates each having the lower portion curved, means for adjustably supporting said plates, a casting provided with a pair of ports, said casting interposed between said plates and forming, in connection with the curvilinear portion of said plates, an expansion chamber through which said vanes are adapted to pass to receive an impact from the incoming motive fluid, a nipple opening into each of said ports and communicating with a motive fluid supply, and means for alternately closing said ports to reverse the operation of the driving disk.

9. An elastic fluid turbine comprising a driving disk having its periphery formed with a circumferentially-extending series of vanes with each of the faces thereof of epicycloidal curvature thereby forming a continuous direct abutment for the motive fluid, a pair of segment-shaped plates each having the lower portion curved, means for adjustably supporting said plates, a casting provided with a pair of ports, said casting interposed between said plates and forming, in connection with the curvilinear portion of said plates, an expansion chamber through which said vanes are adapted to pass to receive an impact from the incoming motive fluid, a nipple opening into each of said ports and communicating with a motive fluid supply, and means for alternately closing said ports to reverse the operation of the driving disk, said casting further provided with a chamber constituting a jacket for the expansion chamber.

10. An elastic fluid turbine comprising a driving disk having its periphery provided with a circumferentially-extending series of vanes, a plurality of pairs of segment-shaped plates inclosing portions of the rim of said disk, a casting interposed between each of said plates and in connection with the lower portion of said plates constituting an expansion chamber through which the vanes travel to receive an impact of motive fluid each of said castings provided at each end with a port opening into the expansion chamber, a pair of motive fluid supply pipes, a motive fluid conducting pipes communicating with each of the supply pipes, a coupling attached to each of said motive fluid conducting pipes and having a pair of branches, a nipple projecting over a branch of each of said couplings and communicating with a port at each end of one of said castings, a motive fluid conducting pipe projecting from the other branch of one of the couplings and terminating in a nipple communicating with a port of another of said castings, one of said motive fluid supply pipes terminating at its inner end with a nipple which communicates with the other port of the last-mentioned casting, a motive fluid conducting pipe projecting from the other branch of the other of said couplings and terminating in a nipple which communicates with the port of the other of said castings, the other of said motive fluid supply pipes terminating in a nipple which communicates with a port of the last-mentioned casting, and means for controlling the supply of motive fluid to said castings.

11. An elastic fluid turbine comprising a driving disk having its periphery provided with a circumferentially-extending series of vanes, a plurality of pairs of segment-shaped plates inclosing portions of the rim of said disk, a casting interposed between each of said plates and in connection with the lower portion of said plates constituting an expansion chamber through which the vanes travel to receive an impact of motive fluid each of said castings provided at each end with a port opening into the expansion chamber, a pair of motive fluid supply pipes, a motive fluid conducting pipe communicating with each of the supply pipes, a coupling attached to each of said motive fluid conducting pipes and having a pair of branches, a nipple projecting over a branch of each of said couplings and communicating with a port at each end of one of said castings, a motive fluid conducting pipe projecting from the other branch of one of the couplings and terminating in a nipple communicating with a port of another of said castings, one of said motive fluid supply pipes terminating at its inner end with a nipple which communicates with the other port of the last-mentioned casting, a motive fluid conducting pipe projecting from the other branch of the other of said couplings and terminating in a nipple which communicates with the port of the other of said castings, the other of said motive fluid supply pipes terminating in a nipple which communicates with a port of the last mentioned casting, cut-offs mounted in the ports of each of said castings, and means for alternately opening and closing the cut-offs in each casting.

12. An elastic fluid turbine comprising a driving disk having its periphery provided with a circumferentially-extending series of vanes, a plurality of pairs of segment-

shaped plates inclosing portions of the rim of said disk, a casting interposed between each of said plates and in connection with the lower portion of said plates constituting an expansion chamber through which the vanes travel to receive an impact of motive fluid each of said castings provided at each end with a port opening into the expansion chamber, a pair of motive fluid supply pipes, a motive fluid conducting pipe communicating with each of the supply pipes, a coupling attached to each of said motive fluid conducting pipes and having a pair of branches, a nipple projecting over a branch of each of said couplings and communicating with a port at each end of one of said castings, a motive fluid conducting pipe projecting from the other branch of one of the couplings and terminating in a nipple communicating with a port of another of said castings, one of said motive fluid supply pipes terminating at its inner end with a nipple which communicates with the other port of the last-mentioned casting, a motive fluid conducting pipe projecting from the other branch of the other of said couplings and terminating in a nipple which communicates with the port of the other of said castings, the other of said motive fluid supply pipes terminating in a nipple which communicates with a port of the last mentioned casting, cut-offs mounted in the ports of each of said castings, means for alternately opening and closing the cut-offs in each casting, and means for adjustably supporting said segment-shaped plates.

13. An elastic fluid turbine comprising a driving disk having its periphery provided with a circumferentially-extending series of vanes, a plurality of pairs of segment-shaped plates inclosing portions of the rim of said disk, a casting interposed between each of said plates and in connection with the lower portion of said plates constituting an expansion chamber through which the vanes travel to receive an impact of motive fluid each of said castings provided at each end with a port opening into the expansion chamber, a pair of motive fluid supply pipes, a motive fluid conducting pipe communicating with each of the supply pipes, a coupling attached to each of said motive fluid conducting pipes and having a pair of branches, a nipple projecting over a branch of each of said couplings and communicating with a port at each end of one of said castings, a motive fluid conducting pipe projecting from the other branch of one of the couplings and terminating in a nipple communicating with a port of another of said castings, one of said motive fluid supply pipes terminating at its inner end with a nipple which communicates with the other port of the last-mentioned casting, a motive fluid conducting pipe projecting from the other branch of the other of said couplings and terminating in a nipple which communicates with the port of the other of said castings, the other of said motive fluid supply pipes terminating in a nipple which communicates with a port of the last mentioned casting, cut-offs mounted in the ports of each of said castings, means for alternately opening and closing the cut-offs in each casting, means for adjustably supporting said segment-shaped plates, and means for controlling the supply of motive fluid to the said supply pipes.

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

JOHN HUTCHINGS.

Witnesses:
ALFRED GEORGE BROOKES,
JOHN COODE HARE.