No. 638,227. Patented Dec. 5, 1899.

# J. FECHTNER.
## ROTARY ENGINE.

(Application filed Apr. 4, 1899.)

(No Model.) 8 Sheets—Sheet 1.

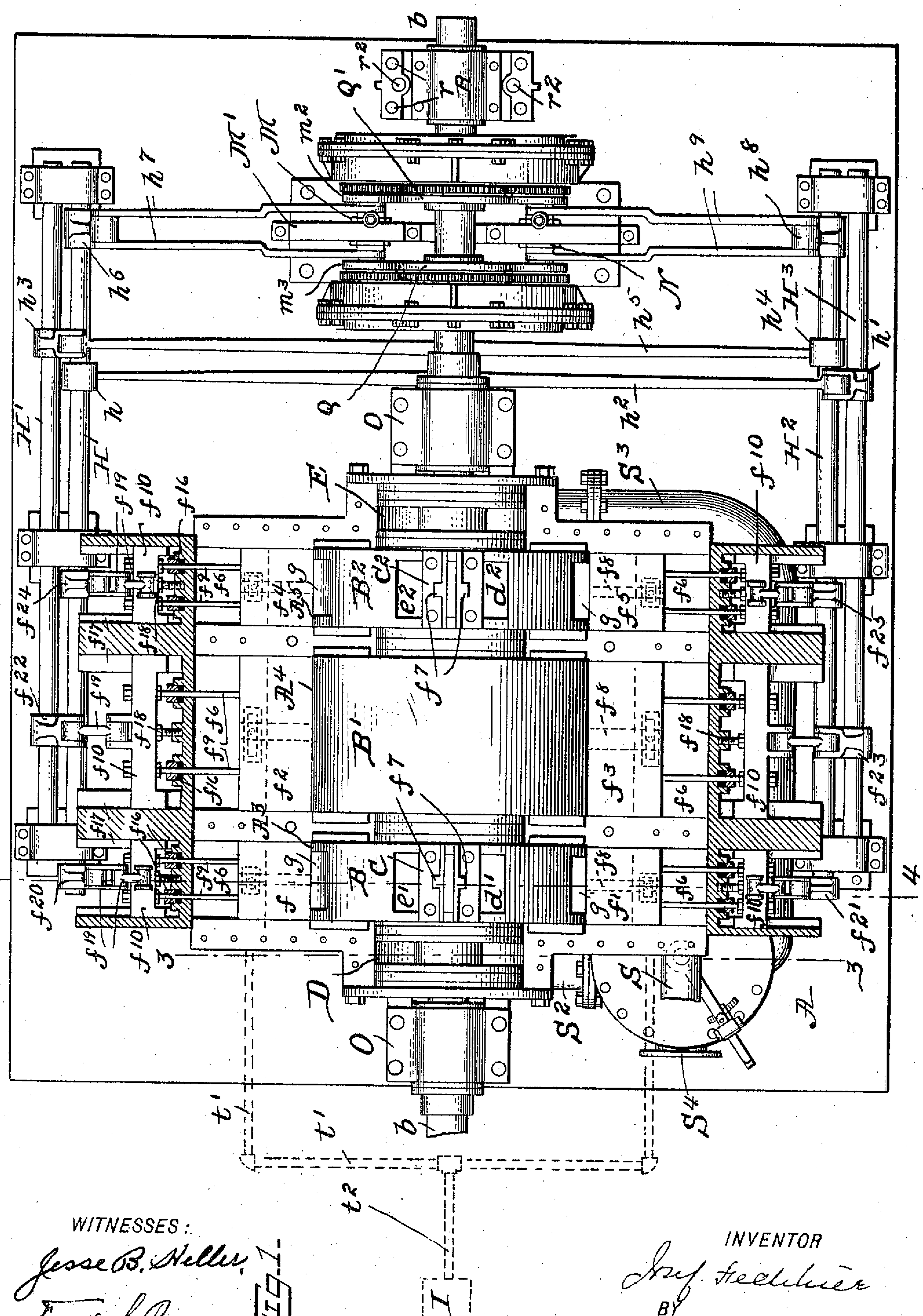

FIG. 1

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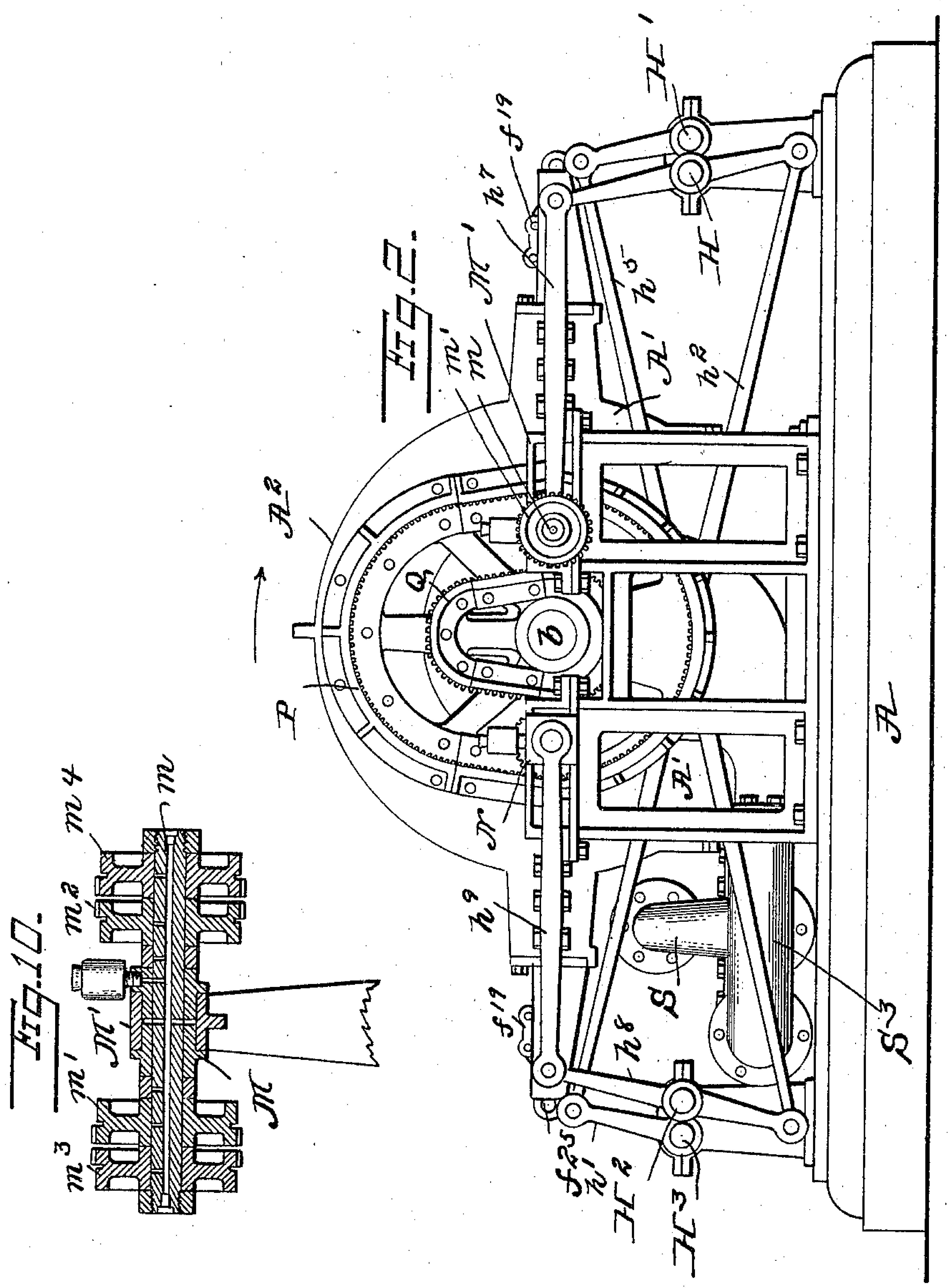

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8 Sheets—Sheet 3.

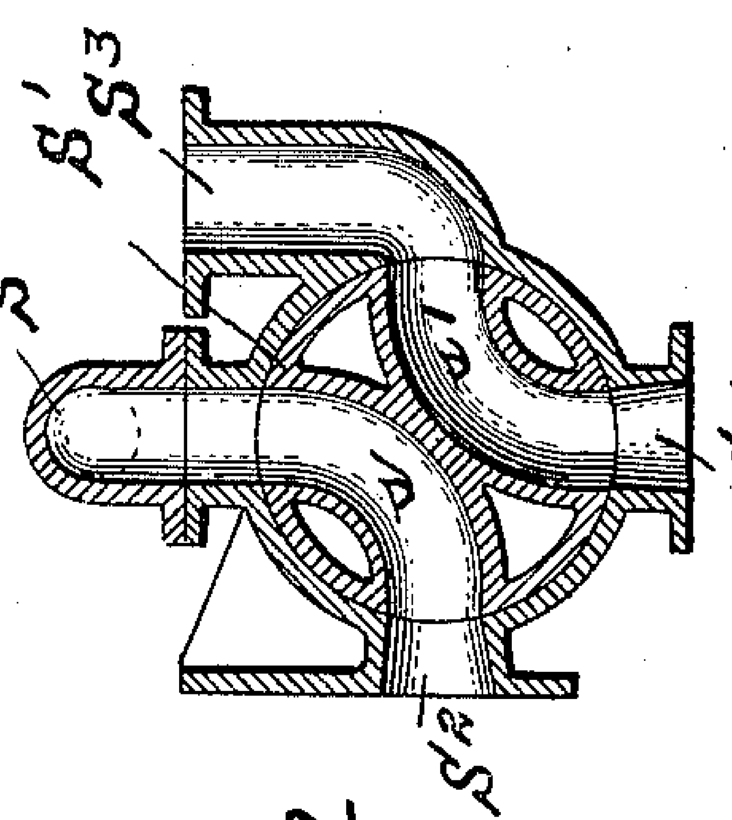

FIG. 7.

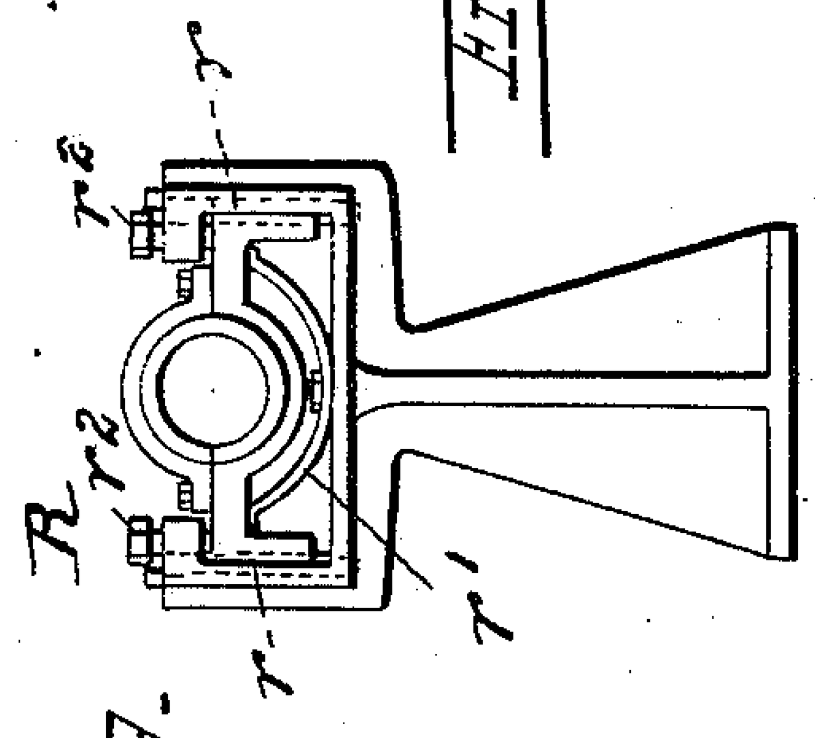

FIG. 8.

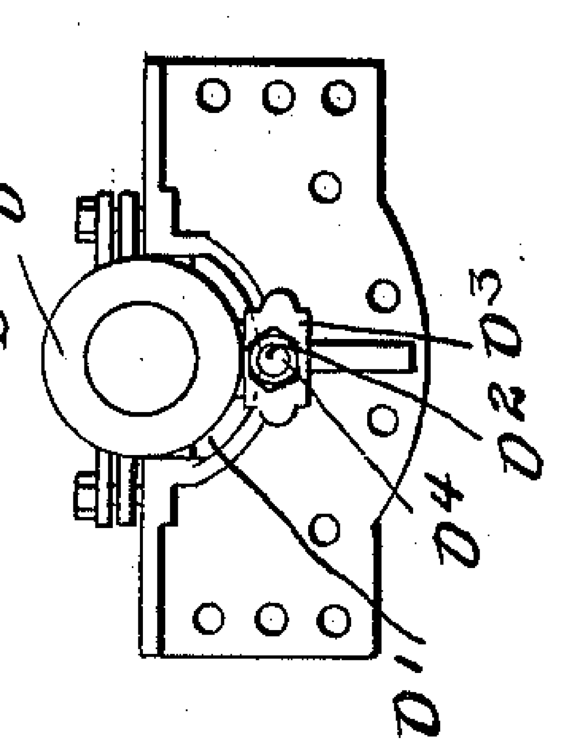

FIG. 9.

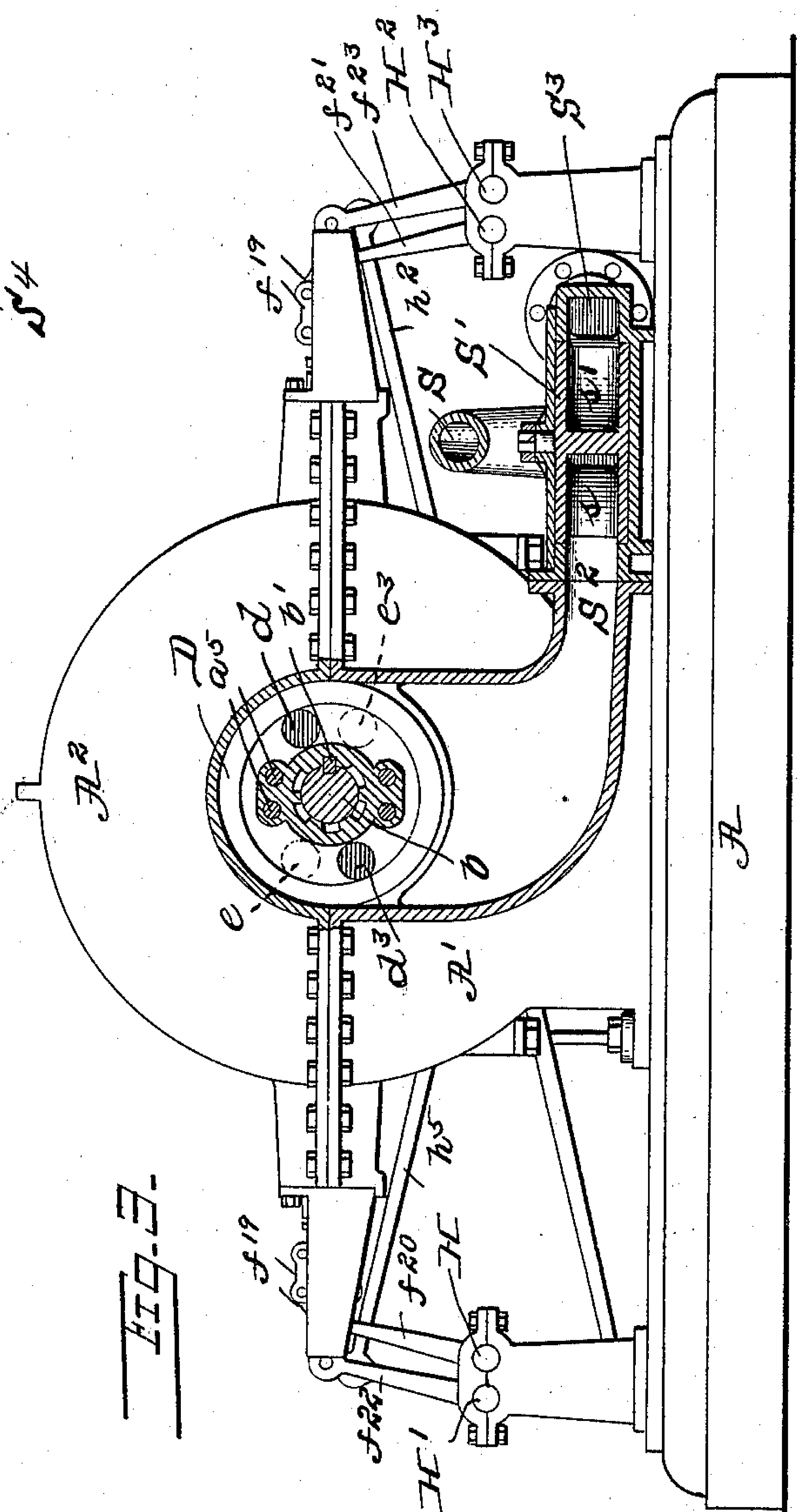

FIG. 3.

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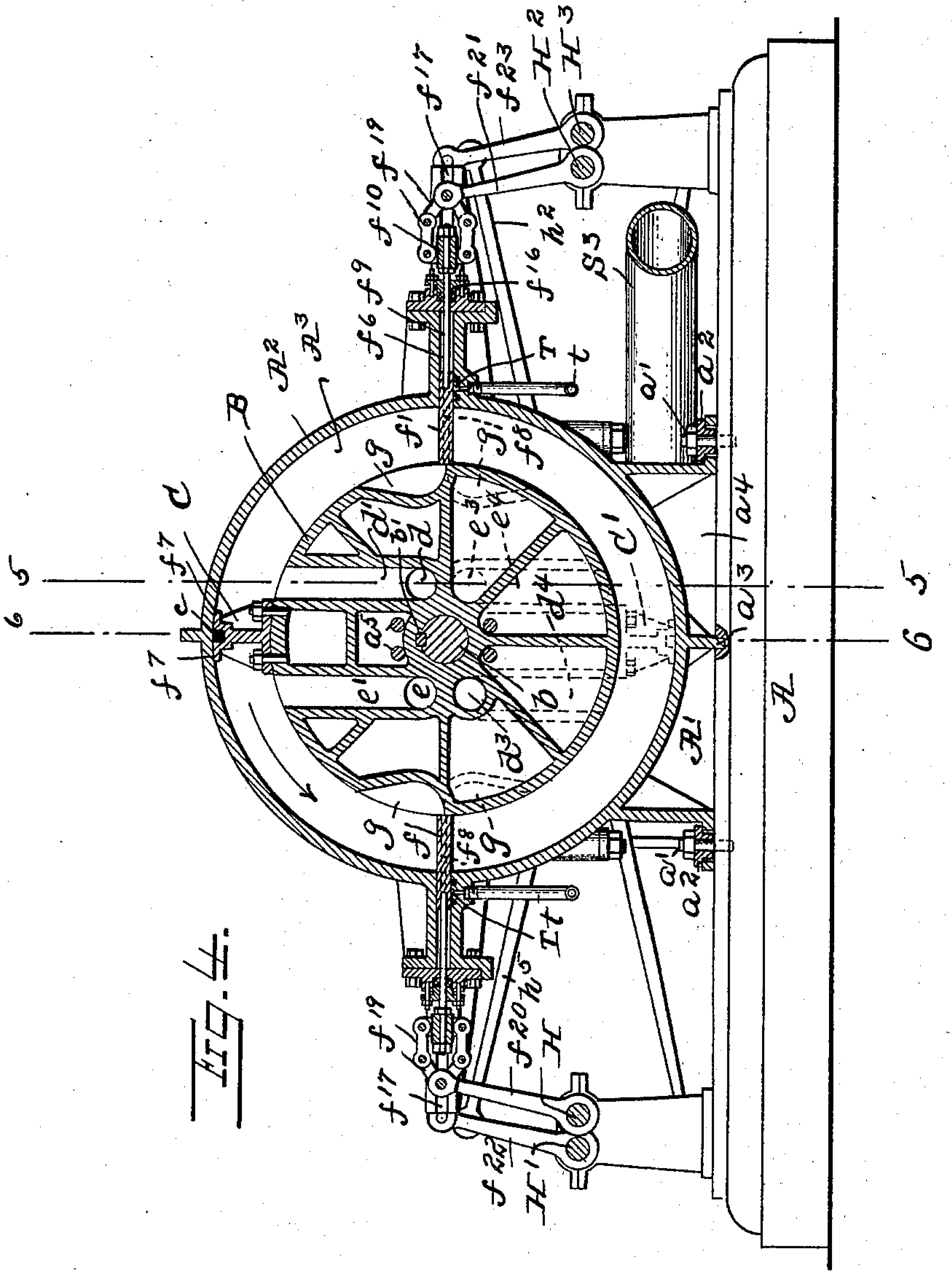
8 Sheets—Sheet 4.



WITNESSES:

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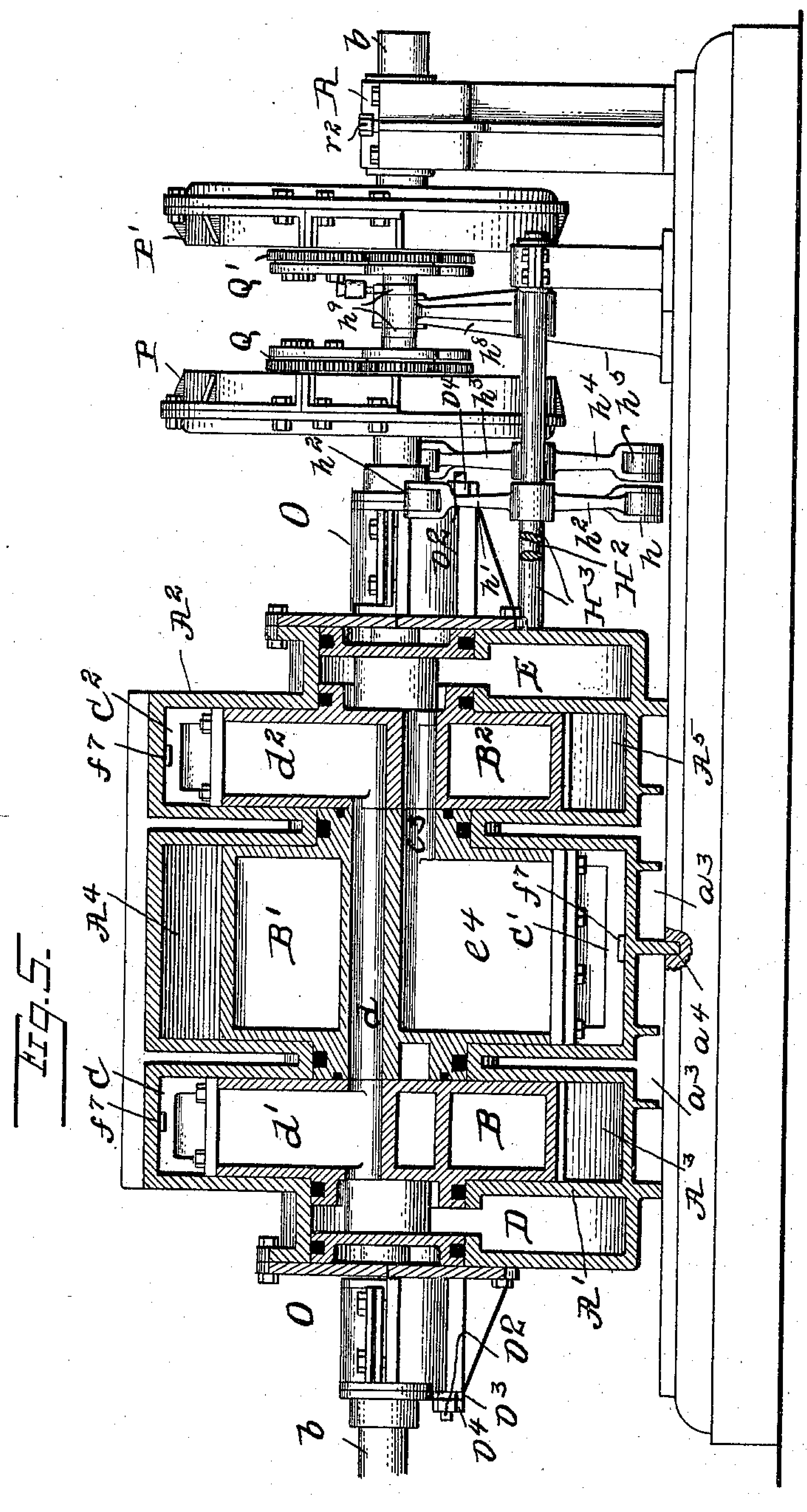

Fig. 5.

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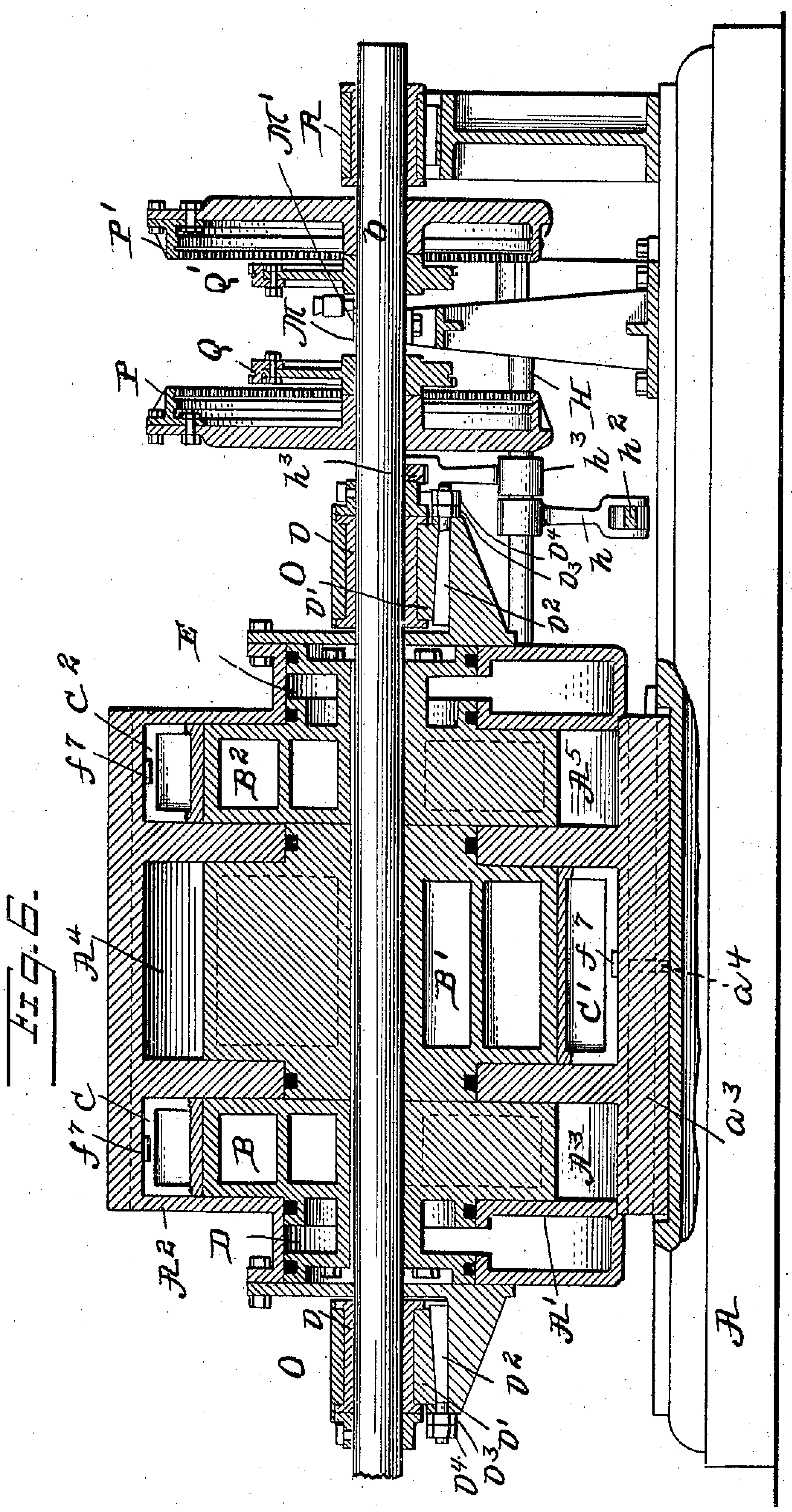

Fig. 6.

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Fig. 12.

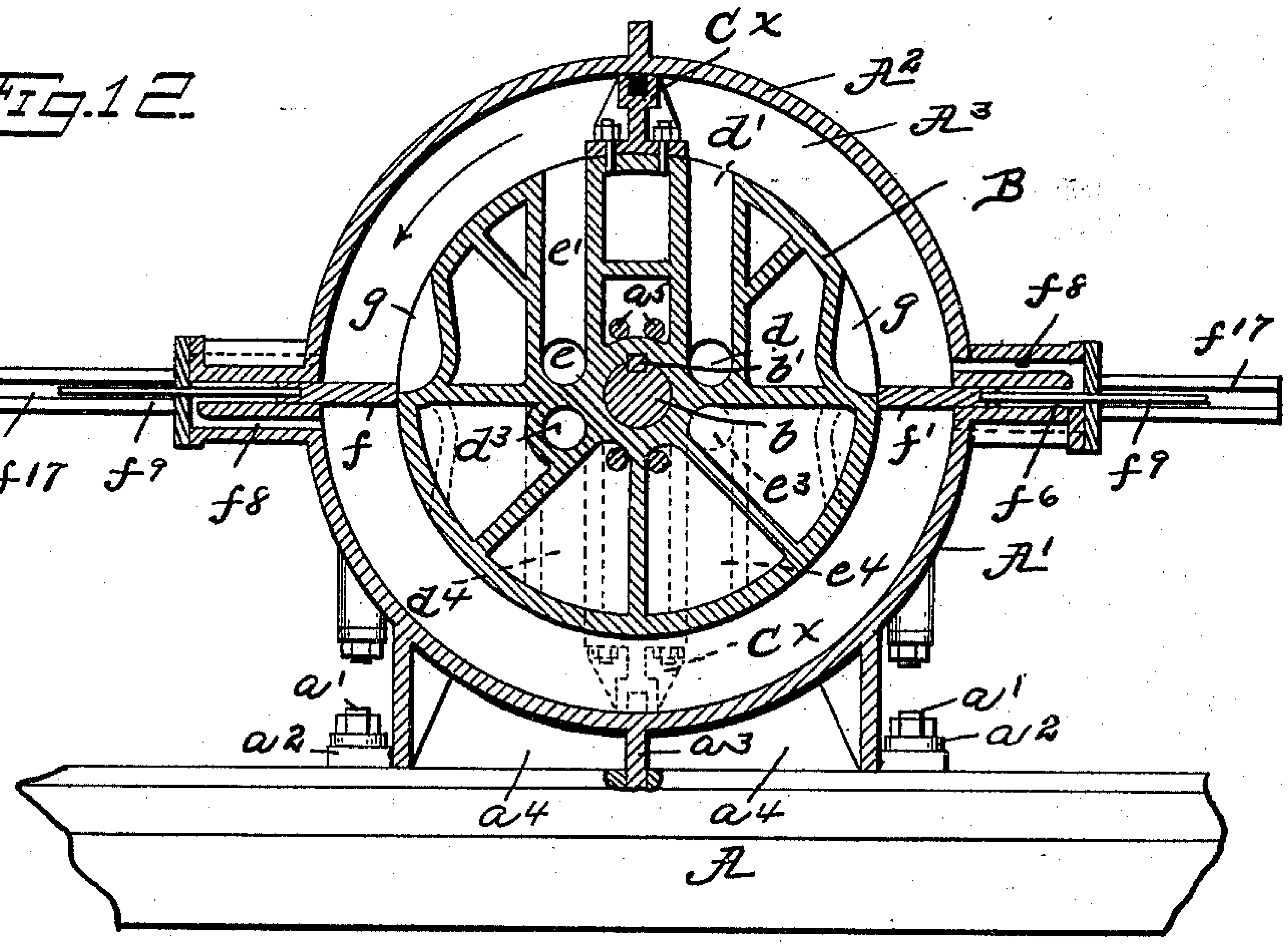
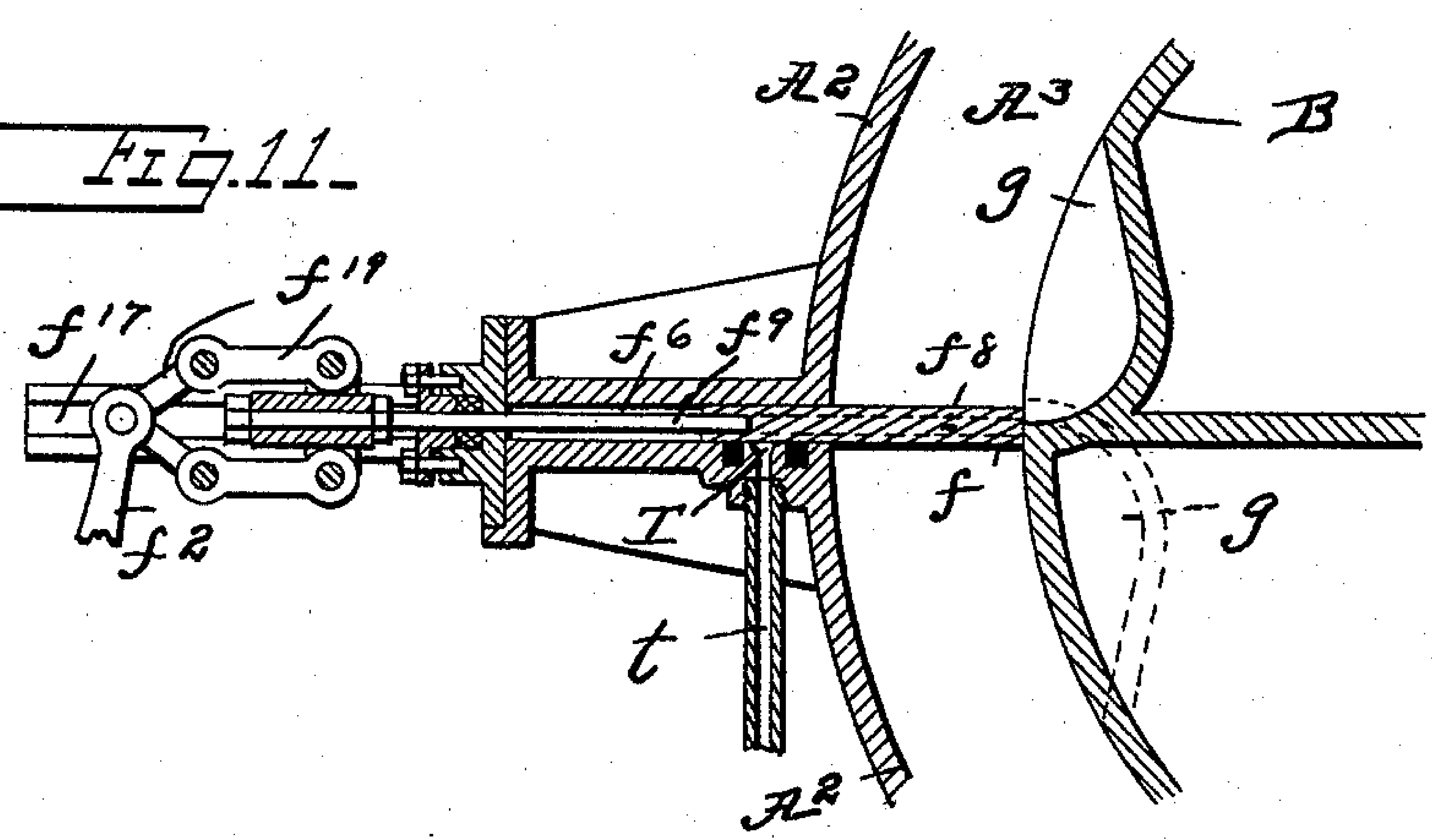



Fig. 11.

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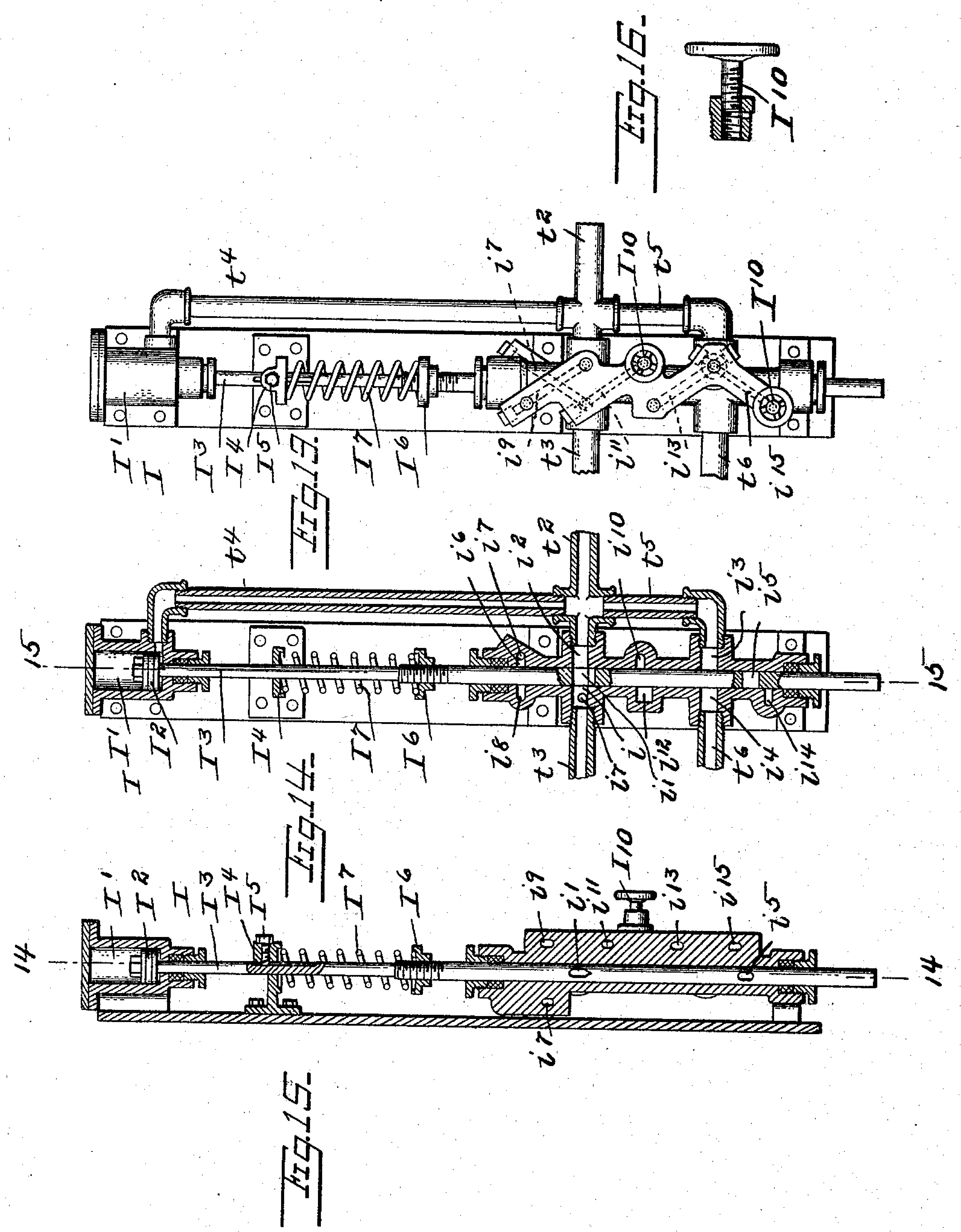

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# UNITED STATES PATENT OFFICE.

JOSEF FECHTNER, OF PHILADELPHIA, PENNSYLVANIA.

## ROTARY ENGINE.

SPECIFICATION forming part of Letters Patent No. 638,227, dated December 5, 1899.

Application filed April 4, 1899. Serial No. 711,661. (No model.)

*To all whom it may concern:*

Be it known that I, JOSEF FECHTNER, a subject of the Emperor of Austria-Hungary, residing at Philadelphia, county of Philadelphia, and State of Pennsylvania, have invented a new and useful Improvement in Rotary Engines, of which the following is a full, clear, and exact description, reference being had to the accompanying drawings, which form a part of this specification.

My invention relates to rotary engines; and it consists of an engine and appurtenant parts exhibiting certain novel features of construction. The engine has a plurality of cylinders having their steam-ports so arranged relatively to each other as to counterbalance the weight and pressure on the driven shaft and also distribute the pressure within and upon all the cylinders as a unit, so as to equalize the wear and friction.

The invention also consists in novel means for fastening the cylinders to the base, so as to compensate for expansion and contraction.

The invention also consists in the provision of sliding blocks which work into and out of the cylinders as the pistons rotate thereon and which perform the function of cylinder-heads.

The invention also consists in novel means for equalizing the steam-pressure upon the pressure-surfaces and ends of the sliding blocks when the same are withdrawn from the cylinders and also for overcoming the weight of the sliding blocks by steam-pressure, so to cause the same to float in their sliding bearings as they slide back and forth into and out of the cylinders.

The invention also consists in novel mechanism for operating the sliding blocks and in means for securing the operation of this mechanism with the least possible friction; also in a novel valve mechanism for reversing the rotation of the engine.

In the drawings, Figure 1 is a plan view of my improved engine with the upper half of the cylinder removed. Fig. 2 is an end view with some of the parts removed. Fig. 3 is a section on the line 3 3 of Fig. 1. Fig. 4 is a section on the line 4 4 of Fig. 1. Fig. 5 is a section on the line 5 5 of Fig. 4. Fig. 6 is a section on the line 6 6 of Fig. 4. Fig. 7 is a horizontal section through the valve. Fig. 8 is an end view of the spring-bearing for the main shaft. Fig. 9 is an end view of one of the bearings for lining up the main shaft. Fig. 10 is an enlarged sectional detail of the rollers and cross-head for operating the sliding blocks. Fig. 11 is an enlarged view of one of the sliding blocks and part of its connections. Fig. 12 is a view similar to Fig. 4 of a modified form of inlet-ports to the back of the sliding block. Fig. 13 is a front view of pressure-controlling device for the bottom of the sliding blocks. Fig. 14 is a section on the line 14 14 of Fig. 15. Fig. 15 is a section on the line 15 15 of Fig. 14. Fig. 16 is a detail view of the draw-off cock for the pressure-controlling device.

A is the base-plate, to which is secured the lower half A′ of the cylinder by means of the bolts $a'$ and the flanged bushings $a^2$.

$a^3$ and $a^4$ are ribs projecting from the lower half of the cylinder A′. These ribs run at right angles to each other and project into grooves in the base A. Therefore when the cylinder expands it will expand in all directions from the dead-center, thereby keeping the shaft in proper alinement.

$A^2$ is the upper half or cover of the cylinder, which is bolted to the lower half A′. This cylinder is divided into three compartments $A^3$, $A^4$, and $A^5$, each of which is a cylinder in itself. Placed in each of these cylinders $A^3$, $A^4$, and $A^5$ are the drums B, B′, and $B^2$, respectively. These drums are bolted together by means of the through bolts or rods $a^5$, and they are also keyed to the shaft $b$ by the spline $b'$.

Secured to the drums B, B′, and $B^2$ are the pistons C, C′, and $C^2$, respectively. The pistons C and $C^2$ are each one-half the width of the piston C′ and are placed on a line with each other and one hundred and eighty degrees or directly opposite from the piston C′, so as to equalize the pressure on both sides of the shaft, thereby preventing the unusual wearing of the cylinder and journals.

$c$ are packing-strips placed in grooves in the pistons.

D is the live-steam chest. Leading from the live-steam chest into the drums B and $B^2$ is the channel $d$, and leading from the channel $d$ into the cylinders $A^3$ and $A^5$ are the steam-inlet passages $d'$ and $d^2$, respectively.

$d^3$ is the channel leading from the live-steam chest D into the drum B', and $d^4$ is the steam-inlet passage leading from the channel $d^3$ into the cylinder $A^4$.

E is the exhaust-steam chest. Leading from this steam-chest into the drums B and $B^2$ is the passage $e$, and leading from this passage $e$ into the cylinders $A^3$ and $A^5$ are the exhaust-passages $e'$ and $e^2$, respectively.

$e^3$ is the channel leading from the exhaust-steam chest into the drum B', and $e^4$ is the exhaust-passage leading from the cylinder $A^4$ into the passage $e^3$.

Extending into each of the cylinders $A^3$, $A^4$, and $A^5$ one hundred and eighty degrees from each other are sliding blocks $f$ and $f'$, $f^2$ and $f^3$, and $f^4$ and $f^5$, respectively. These sliding blocks act as steam-abutments or cylinder-heads. Each of the drums B, B', and $B^2$ has the two cut-away portions $g$, for the purpose hereinafter described. The sliding blocks slide in chambers $f^6$ formed between the upper half $A^2$ and lower half A' of the cylinders. Cut through each of the sliding blocks $f\,f'\,f^2\,f^3\,f^4\,f^5$ and in line of travel of the projections $f^7\,f^7$ on the pistons C, C', and $C^2$ are the passages $f^8$. Each of the sliding blocks $f\,f'\,f^2\,f^3\,f^4\,f^5$ is connected to a cross-head $f^{10}$ by means of the connecting-rods $f^9$, which pass through stuffing-boxes $f^{16}$. These cross-heads slide in the guides $f^{17}$. $f^{18}$ are adjustable stops for the cross-heads $f^{10}$, so that the sliding blocks $f$, $f'$, $f^2$, $f^3$, $f^4$, and $f^5$ will not be forced against the drums B, B', and $B^2$, and thereby create friction. Each of the cross-heads $f^{10}$ is connected by means of the links $f^{19}$ with the levers $f^{20}\,f^{21}\,f^{22}\,f^{23}\,f^{24}\,f^{25}$. The levers $f^{20}$ and $f^{24}$ are connected to the rock-shaft H, lever $f^{22}$ to rock-shaft H', levers $f^{21}$ and $f^{25}$ to rock-shaft $H^2$, and lever $f^{23}$ to rock-shaft $H^3$. Rock-shafts H and $H^3$ are connected by means of the levers $h$ $h'$ and link $h^2$, and rock-shafts H' and $H^2$ by levers $h^3$ $h^4$ and link $h^5$. Connected to the rock-shaft H is the lever $h^6$. This lever $h^6$ is connected to the cross-head M by means of the links $h^7$, and the shaft $H^2$ is connected to the cross-head M by means of the lever $H^8$ and links $h^9$.

The cross-heads M and N being duplicates and each having the same parts, only the cross-head M will be described. The cross-head M works in a guide M'. Secured to this cross-head M is the shaft H, having the rollers $m'$, $m^2$, $m^3$, and $m^4$, each of these rollers having a plain surface and a gear-surface. (See Fig. 10.) The pitch-line of the teeth or gears is of the same radius as the periphery of the plain surface. Secured to the shaft $b$ are the cams P P' and Q Q', each cam having a plain surface and a gear-surface, the pitch-line of each of the gear-surfaces being of the same radius as the corresponding plain surface. The rollers $m'$ and $m^4$ work in the cams P and P', respectively, and the rollers $m^2$ and $m^3$ work on the cams Q and Q', respectively. The gear-surface is placed on the cams and their respective rollers to reduce the friction to a minimum. The gears on the cams will rotate the rollers, and as their pitch-line is of the same radius as the plain surface the rollers will be positively rotated at the proper speed, thereby overcoming the friction which would be produced by rotating the rollers by their rolling on a plain surface.

O are the bearings, bolted to the ends of the cylinder, each having the Babbitt metal $o$ resting in the block $o'$, the block $o'$, resting on the wedge-shaped bolt $o^2$, passing through the plate $o^3$ on the outer end of the bearing and having the nut $o^4$. By moving this wedge-shaped bolt out the wear in the bearing can be taken up.

R is the bearing which supports the outer end of the shaft $b$. This bearing slides on the guides $r$ $r$ and rests on the spring $r'$.

$r^2$ $r^2$ are the adjustable stops. After the engine has been set up the stops $r^2$ $r^2$ are elevated and steam is turned into the engine until it is heated, so as to expand the metal to its greatest point of expansion when running. The stops are then brought down against the bearing. When the engine cools off and the metal in the cylinder contracts, it will compress the spring $r'$, and as soon as the engine is started and begins to expand the shaft will be elevated. As can be seen, the shaft will always be in perfect alinement.

S is the steam-inlet pipe which leads to the valve S'.

$S^2$ is the pipe leading from the valve to the live-steam chest D.

$S^3$ is the pipe leading from the valve to the exhaust-steam chest E.

$S^4$ is the pipe leading from the valve to the atmosphere.

$s$ and $r'$ are connecting-ports in the valve $s'$.

The operation is as follows: Steam is admitted into the pipe S, passes through the passage $s$ in the valve S', pipe $S^2$, and into the live-steam chest D, from which it passes into the cylinders $A^3$, $A^4$, and $A^5$ through the passages $d$ and $d^3$ and the inlet-passages $d'$, $d^2$, and $d^4$. The steam will be confined between the pistons C, C', and $C^2$ and the slide-blocks $f'$, $f^5$, and $f^2$, rotating the drums B B' $B^2$ and the shaft in the direction indicated by the arrow in Fig. 4. As the cams P, P', Q, and Q' rotate with the shaft the cams Q and Q' will force the cross-head M away from the center of the engine through the medium of the rollers $M^2$ and $M^3$, thereby rocking the shafts H and $H^3$ and withdrawing the sliding blocks $f$, $f^4$, and $f^3$, so as to allow the pistons to pass when they reach that point. After the pistons have passed the sliding blocks $f$, $f^4$, and $f^3$ the latter are returned by means of the cams P and P' and their rollers $m'$ and $m^4$ drawing the cross-head M toward the center of the engine, thereby returning the shafts H and $H^3$ to their initial position. After the pistons have passed the sliding blocks $f'$, $f^4$, and $f^3$ and the latter are returned as described the steam will be confined between the pistons C C′ $C^2$ and the sliding blocks $f$, $f^4$, and $f^3$, respectively. The steam which was confined between the pistons C C′ $C^2$ and the sliding blocks $f'$ $f^5$ $f^2$ is now confined between the sliding blocks $f$ and $f'$, $f^2$ and $f^3$, and $f^4$ and $f^5$, respectively, in the part of the cylinders $A^3$, $A^4$, and $A^5$ opposite the part in which the respective pistons C, C′, and $C^2$ are rotating and will remain in that half of the respective cylinders $A^3$, $A^4$, and $A^5$ until the sliding blocks $f'$, $f^5$, and $f^2$ begin to be withdrawn. The pistons are now immediately opposite the starting-points. During this half-cycle of the engine the cross-head N and the rock-shaft H′ $H^2$ and the sliding blocks $f'$, $f^5$, and $f^2$ have remained stationary, due to the cams P, P′, Q, and Q′ being concentric with the shaft $b$. At this time the shaft $b$ has made one-half of a revolution. The cross-head N will now be forced away from the center of the engine by the cams Q and Q′ working on their rollers, and the rock-shafts H′ $H^2$ will be rocked and the sliding blocks $f'$, $f^5$, and $f^2$ will be withdrawn through the medium of their connections. As soon as the pistons C, C′, and $C^2$ have passed the sliding blocks $f'$, $f^5$, and $f^2$ the latter will be returned by the cams P and P′, returning the rock-shafts H′ and $H^2$ to their initial position, and the steam will then be confined between these last-mentioned blocks and the pistons. As soon as the blocks $f$, $f^4$, and $f^3$ are withdrawn the steam which was confined in the cylinders $A^3$, $A^4$, and $A^5$ and which operated the engine the first half-cycle can exhaust from the cylinders $A^3$ and $A^5$ through the exhaust-passages $e'$ $e^2$ and passage $e$ to the exhaust-steam chest E′ and from the cylinder $A^4$ through exhaust-passage $e^4$ and passage $e^3$ to the exhaust-steam chest E. From the exhaust-steam chest the exhaust passes through pipe $S^3$ and passage $s'$ in the valve S′ to the exhaust-pipe $S^4$.

It can readily be understood from the foregoing description that steam is always flowing into the cylinders $A^3$, $A^4$, and $A^5$ through the inlet-passages $d'$, $d^2$, and $d^4$ and always exhausting through the exhaust-passages $e'$, $e^2$, and $e^4$. If it is desired to reverse the engine, the valve S′ is turned ninety degrees, which will connect the steam-chest E with the live steam by passage $s$ and connect the steam-chest D with the exhaust by passage $s'$ in the valve S′.

The cut-away portions $g$ in the drums B, B′, and $B^2$ allow the steam which is to be exhausted to pass on the opposite side of the sliding blocks $f$, $f'$, $f^2$, $f^3$, $f^4$, and $f^5$, so as to equalize the pressure before they are withdrawn. At the same time the passages $f^8$ cut in the sliding blocks are uncovered, which will equalize the pressure in the chambers $f^6$, in which the blocks slide. It can therefore be readily understood that the sliding-block-reciprocating mechanism has no steam-pressure to work against. The projections $f^7$ $f^7$ on each of the pistons C, C′, and $C^2$ seal the passages $f^8$ and will not allow the steam-pressure to get in the chamber $f^6$ until after the pistons have passed the sliding blocks. This is caused by the full pressure being on the front of the blocks and a partial vacuum in the chamber $f^6$. Therefore all the slack in the sliding-block-operating mechanism will be taken up before any pressure will be exerted against the pistons while passing, and after the projections have passed the pressure will again be equalized.

In Fig. 12 I have shown a single-acting engine, and the piston $C^{\times}$ has no projections, and the passage $f^8$ extends through the casing and is placed at the far side of the slide-block and is not uncovered until after the piston $C^{\times}$ passes the port, when the pressure will be equalized.

In order to overcome the weight of the sliding blocks, thereby overcoming the friction as well as wear on the sliding blocks and their guides, I provide the following: Beneath each of the sliding blocks and in the chamber $f^6$ is a pressure-cavity T in combination with the pipe $t$, leading into a pipe $t'$, which is in communication with the pipe $t^2$, leading from a pressure-regulating valve I. Referring now to Figs. 13, 14, 15, and 16, $t^3$ is the high-pressure inlet-pipe which leads into the chamber $i$, having the valve $i'$. On each side of the valve $i'$ is the chamber $i^2$, which is in communication with the pipes $t^2$, $t^4$, and $t^5$. The pipe $t^4$ leads to the cylinder I′, having the piston $I^2$ on the valve-stem $I^3$. This valve-stem $I^3$ passes down through the guide $I^4$ and the valve-casing, the guide $I^4$ having the screw $I^5$ working in a groove in the valve-stem, so as to prevent it from turning. Working on a thread on the valve-stem below the guide $I^4$ is an adjustable nut $I^6$, and interposed between this nut $I^6$ and the guide $I^4$ is the coil-spring $I^7$. The pipe $t^5$ leads into the chamber $i^3$. $t^6$ is the exhaust-pipe, which leads from the chamber $i^4$. $i^5$ is a valve which opens communications between chambers $i^3$ and $i^4$ when the valve-stem is elevated.

The operation is as follows: Assuming that the high pressure is one hundred pounds to the square inch and that it will take a pressure of forty pounds to the square inch to balance the weight of the sliding blocks, when the steam is admitted into the pipe $t^3$ it passes through the valve $i'$ into the pipe $t^2$, pipe $t'$, and $t$ to the pressure-cavity T. It also backs up pipe $t^4$ in the cylinder I′ and raises the piston $I^2$, and with it the valve-stem $I^3$, against the action of the spring $I^7$. This will close valve $i'$ and open the valve $i^5$ and exhaust through pipes $t^5$ and $t^6$. If the pressure has risen above forty pounds, as soon as the the forty-pound mark is reached both valves will be closed and will remain closed until the pressure changes. If it falls, the spring which has been adjusted for this pressure will depress the rod, thereby slightly opening the valve $i'$ until the pressure is raised again, when the piston will close the valve. It can readily be understood that when the forty-pound mark is reached the piston $I^2$ and spring $I^7$ counterbalance each other, thereby retaining just forty pounds under the sliding blocks at all times.

In order to equalize the pressure on both sides of the valve-stem $I^3$, I provide the following, and in order to clarify the description I will term the side on which the pipe $i^3$ enters the "high-pressure" side and the side on which the pipe $i^2$ enters the "low-pressure" side. Leading from the chamber $i$ on the high-pressure side to the chambers $i^6$ and $i^{10}$ on the low-pressure side are the passages $i^7$ and $i^{11}$. Leading from the chamber $i^2$ on the low-pressure side to the chamber $i^8$ on the high-pressure side is the passage $i^9$. Leading from the chamber $i^3$ on the low-pressure side to the chambers $i$, $i^2$, and $i^3$ on the high-pressure side are the passages $i$, $i^3$, and $i^{15}$. The chambers $i$, $i^2$, $i^{12}$, $i^3$, and $i^4$ each have an area of two, while the chambers $i^6$, $i^8$, $i^{10}$, and $i^{14}$ each have an area of one. Therefore the total pressure on the high-pressure side would be $i^8$, forty; $i$, two hundred; $i^2$, eighty; $i^4$, atmosphere or zero, and $i^{14}$, forty; total, three hundred and sixty units. On the low-pressure side the total pressure would be $i^6$, one hundred; $i^2$, eighty; $i^{10}$, one hundred; $i^3$, eighty; total, three hundred and sixty units. It can therefore be seen that the pressure on one side will equalize the pressure on the other side of the valve-stem $I^3$.

$I^{10}$ are draw-off cocks placed in the chambers $i^{14}$ and $i^{10}$.

It will be observed that by virtue of arranging the drum, piston, ports, and passages of the middle cylinder oppositely with respect to the arrangement of the drums, ports, pistons, and passages of the outside cylinders and by reason of the width of the middle cylinder being equal to the combined width of the two outside cylinders the pressure or strain upon each end of the shaft is in the same direction, which pressure and strain is counterbalanced by the pressure or strain in the opposite direction upon the central portion of the shaft. This avoids friction in the bearings, which would otherwise occur by reason of an unequal strain upon different portions of the shaft. In other words, the pressure of the motive fluid acting against one side of the central portion of the shaft is counteracted by an equivalent pressure acting in an opposite direction upon each end of the shaft.

Having now fully described my invention, what I claim, and desire to protect by Letters Patent, is—

1. In a rotary engine, the combination with three or more cylinders, of a shaft extending through the same, drums secured to the shaft within the cylinders and corresponding in number thereto, and a piston secured to each drum, live and exhaust steam chests, there being passages and ports leading therefrom through each drum to the space between said drum and its corresponding cylinder, whereby live steam of uniform pressure is admitted to each cylinder; the parts of two or more of said drums, the pistons carried thereby, and the ports and passages therein being arranged oppositely with respect to the corresponding parts of the remaining drum or drums, the piston or pistons carried thereby and the corresponding ports and passages therein; the cylinders containing the first-named drums being arranged on each side of the remaining cylinder or cylinders; the total width of the first-named drums being substantially equal to the total width of the last-named drum or drums; thereby avoiding unequal strain upon the shaft, creating equal pressure in the same direction upon the ends of the shaft, and counterbalancing the end pressure by an equal and opposite intermediate pressure.

2. In a rotary engine, the combination with three cylinders, and a shaft extending through the same, drums secured to the shaft within the cylinders and corresponding in number thereto, and a piston secured to each drum, live and exhaust steam chests, there being ports and passages leading therefrom through each drum to the space between said drum and its corresponding cylinder, whereby live steam of uniform pressure is admitted to each cylinder; the central cylinder being twice the width of each of the other two cylinders, the parts of the central drum; the piston carried thereby, and the ports and passages therein being arranged oppositely with respect to the corresponding ports of the other two drums, their pistons and the corresponding ports and passages therein; thereby avoiding unequal strain upon the shaft, creating equal pressure in the same direction upon the ends of the shaft, and counterbalancing the end pressure by an equal and opposite intermediate pressure.

3. In a rotary engine, the combination with the cylinder, of a shaft extending through the same, a drum secured to the shaft within the cylinder having a periphery substantially concentric with the cylinder, a piston secured to said drum on the periphery thereof and contacting with the wall of the cylinder, there being a passage in the drum adapted to be connected with a source of steam-supply and having a port on its periphery opening into said cylinder on one side of said piston, and a passage in the drum adapted to be connected with the exhaust having a port on its periphery opening into the cylinder on the other side of said piston, the drum being provided with grooved passages, as $g$, one in advance of said exhaust-port and the other behind said supply-port, cylinder-heads on opposite sides of said cylinder extending into said cylinder into alinement with the periphery of said drum, and mechanism connected with and actuated by said shaft and

connected with and actuating said cylinder-heads whereby said cylinder-heads are alternately withdrawn and inserted.

4. The combination, with the shaft, of concave and convex cams on said shaft, each having a gear-surface and a plain rolling-surface, of rollers each having a corresponding gear-periphery and plain rolling-periphery, said rollers engaging respectively the said concave and convex cams, the rollers being mounted on a common shaft adapted to slide in bearings, whereby the rotation of the cam-shaft imparts a reciprocating movement to the roller-shaft by the engagement of the cams with their respective rollers.

5. The combination with the shaft, of concave and convex cams on said shaft, each cam having a gear-surface and a plain rolling-surface, a portion of the cam-surface being concentric with the shaft and a portion eccentric thereto, the cams having their cam-surfaces parallel with each other, of rollers having a corresponding gear-periphery and plain rolling-periphery, said rollers engaging respectively the said concave and convex cams, the rollers being mounted on a common shaft adapted to slide in bearings, whereby the rotation of the cam-shaft imparts an intermittent reciprocating movement to the roller-shaft by the engagement of the cams with their respective rollers.

6. In a rotary engine, the combination with the cylinder, the main shaft and a piston carried by said shaft and rotating in said cylinder, of a cylinder-head extending into the same, of concave and convex cams on said shaft, each having a gear-surface and a plain rolling-surface, of rollers each having a corresponding gear-periphery and plain rolling-periphery said rollers engaging respectively the said concave and convex cams, the rollers being mounted on a common shaft adapted to slide in bearings, whereby the rotation of the cam-shaft imparts a reciprocating movement to the roller-shaft by the engagement of the cams with their respective rollers, and connections between said rollers and the cylinder-head, whereby the reciprocation of the rollers withdraws and inserts the cylinder-head.

7. In a rotary engine, the combination with the cylinder, the main shaft, and a piston carried by said shaft and rotating in said cylinder, a cylinder-head extending into the same, concave and convex cams on said shaft, each cam having a gear-surface and a plain rolling-surface, a portion of the cam-surface of each cam being concentric with the shaft and a portion eccentric thereto, the cams having their cam-surfaces parallel with each other, of roller having a corresponding gear-periphery and plain rolling-periphery, said rollers engaging respectively the said concave and convex cams, the rollers being mounted on a common shaft adapted to slide in bearings, whereby the rotation of the cam-shaft imparts an intermittent reciprocating movement to the roller-shaft by the engagement of the cams with their respective rollers, and connections between said rollers and the cylinder-head, whereby the reciprocation of the roller-shaft intermittently withdraws and inserts the cylinder-head.

8. In a rotary engine, the combination with the cylinder, the main shaft, a piston carried by said shaft and rotating in said cylinder, of the cylinder-heads on opposite side of said cylinder extending into the same, concave and convex cams on said shaft, each cam having a gear-surface and a plain rolling-surface, a portion of the cam-surface of each cam being concentric with the shaft and a portion eccentric thereto, the cams having their cam-surfaces parallel with each other, of rollers having a corresponding gear-periphery and plain rolling-periphery, said rollers engaging respectively the said concave and convex cams, the rollers being mounted on a common shaft adapted to slide in bearings, whereby the rotation of the cam-shaft imparts an intermittent reciprocating movement to the roller-shaft by the engagement of the cams with their respective rollers, a corresponding set of rollers respectively engaging said cams on the opposite sides of the first-mentioned set of rollers, whereby the second set of rollers is reciprocated while the first set of rollers is stationary and vice versa, and connections between one set of rollers and one of cylinder-heads and between the second set of rollers and the other of said cylinder-heads, whereby rotation of said shaft and the intermittent and alternate reciprocation of said sets of rollers, withdraws and inserts one cylinder-head while the other remains stationary, and vice versa.

9. In a rotary engine, the combination with the cylinder, the main shaft, the piston secured thereto, and the cylinder-heads adapted to be inserted and withdrawn from said cylinder, of a bearing in which said cylinder-head is adapted to slide, there being a passage extending from said cylinder to the space within said bearing in which said cylinder-head reciprocates, there being an exhaust-port extending into said cylinder in advance of said piston and rotating therewith and a supply-port extending into said cylinder behind the piston and rotating therewith, and means for connecting said passage with the exhaust when the cylinder-head is being withdrawn and for connecting said passage with the supply as the cylinder-head is being inserted.

10. In a rotary engine, the combination with the cylinder, the main shaft, the piston secured thereto, and the cylinder-heads adapted to be inserted and withdrawn from said cylinder, of a bearing in which said cylinder-head is adapted to slide, there being a passage extending from said cylinder to the space within said bearing in which said cylinder-head reciprocates, there being an exhaust-port extending into said cylinder in advance

of said piston and rotating therewith and a supply-port extending into said cylinder behind the piston and rotating therewith, and means for connecting said passage with the exhaust when the cylinder-head is being withdrawn and for connecting said passage with the supply as the cylinder-head is being inserted, the said passage being adapted to be covered and uncovered by the piston during its rotation.

11. In a rotary engine, the combination with the cylinder and cylinder-heads adapted to be inserted and withdrawn from said cylinder, bearings in which said cylinder-heads are adapted to slide, of means for creating a pressure against the under surface of said cylinder-head to counterbalance the weight of said cylinder-head and eliminate or minimize friction.

12. In a rotary engine, the combination with the cylinder and cylinder-heads adapted to be inserted and withdrawn from said cylinder, bearings in which said cylinder-heads are adapted to slide, a pipe in communication with the under surface of said cylinder-head, and means for maintaining a uniform pressure in said pipe, whereby the weight of said cylinder-head is overcome and friction minimized or eliminated.

13. The combination with a pipe from a source of steam-supply, a pipe leading to exhaust, pipes in line with the supply and exhaust pipes, a pressure-chamber, a pipe connected with the last-mentioned pipes leading to the pressure-chamber, valves interposed in the connections between the supply and exhaust pipes and the pipes in line therewith, the stem of which extends into said pressure-chamber, a piston on said valve-stem within said pressure-chamber, and means tending to move said piston in opposition to the pressure within the pressure-chamber pipe, whereby when the pressure in said pressure-chamber pipe exceeds a predetermined amount, the valve-stem is operated to connect the last-mentioned pipe with the exhaust, and whereby when the pressure in said pressure-chamber pipe falls below a predetermined amount, the said valve-stem is operated to connect the said pipe with the supply.

14. In a rotary engine, the combination with a pipe from a source of steam-supply, a pipe leading to the exhaust, pipes in line with the supply and exhaust pipes, a pipe connected with the pipes in line with the supply and exhaust pipes, valves interposed in the connections between the supply and exhaust pipes and the pipes in line therewith, mechanism connected with said valves and adapted to be actuated by the pressure within said last-mentioned pipe and means acting upon said mechanism in opposition to the pressure within said pipe, whereby when the pressure in said pipe exceeds or falls below a predetermined amount, the said pipe is connected with the exhaust or supply respectively by the operation of said valves.

15. The combination with a pipe from a source of steam-supply, a pipe leading to exhaust, pipes in line with the supply and exhaust pipes, a pressure-chamber, a pipe connected with the last-mentioned pipes leading to the pressure-chamber, valves interposed in the connections between the supply and exhaust pipes and the pipes in line therewith, the stem of which extends into said pressure-chamber, a piston on said valve-stem within said pressure-chamber, and means tending to move said piston in opposition to the pressure within the pressure-chamber pipe, whereby when the pressure in said pressure-chamber pipe exceeds a predetermined amount, the valve-stem is operated to connect the last-mentioned pipe with the exhaust, and whereby when the pressure in said pressure-chamber pipe falls below a predetermined amount, the said valve-stem is operated to connect the said pipe with the supply, and means for equalizing the pressure on opposite sides of said valve-stem.

16. The combination, with differential pressure-pipes, of a valve-stem having a valve adapted to normally close connection between said pipes, of a plurality of passages communicating with the said pipes, and with chambers on opposite sides of said valve-stem, whereby the excess pressure upon the high-pressure side of said valve is equalized by a substantially equivalent excess pressure on the opposite side of said valve-stem.

In testimony of which invention I have hereunto set my hand, at Philadelphia, Pennsylvania, on this 30th day of March, 1899.

JOSEF FECHTNER.

Witnesses:
JESSE B. HELLER,
FRANK S. BUSSER.