No. 749,654. PATENTED JAN. 12, 1904.

B. BANTA & C. MATHEWS.

ROTARY EXPLOSIVE ENGINE.

APPLICATION FILED APR. 21, 1903.

NO MODEL. 6 SHEETS—SHEET 1.

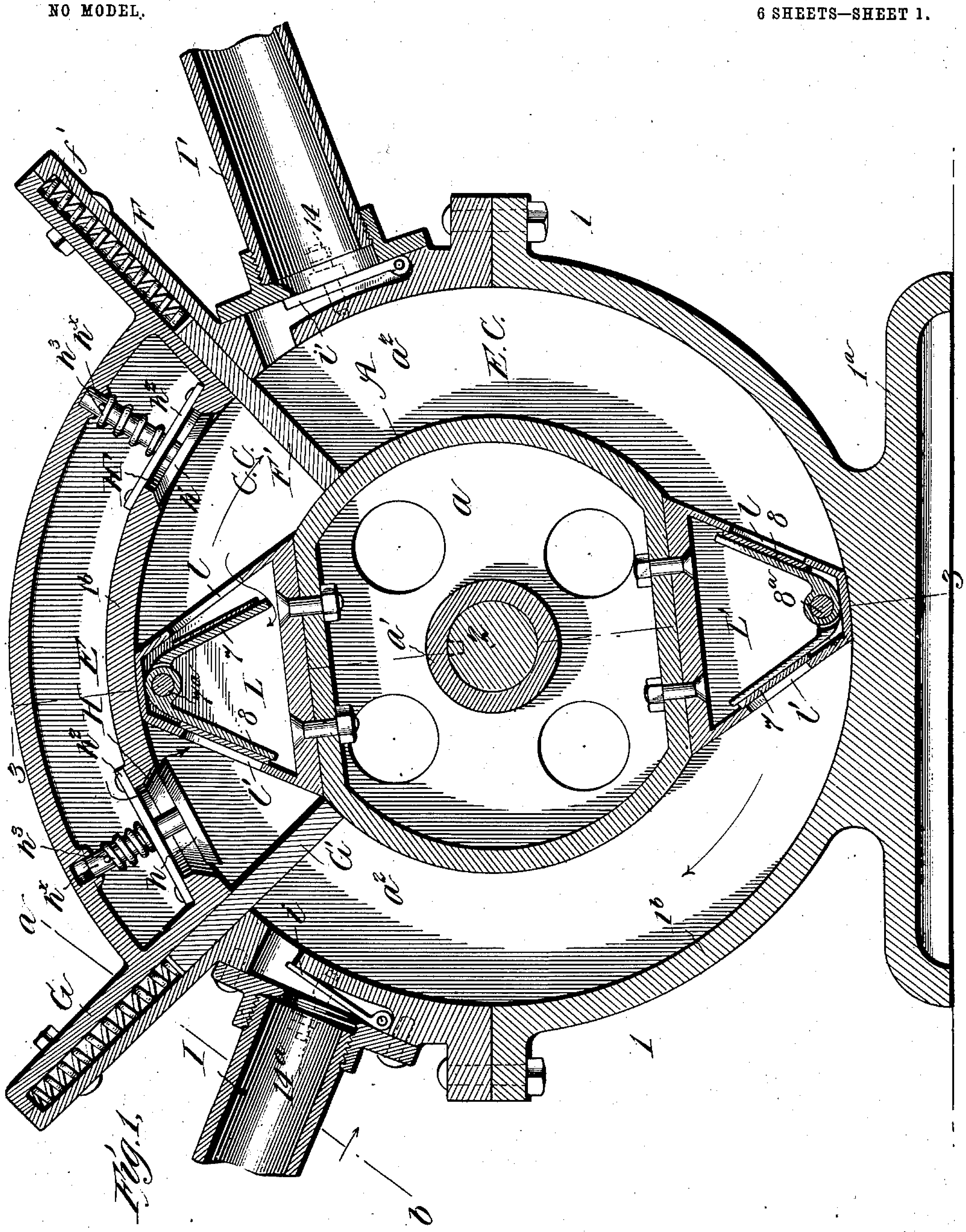

Fig. 1.

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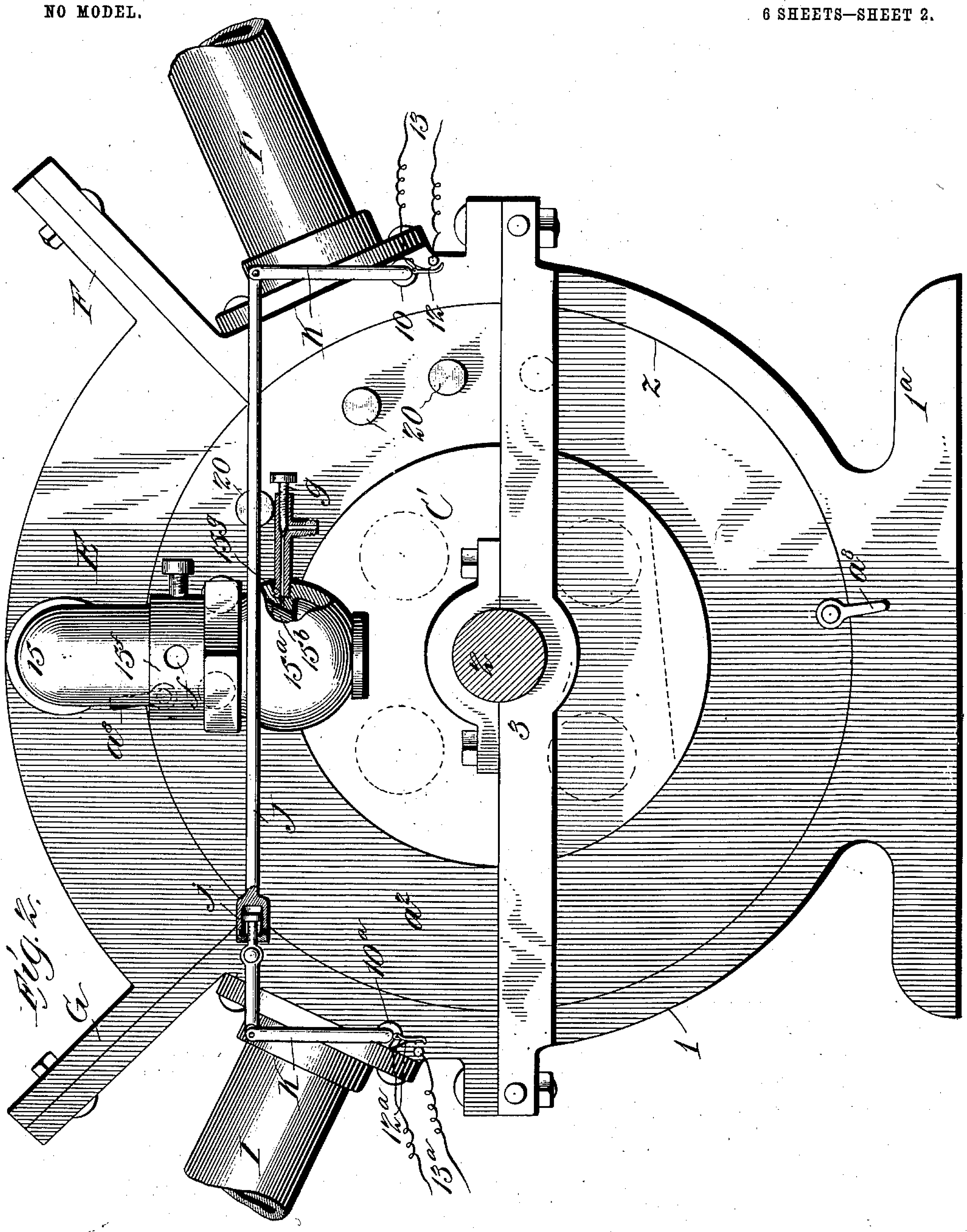

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NO MODEL. 6 SHEETS—SHEET 3.

Fig. 3,

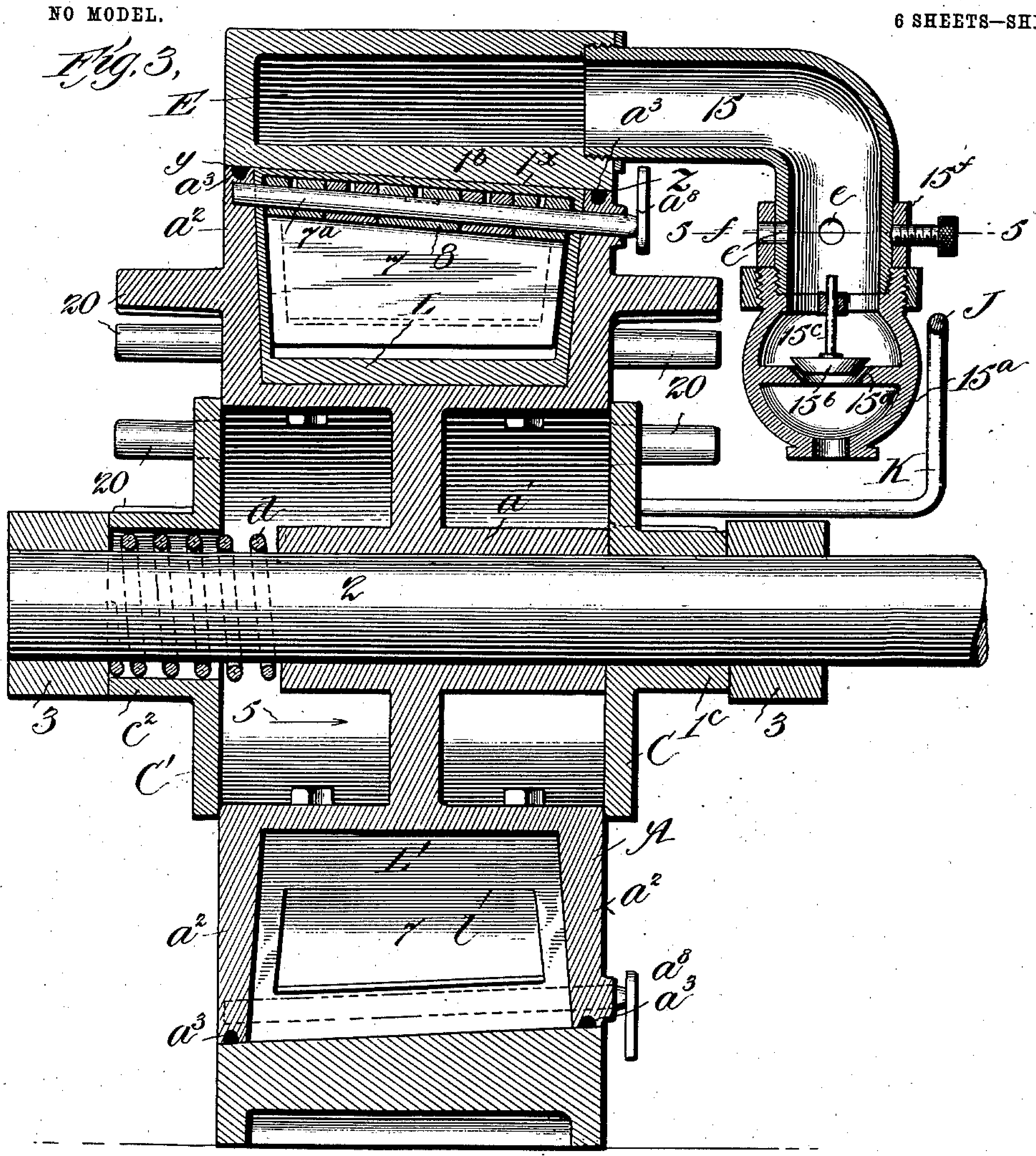
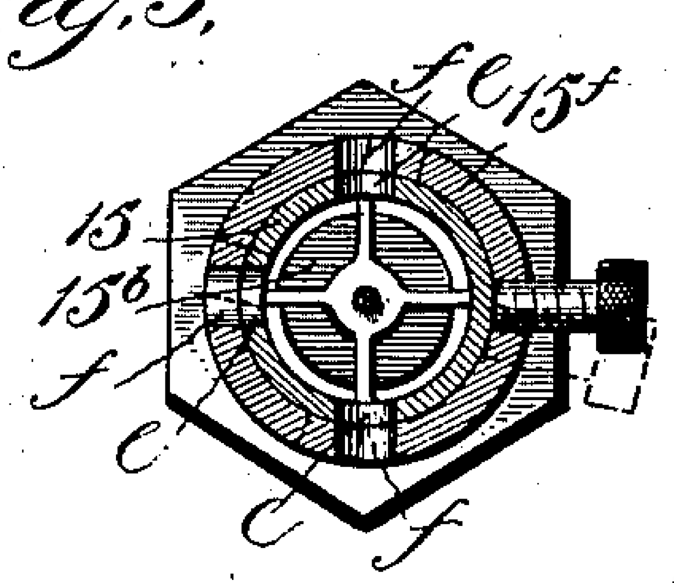


Fig. 5.



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NO MODEL. 6 SHEETS—SHEET 4.

Fig. 6.

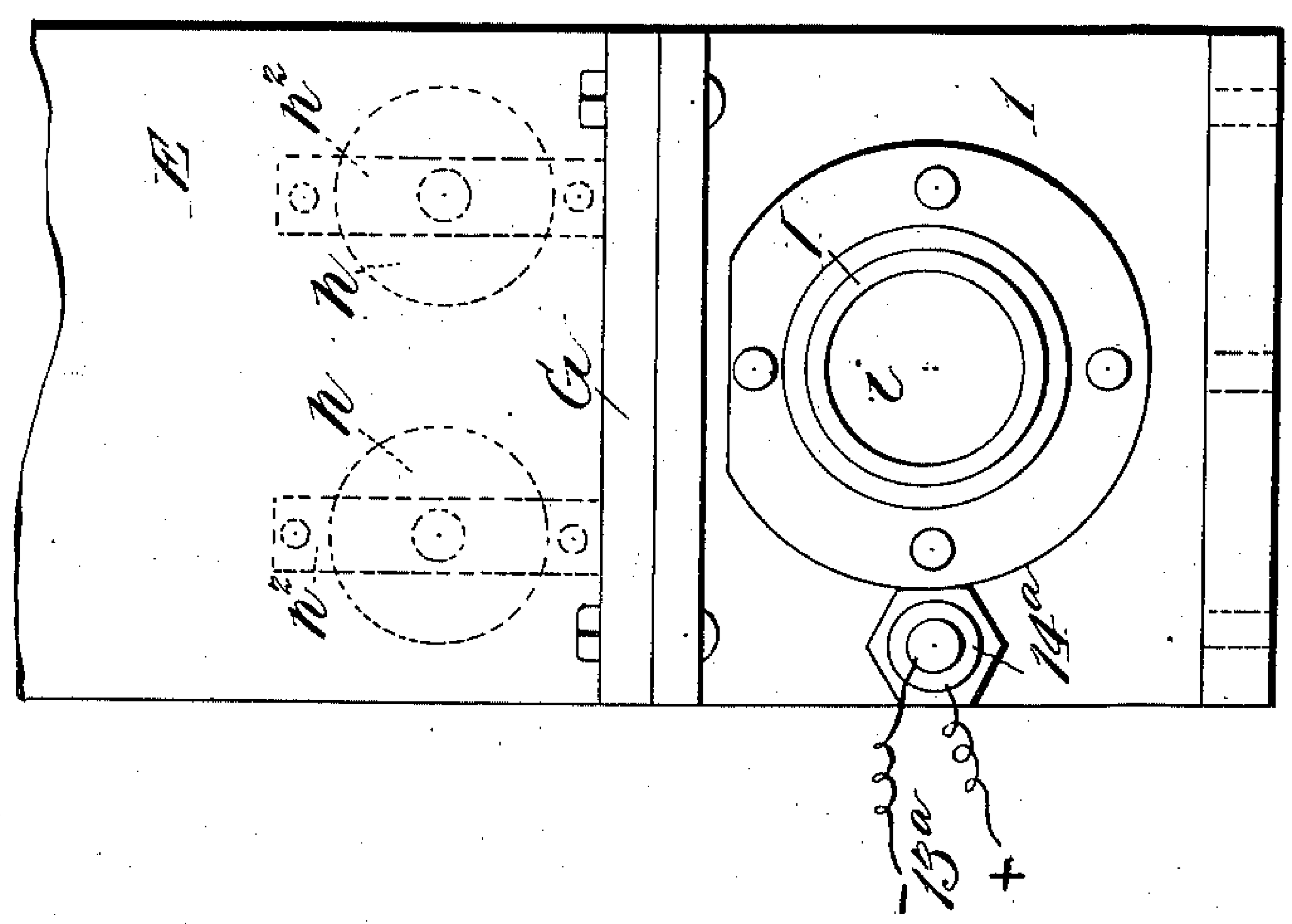
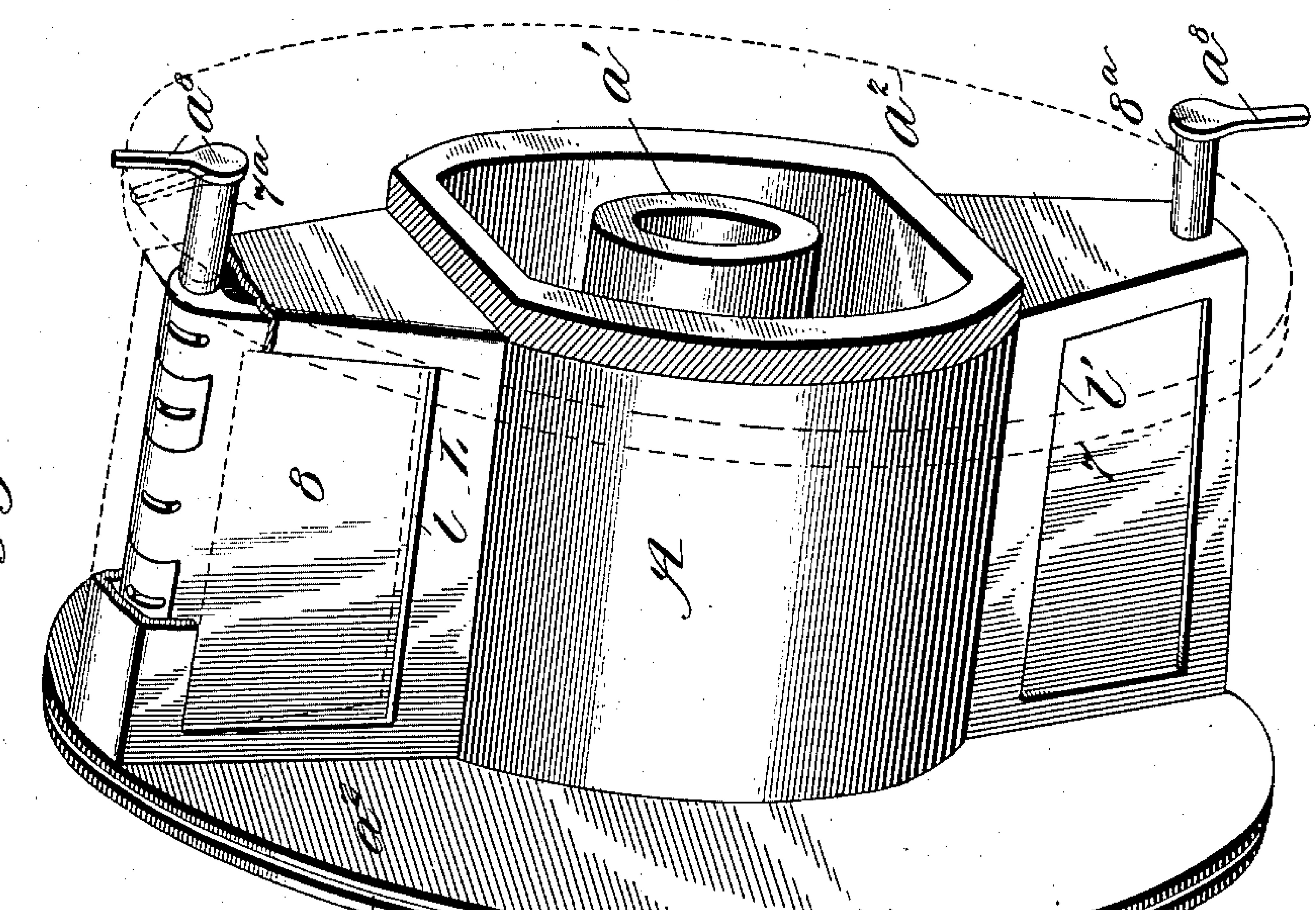


Fig. 4.



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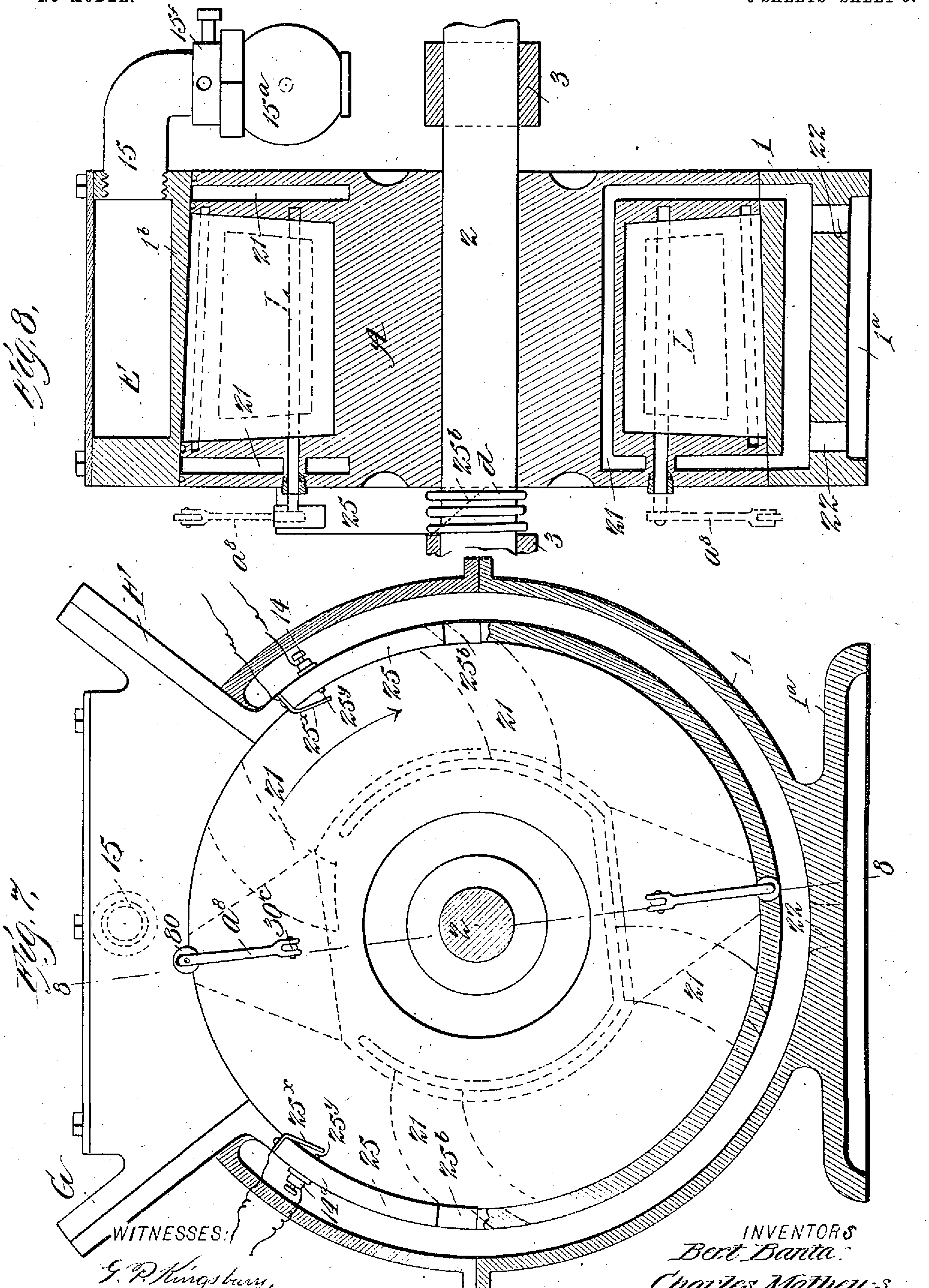
NO MODEL. 6 SHEETS—SHEET 5.



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NO MODEL. 6 SHEETS—SHEET 6.

Fig. 9.

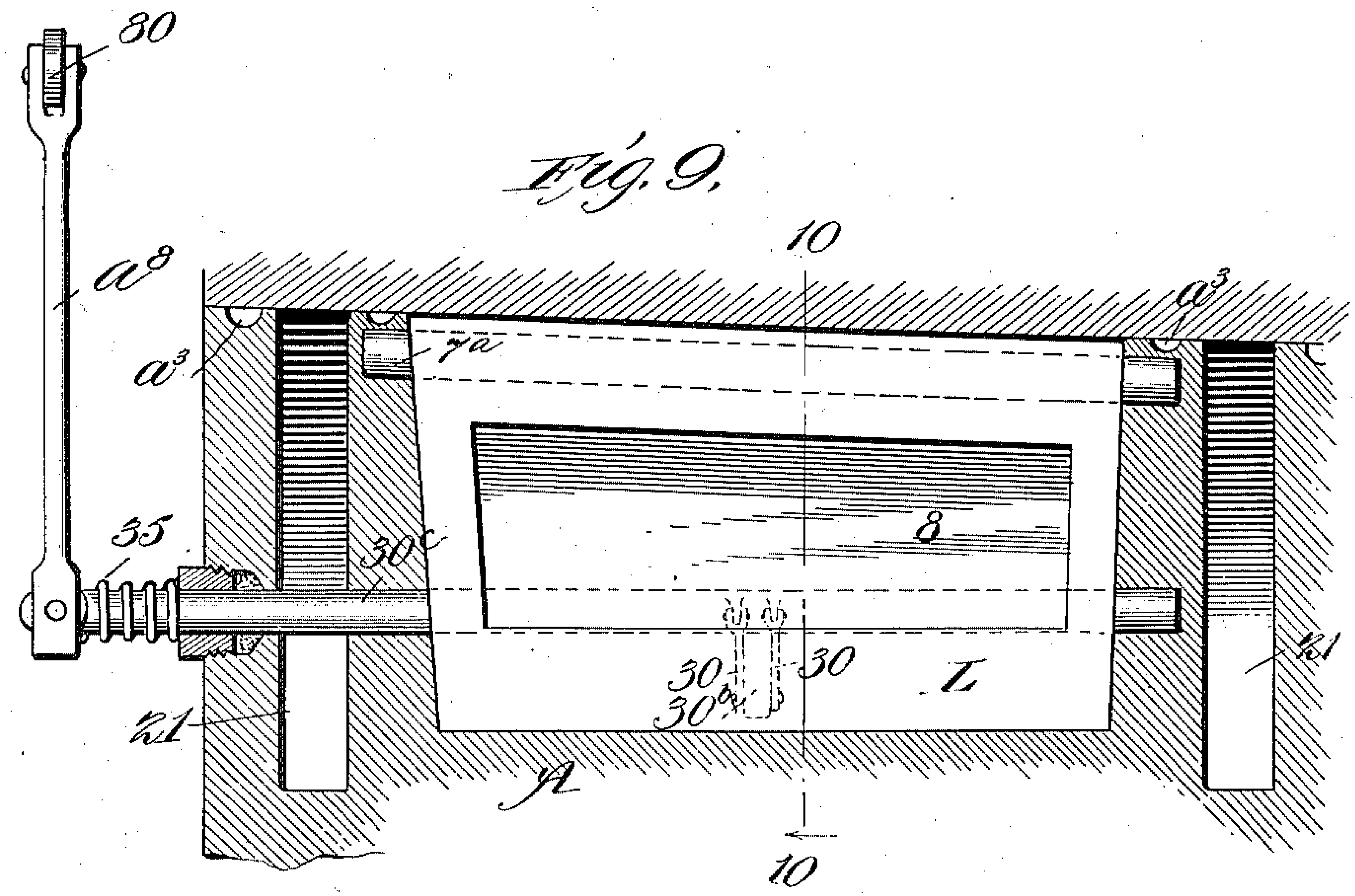


Fig. 10.

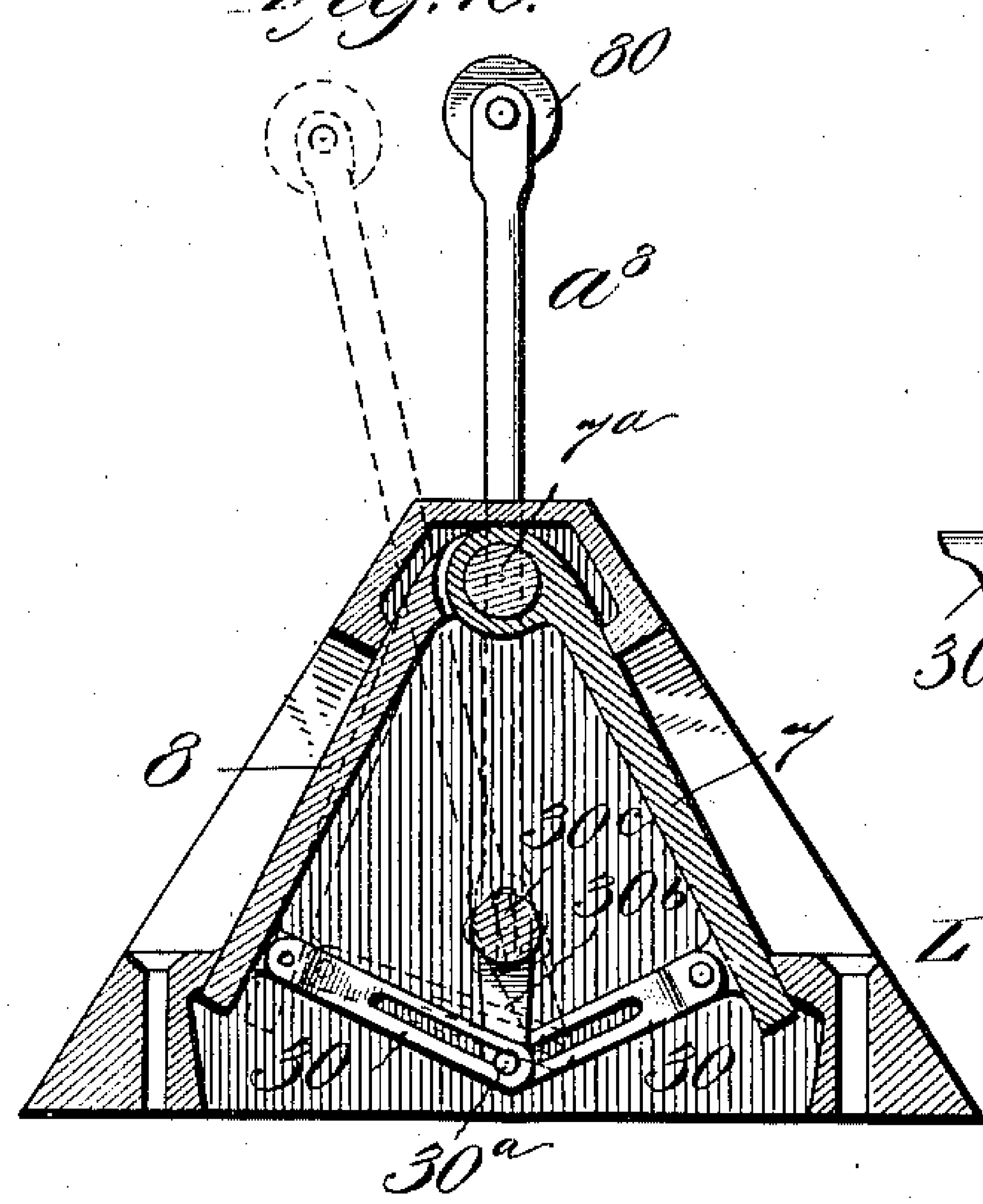


Fig. 11.

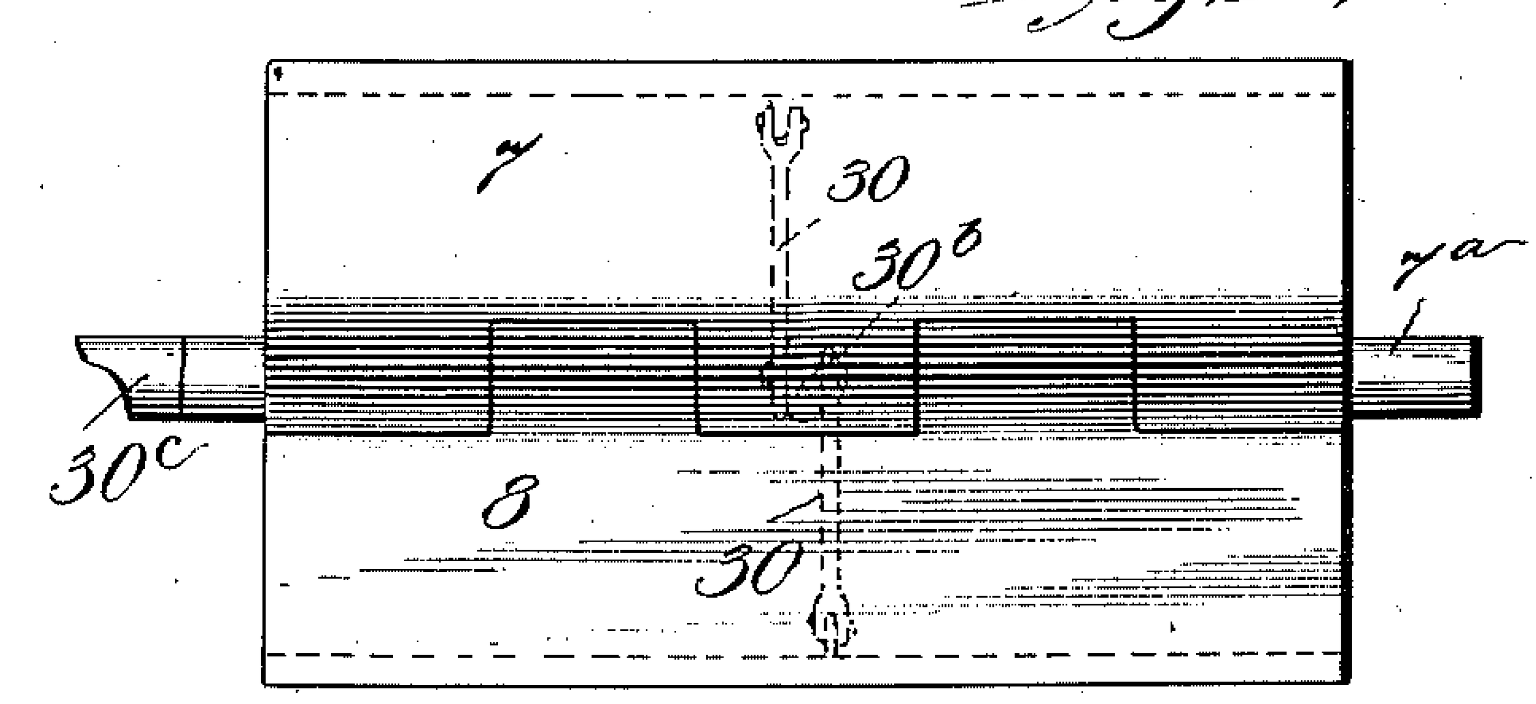
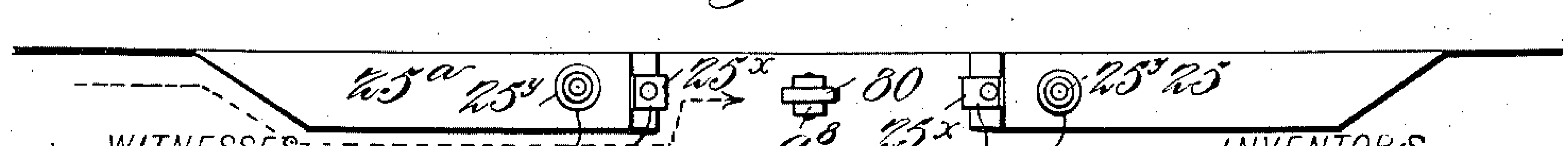


Fig. 12.



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No. 749,654. Patented January 12, 1904.

UNITED STATES PATENT OFFICE.

BERT BANTA AND CHARLES MATHEWS, OF FENTON, MICHIGAN.

ROTARY EXPLOSIVE-ENGINE.

SPECIFICATION forming part of Letters Patent No. 749,654, dated January 12, 1904.

Application filed April 21, 1903. Serial No. 153,644. (No model.)

To all whom it may concern:

Be it known that we, BERT BANTA and CHARLES MATHEWS, residing at Fenton, in the county of Genesee and State of Michigan, have invented a new and Improved Rotary Explosive-Engine, of which the following is a specification.

Our invention is in the nature of an improved rotary engine especially designed to actuate under an explosive mixture, reversible under two or more propelling impulses in a single revolution, and it primarily seeks to provide an engine of this character of a simple, compact, and durable nature, in which the use of toothed gear-wheels or disk connections are dispensed with and in which the several parts are coöperatively arranged to effect an even and uniform operation and in which the action of reversing or regulating the speed can be quickly and conveniently accomplished.

In its generic nature our invention comprehends an annular casing, a shaft-carried head or disk rotatable within the said casing provided with a plurality, preferably two, of diametrically opposite disposed hollow pistons, hereinafter termed "storage-chambers," each having a pair of inwardly-opening valves in their impacting or pushing faces, a pair of sliding abutments automatically closable and movable to their open position by the contact therewith of the passing piston or storage chambers, a valved exhaust coöperative with each abutment, a mixing-chamber having a plurality of valved inlets communicating with the casing in which the hollow piston-equipped rotator is mounted, automatically-actuated feed devices for admitting the working agent (air and gas) into the mixing-chamber, and suitable trip mechanism for actuating the several valves within the hollow pistons at predetermined times and for setting in operation the igniting devices.

Our invention in its more complete nature also embodies a special arrangement of sliding abutment, a valved exhaust for each abutment, a coöperative rotator having tapering hollow pistons, each provided with an inwardly-opening valve in its pushing-faces and a means for shifting the valves of the exhaust whereby to bank the burned mixture when going in one direction to produce an air-cushion for reversing the motion of the rotator and the action of its valved hollow pistons or storing-chambers.

Again, our invention includes certain peculiar arrangements of the casing portions, the abutment-housings, and the abutments operating therein, whereby to effect an air and fluid tight connection of the several parts without the aid of packing or clamping means, and in its still more subordinate features our invention consists in certain details of construction and peculiar combination of parts, all of which will hereinafter be fully described, and specifically pointed out in the appended claims, reference being had to the accompanying drawings, in which—

Figure 1 is a vertical longitudinal section of our improved type of rotary engine, the several parts being shown in the position they assume when the engine is to run in the direction indicated by the arrow X. Fig. 2 is a side elevation thereof, the location of the electric switch devices for igniting the sparking devices being diagrammatically shown and the exhaust-valve-shifting devices being shown in full line adjusted to close the exhaust at the right and for opening the exhaust at the left. Fig. 3 is a transverse section of the engine, taken practically on the line 3 3 of Fig. 1 looking in the direction of the arrow. Fig. 4 is a perspective view of the rotator with the rotary pistons or storage-chambers attached. Fig. 5 is a detail horizontal section of the mixing-valve, taken on the line 5 5 of Fig. 3. Fig. 6 is a diagrammatic plan view of a portion of a top of the engine looking in the direction of the line A B, Fig. 1, and illustrating the correlative arrangement of the abutment-housing, the exhaust adjacent the housing, and the valves that control the openings adjacent the abutment that connects the mixing and compressing chambers of the engine. Fig. 7 is a diagrammatic longitudinal section of the engine-casing and illustrates a modified arrangement of the cooling means. Fig. 8 is a cross-section of the same on the line 8 8 of Fig. 7, a modified construction of the hollow pistons or storing-chambers being shown in dotted lines. Fig. 9 is a side elevation, parts being in section, of the modified construction of the piston. Fig. 10 is a cross-section of the same on the line 10 10 of Fig. 9. Fig. 11 is a detail plan view of the hinged valve members 7 and 8 shown in Fig. 10. Fig. 12 is a detail plan view of a modified construction of the switch and cam devices engaged by the arms that control the valves of the hollow pistons shown in Figs. 9 and 10.

In the practical embodiment of our invention the body of the engine comprises a cylindrical casing 1, mounted on a suitable base 1^a, and the said casing is formed of an annular rim 1^b, whose internal face 1^x tapers from a maximum diameter at the outer edge *y* to a minimum diameter at the inner edge *z*, the reason for which will presently appear.

The shaft 2 is mounted in fixedly-held bearings 3 3, and upon said shaft is keyed a rotator or head A, which comprises a central or spider portion *a*, which includes the hub *a'* for engaging the shaft and which at one side extends through a boss 1^c on the end plate C, and at the opposite end it bears against a stout coiled spring *d*, located in the socket c^2 of the end plate C', and the said spring also engages the adjacent bearing 3, as clearly shown, and it is provided to normally force the rotator A in the direction indicated by the arrow 5 on Fig. 3 to produce a wedged tight closure between the rotator and the casing, as will presently more fully appear.

On the upper end of the casing 1 is integrally formed a segmental mixing-chamber E, one end of which merges with the radially-extended housing F for the sliding abutment or gate F', which is normally forced into the casing by the stout coil-spring *f'*, and the opposite end of the mixing-chamber merges with another opposing abutment-housing G, which projects radially with respect to the axis of the engine-shaft and at right angles to the abutment-housing F, and within the housing G operates the abutment or gate G', which is also spring-actuated to its closure position.

The mixing-chamber E communicates with the annular space between the periphery of the rotator and the casing-rim through two pair of openings H H', spaced equidistantly from a line taken vertically through the engine-axis, (see Fig. 1,) and the said openings H H' are controlled by spring-closed valves *h h'*, each having a stem $h^\times$ $h^\times$ working through a bridge-piece h^2 h^2 and carrying a coil-spring h^2.

At each side and just in advance of the abutments are located the exhausts I I, each of which has an inwardly-closing controlling-valve *i i'*, and the two valves *i i'* are joined to a shifting-lever J, disposed outside the casing, (see Fig. 2,) with which they connect by crank-arms K K, and the said valves *i i'* are arranged to operate alternately—that is, when the valve *i* at the left of Fig. 1 is open, which occurs when the engine is running in the direction indicated by Fig. 1, the valve *i* at the right is closed, and vice versa.

As best shown in Fig. 1, the rotator has diametrically oppositely disposed flat surfaces parallel with respect to each other and tangential to the shaft-axis, and on each of said flat surfaces is firmly bolted a triangular-shaped hollow piston, (designated L L',) which in our construction of engine forms storage-chambers, as in them is stored the working agent in the manner presently explained.

Each storage chamber or piston L L' has openings 1 1' in the opposite impacting faces normally closed by hinged valved plates 7 7 8 8, which are fulcrumed on independently-rocking pintles 7^a 8^a, that project through the side rims a^2 a^2, which form a part of the rotator A and which, together with the rim 1^b, form the annular combined compression and explosion chamber, as clearly shown in Fig. 3, from which it will also be noticed the opposite rims a^2 a^2 are of slightly-different diameter, whereby when the rotator is drawn or adjusted in the direction indicated by arrow 5 on Fig. 3 a close fluid and air tight joint is made between the rotator and annular rim or casing 1^b, and to reduce friction the peripheral edges of the rims a^2 a^2 have annular lubricant-holding grooves a^3, supplied in any well-known manner.

The pintles 7^a 8^a each carry a crank-arm a^8, and the several crank-arms a^8 are so arranged (assuming the rotator to be running in the direction indicated by the arrow in Fig. 1) that just after the downgoing or charged storage-chamber or piston-head passes under the abutment-slide or gate F' the crank-arm a^8 of the said storage-chamber L engages with a stud-pin 10, which shifts the arm a^8 to open the valve 8, controlled thereby for the reason presently explained, it being understood that on the opposite movement of the rotator or head A the crank a^8 of the hollow piston or chamber L' likewise engages a stud 10^a on the opposite side of the cylinder to cause the valve 7 in the said chamber L' to open, and adjacent each of the studs 10 10^a is mounted a switch 12 12^a, which switches control a pair of independent circuits 13 13^a to the igniting or sparking plugs 14 14^a of any approved construction and which extend to the annular space between the rotator and the cylinder-rim at a point just beyond and close up to the abutment-slides.

The working agent, a mixture of gas or gasolene and air, is fed into the mixing-chamber E through the feed-pipe 15, (see Fig. 3,) that connects with the valve-casing 15^a, in which is held a regulating-valve 15^b, connecting with an adjusting member 15^c, and which engages a seat 15^d in the casing 15^a, with which communicates the gas or gasolene feed-port 15^g and the main air-feed 15^e, the feed-port 15^g being controlled by a needle-valve *g* of any well-known construction.

To regulate the air-feed, supplemental air-inlets *e* are formed in the pipe 15 just above the valve-seat, which are surrounded by a cut-off ring 15^f, having a series of air-inlets *f*, which by turning the said ring can be brought more or less in register with the supplemental inlets *e*, as will be clearly understood from Fig. 5.

So far as described the operation of our improved explosive-engine is best explained as follows: To start the engine to run in the direction indicated by the full-line arrow, the shaft, with the rotator, is manually turned a number of revolutions, and in so doing a vacuum is formed within the annular cylinder-space between the storage chamber or piston L in Fig. 1 and the sliding abutment G′ at the left thereof. This causes the controlling-valve 15^b to rise from its seat and admit a charge of working agent, the mixture of which is readily regulated by the needle-valve and air-controlling devices, heretofore referred to, which working charge is drawn into the mixing-chamber E. After the rotator A has been turned enough to fill the mixing-chamber E the storage chamber or piston L is passing through that part of the annular space under the casing-rim 1^b designated C C, (compression-chamber,) the valve *h* back of the member L opens to let in the working agent between the member L and the abutment G′ back of it, and (assuming the rotator has made a complete rotation) the power-supply now in front of the member L is being compressed in the compression-chamber and forced back into the hollow of the member L through the valved opening in the front or compressing face thereof. The member L, with the charge of working agent within it, then passes under and lifts the abutment F′, at which time the pressure of the working agent within the member L closes both valves in the said member. After the piston or hollow member L passes beyond the abutment F′ the latter immediately closes automatically and closes the compression-chamber from the E C (explosion-chamber) through which the charged hollow member is now passing. After the abutment F′ is closed the crank-arm that joins with the valve 7 of the member L engages the stud 10 and is thereby tripped to open the valve 7 to allow the charge in the said member L to escape into the E P space between the member L and the abutment F′ back of it, and immediately after the valve 7 has been thus tripped the crank member 7^a of the valve engages the electric circuit-closer which controls the sparking device in the explosive-chamber now back of the member L, which ignites said charge and impels the rotator forward, it being understood that the several parts are so coöperatively joined and timed in their actions that the explosion occurs just as the opposing piston or storage chamber L′ approaches the abutment G′ at the left, and the member L′ then proceeds forward under the same cycle of movements with the member L, and as the member L′ enters the combustion-chamber the member L then forces out any burned mixture from a prior explosion in advance of it through the exhaust I, as clearly shown in Fig. 1.

It is deemed proper to here point out that while the ignition occurs almost instantly after the charge is permitted to escape from the storage-piston into the explosion-space the interval between the escape of the charge and its explosion is sufficient to utilize the expansive force of the said charge to assist in balancing the resistance effected with respect to the speed of the rotator by reason of the compression of the working agent between the filled hollow piston and the abutment in advance of the then compressing-piston or storage member.

During the operation of the engine in the direction indicated the valve *h*′ for the mixing-chamber outlet remains permanently closed by the action of the spring h^3 and the compression of the charge underneath it; but when the engine is running in the reverse direction the said valve *h*′ opens and the other valve *h* remains closed.

To reverse the engine while running, the lever-bar J, which includes a supplemental shiftable member *j*, is adjusted to close the exhaust-valve *i* without opening the valve *i*′, thereby cutting off both exhausts I I′. When the exhausts are thus closed, the hollow piston that approaches the abutment F compresses the burned mixture, and since there is no escape for the said mixture the same is trapped and forms a cushion which overcomes the inertia of the said rotator, springs it back, and causes the storage-chamber (which under normal conditions would have been drawing in a new charge between it and the abutment F) to immediately close the valve H and at the same time open the valve H′ and now draw in the charge from the opposite direction. After this is done and a single explosion occurs, the shifter *j* is further adjusted to now open the exhaust-valve *i*′ in the exhaust I′, and as the rotator moves reversely the crank member on the valve 8 in the storage-chamber L will then engage the stud 10^a and the electric switch devices for the sparking or igniting devices at the other side, the operation of the parts then being effected in the same manner as before described, but in a reverse direction.

In the practical construction of our invention the side walls of the combined compression and explosion chamber, which are integral with and move with the rotator-head, are cooled by suitable means, which may be in the nature of ribs 20 20, (shown in Fig. 3 or as shown in the modified constructions Figs. 7 and 8,) in which the sides of the annular chamber or space are formed with annular pockets to receive a cooling fluid, said pockets 21 having suitably-arranged inlets and outlets that communicate with the water-passages 22 in the cylinder-rim.

While we have illustrated a cooling means, it is manifest that our invention is not restricted to the use of a cooling means of any specific type, and while it is preferred to provide a cylinder cooling means, yet the same might be entirely omitted.

We do not confine ourselves to any specific form of electric switch or contact-making devices, as the same may be modified to suit the desired conditions so long as they are placed in the plane of an actuating-arm carried by the rotator. For example, the switch devices may be arranged as shown diametrically in Figs. 11 and 12, in which a pair of oppositely-disposed cams concentric with the shaft-axis are provided and which are designated 25 25^a and which have their adjacent ends radial to the shaft-axis and in the path of movement of the arm a^8 and mounted on the stem of the valves in the storage-chamber that let out the working charge into the explosion-chamber. In this latter arrangement it will be noticed when the rotator is moving in the direction indicated the arm a^8 is forced to pass under a cam 25 and is controlled thereby, and in passing under said cam 25 it engages the electric-circuit contacts 25^x 25^y and closes the circuit for the proper igniting plug or device. When, however, the arm a^8 reaches the other cam 25^a, the said arm by reason of its pivotal connection and the beveled edge 25^b on the cam 25^a does not pass under the said cam, but over the outer face thereof, as indicated by the curved arrow on Fig. 12, and thereby leaves its valve or gate closed and does not engage the switch devices of the said cam 25^a, it being understood that the arm a^8 on the diametrically opposite storage-chamber on the reverse motion of the engine engages the cam 25^a and the electric contacts thereon in the same manner that the other arm a^8 engages the cam 25 and the electrical devices carried thereby. When this latter form of cam and electric-contact devices are used, we prefer to arrange the valves within the storage-chambers L L', as shown in Figs. 9 and 10, in which the two valves in each storage-chamber are shown joined by an ordinary gate-hinge connection at the apex of the chamber, and each valve is provided with an inwardly-projected slotted arm 30, and the two arms 30 lap each other, whereby to conveniently receive a cross-stud 30^a, mounted on the lower end of a crank 30^b on a rocker-bar 30^c, mounted transversely over the bottom of the storage-chamber and having one end projected beyond the casing-wall to receive the arm a^8, the upper end of which is forked to receive a roller-bearing 80, (see Fig. 9,) by reference to which it will also be noticed a tension-spring 35 is provided to maintain the arm in its several adjusted positions.

By arranging the parts as just described when one of the valves is operated it does not affect the movement of the other valves.

From the foregoing, taken in connection with the drawings, the complete operation and the advantages of our invention will, it is believed, be readily understood by those skilled in the art to which it appertains.

Among the advantages it is deemed proper to call attention to the provision made for slowing down the engine speed and reversing the same, the latter action being practically automatic. The parts are so combined that packing is not required, and by reason of the taper of the side walls of the annular space in the cylinder and the taper of the abutments or gates the latter are maintained in a fluid-tight condition during their shifted or closure adjustments.

While the structural features shown and described illustrate a preferred arrangement of parts constituting our engine, it will be readily apparent the said parts may be modified or varied without departing from the principle of our invention and the scope of the appended claims.

Having thus described our invention, what we claim, and desire to secure by Letters Patent, is—

1. A rotary explosive-engine, comprising a cylindrical casing, a pair of oppositely-disposed radial abutments automatically closable, a mixing-chamber mounted externally of the casing between the abutments, means for supplying a working agent to the mixing-chamber, a valved exhaust connecting with the cylinder, a rotator mounted within the cylinder and including a hollow rotary piston having openings in the opposite impacting or pushing faces and whose outer end travels close against the inner face of the annular wall of the cylinder, a pair of oppositely-disposed internally-opening valves mounted within the hollow piston, a feed-port connecting the mixing-chamber with the cylinder at a point between the abutments, an automatically-actuated valve-operating means for tripping one of the hollow piston-valves to let out the charge in the said hollow piston when the said piston passes under the sliding abutment on the down-going side of the cylinder, and means actuated by the movement of the rotator for igniting the charge from the hollow piston, as set forth.

2. A rotary explosive-engine, comprising a cylinder, a rotator mounted therein, a mixing-chamber, a valved working-agent feed therefor controlled by the movement of the rotator, means mounted on the cylinder and the rotator coöperatively arranged whereby to draw in a charge into the cylinder, a second means actuated by the movement of the rotator for conveying the charge to a predetermined point within the cylinder, a valved exhaust for the

cylinder and an igniting means actuated by the movement of the rotator for exploding the charge conveyed by the rotator, as set forth.

3. In a rotary gas-engine of the character described; a cylinder having valved induction and exhaust ports, a rotator within the cylinder having a radially-disposed hollow piston provided with an opening in each opposite or impacting face, valves automatically adjusted by the fluid-pressure in the cylinder externally or internally of the hollow piston, a pair of radially-sliding abutments automatically closable, said abutments being oppositely disposed, one at each side between the induction and exhaust ports of the cylinder, a means for tripping the valve on the rear side of the radial piston member after it passes under one of the abutments whereby to discharge the working agent within the hollow piston between said piston and the abutment, and a second means controlled by the forward motion of the rotator for igniting the said charge for the purposes set forth.

4. In a rotary explosive-engine; the combination with a cylinder, a pair of slidable radial abutments, an exhaust in advance of said abutments, an induction-port communicating with the cylinder at a point between the abutments, a rotator axially mounted within the cylinder including a hollow piston radially projected therefrom, said piston having an opening in each impacting face, a valve for each of said openings mounted within the said piston and actuated by the working-agent pressure in the cylinder externally and internally of the hollow piston whereby in approaching one of the said abutments, the valve on the front impacting face opens to let in a charge of igniting agent and hold the other valve to its closed position to create a vacuum between the rear face of the said hollow piston and the other abutment and thereby draw in a fresh charge through the induction-port, said hollow-piston having its impacting faces inclined whereby to raise the abutment-slides, a means controlled by the forward movement of the rotator for tripping the valve on the rear face of the piston to let out the charge held therein when the said face is passing under the abutment, means for automatically closing said abutment and igniting devices including an actuating member carried by the rotator for setting in operation said igniting devices immediately after the discharge passes from the hollow piston into the cylinder-space between it and the abutment under which it last passed, as set forth.

5. In a rotary gas-engine; the combination with the cylinder having induction and exhaust ports, of a piston rotatably mounted therein and including hollow radial projections whose opposite impacting faces are tapering, and each having an opening, valves located within the hollow projections inwardly and outwardly shiftable under external and internal fluid-pressure, and means controlled by the forward movement of the rotatable piston for opening the rear valve to exhaust the working charge into the cylinder between the back of the piston and an adjacent abutment, and for igniting the working charge, as set forth.

6. A rotary gas-engine, comprising an annular casing, a shaft-carried rotator or piston having a pair of diametrically opposite hollow radial chambers, each having an opening, and inwardly-opening valves on their impacting or pushing faces, a pair of sliding abutments automatically closable and movable to their open position by contact with the passing hollow piston-chambers, a valved exhaust coöperative with each abutment, a mixing-chamber having a plurality of valved inlets communicating with the casing in which the hollow piston-equipped rotator is mounted, automatically-actuated devices for admitting the explosive agent into the mixing-chamber, and trip mechanism for actuating the several valves within the hollow piston members at predetermined times and for setting in operation the igniting means, as set forth.

7. A rotary gas-engine of the character described, comprising an annular casing, a pair of oppositely-disposed sliding abutments automatically closable, a valved exhaust in advance of each abutment, a coöperative axially-disposed rotator within the casing having tapering hollow pistons projected radially, each provided with inwardly-opening valves in the pushing faces thereof, and a means for shifting the exhaust-valves whereby to bank the burned mixture when going in one direction to provide an air-cushion for reversing the motion of the rotator and the action of its valved hollow piston members, as set forth.

8. In a rotary gas-engine as described; an annular casing, a pair of oppositely and radially disposed sliding abutments automatically closable, induction-openings in the casing disposed between the abutments, one adjacent each abutment, a valve for each induction-opening automatically closable, a mixing-chamber with which the induction-openings communicate, a valved feed-pipe for leading the working agent to the mixing-chamber, a valved exhaust adjacent to and in advance of each sliding abutment, a rotator axially mounted within the casing having radial hollow piston members whose opposite faces are tapering and each formed with an opening, a valve for each opening hinged within the hollow piston, said valves being alternately held, one to its closed, and the other, to its open position by the influx of the working agent into the hollow pistons, said rotator, the hollow pistons, the valves therein and the mixing-chamber induction-ports and the sliding abutments, being coöperatively arranged whereby the charge within the cylinder between the abutments is forced into the hollow piston

member and in passing through the said cylinder-space as a new charge is being sucked into the said space between the rear of the piston and its adjacent closed abutment, and means actuated by the down-going movement of the rotator for shifting the back face-valve of the hollow piston after it passes under the forward abutments to exhaust the charge contained within the hollow piston member into the cylinder between the said piston and the adjacent abutment and an igniting device set in operation by the movement of the rotator for exploding the said charge, as set forth.

9. In a rotary gas-engine, the combination with a cylinder having induction and exhaust ports, the latter being oppositely disposed and each having a cut-off valve, a pair of abutments piston-actuated to their open position, a piston rotatable in the cylinder, said piston including diametrically-disposed hollow radial extensions having an opening in each impacting or pushing face, valves for controlling said openings adapted to be moved to an open or closed position by fluid-pressure, a means controlled by the movement of the piston for opening said valves while under fluid-pressure and a shifting device external of the casing adapted when shifted to first close the exhaust-valve on the exhaust side of the cylinder and then open the valve for the opposite exhaust, for the purposes specified.

10. In a rotary gas-engine of the character described; the combination of an annular casing whose inner face is wedge-shaped in cross-section, a rotator axially mounted in said casing and comprising a central spider-frame and an annular chamber portion, the peripheral edge of which is wedge-shaped to fit wedge-tight within the annular casing, induction and exhaust ports communicating with the said chamber, said rotator also including diametrically and oppositely disposed radially-extended hollow chambers having tapering pushing or impacting faces, each of which has an opening, valves carried within the hollow chambers for closing said openings, and a pair of sliding abutments automatically closable and movable outward by the hollow pistons, and means for tripping said valves and for igniting the working-agent charge at predetermined intervals, as set forth.

11. In a rotary gas-engine as described; in combination with the cylinder, the inlets, the exhausts and the sliding abutments arranged substantially as shown, of the rotator including hollow radial piston members having tapering impacting surfaces in each of which is an opening, a pair of hinged valves in each hollow piston member adapted to be swung to an open or closing position under fluid pressure, and external means controlled by the down-going movement of the rotator to open the rear main one of the hinged valves against the fluid-pressure thereon to permit the escape of the working-agent charge within the hollow piston member into the explosion portion of the cylinder, means operable by the said down-going movement of the rotator for igniting the said charge when it passes into the said explosion-chamber, as set forth.

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Witnesses:
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