(No Model.)

4 Sheets—Sheet 1.

M. W. HALL.

STEAM ENGINE.

No. 409,284. Patented Aug. 20, 1889.

Fig. 1,

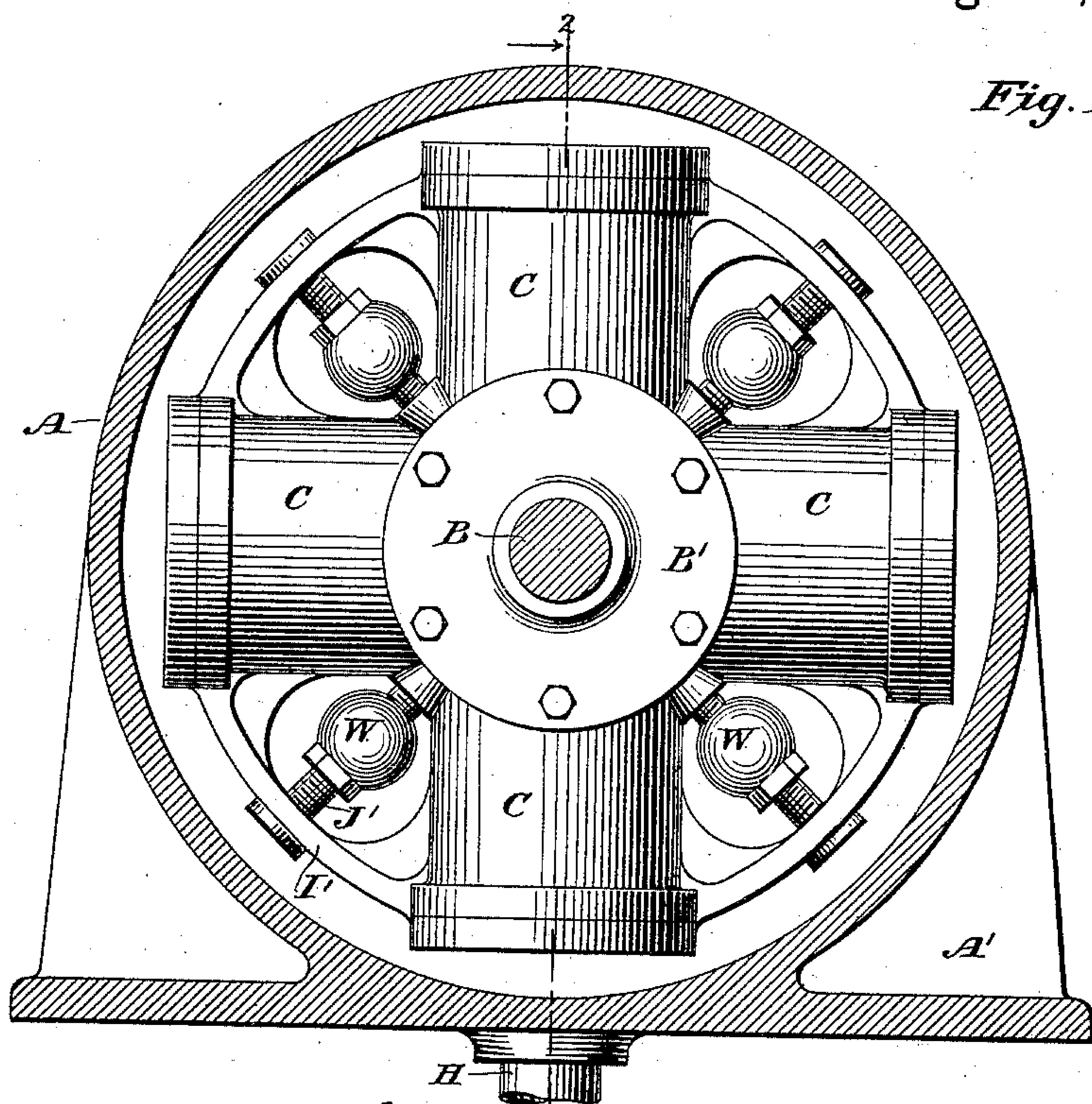

Fig. 2,

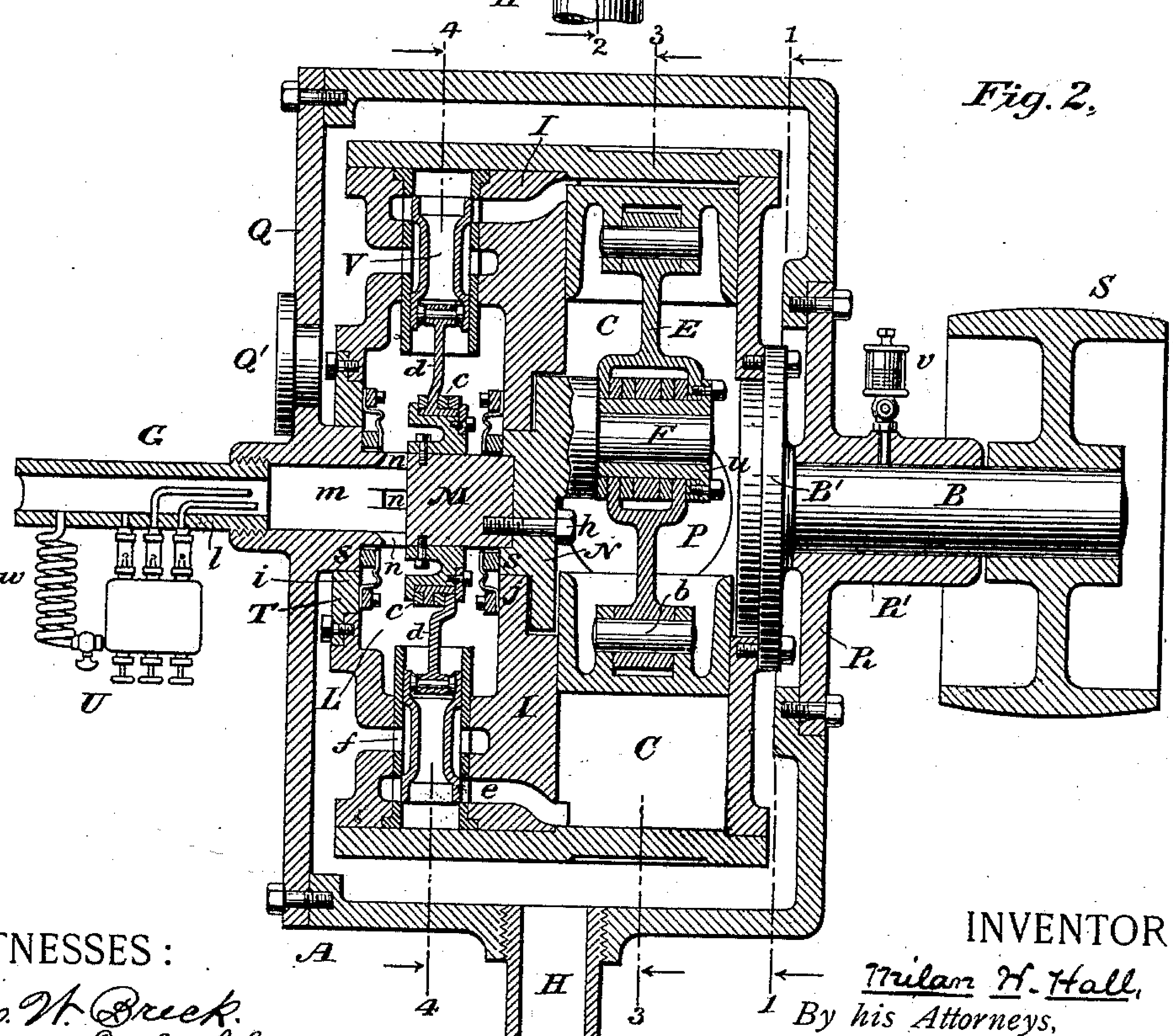

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Fig. 3.

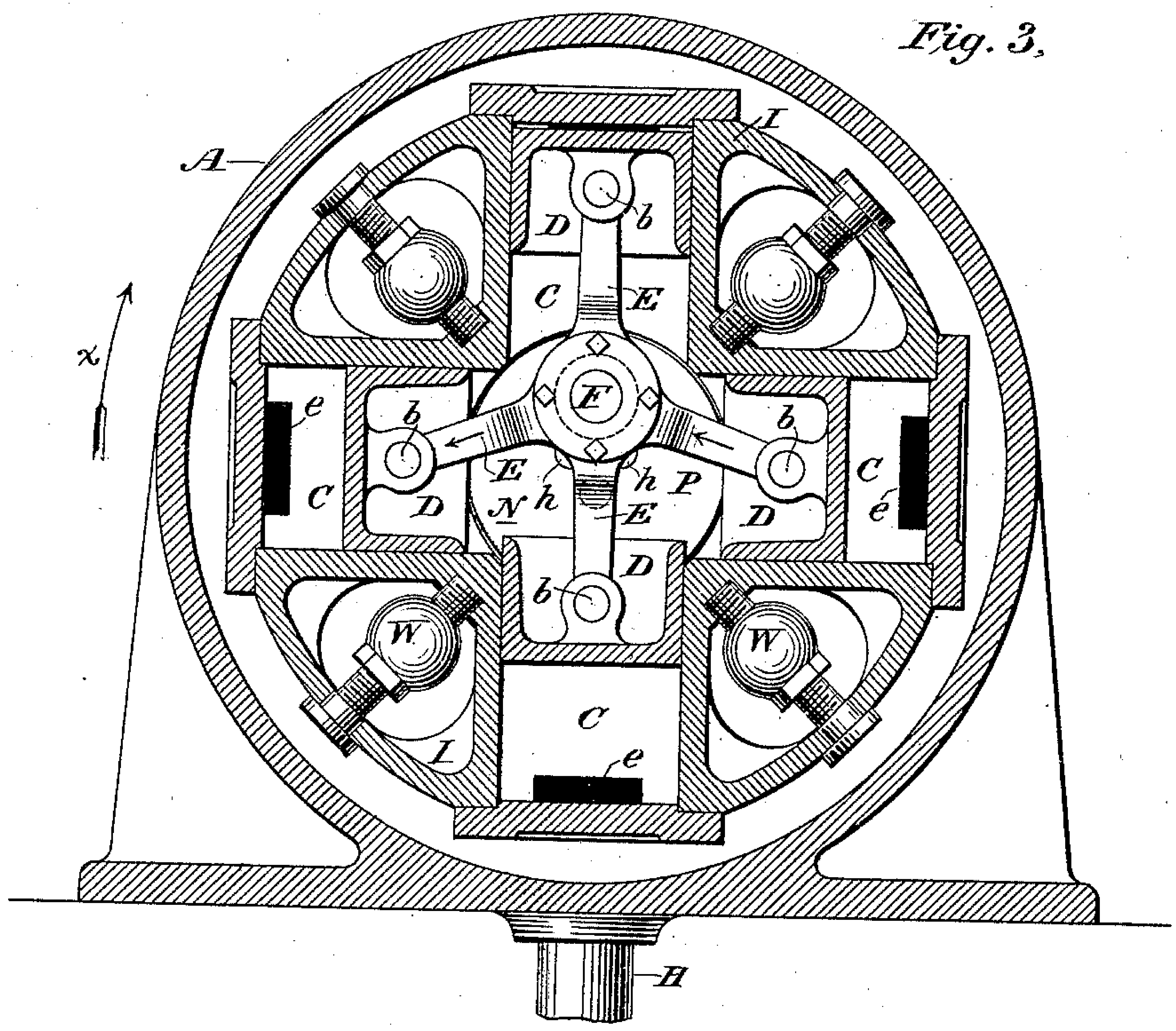

Fig. 4.

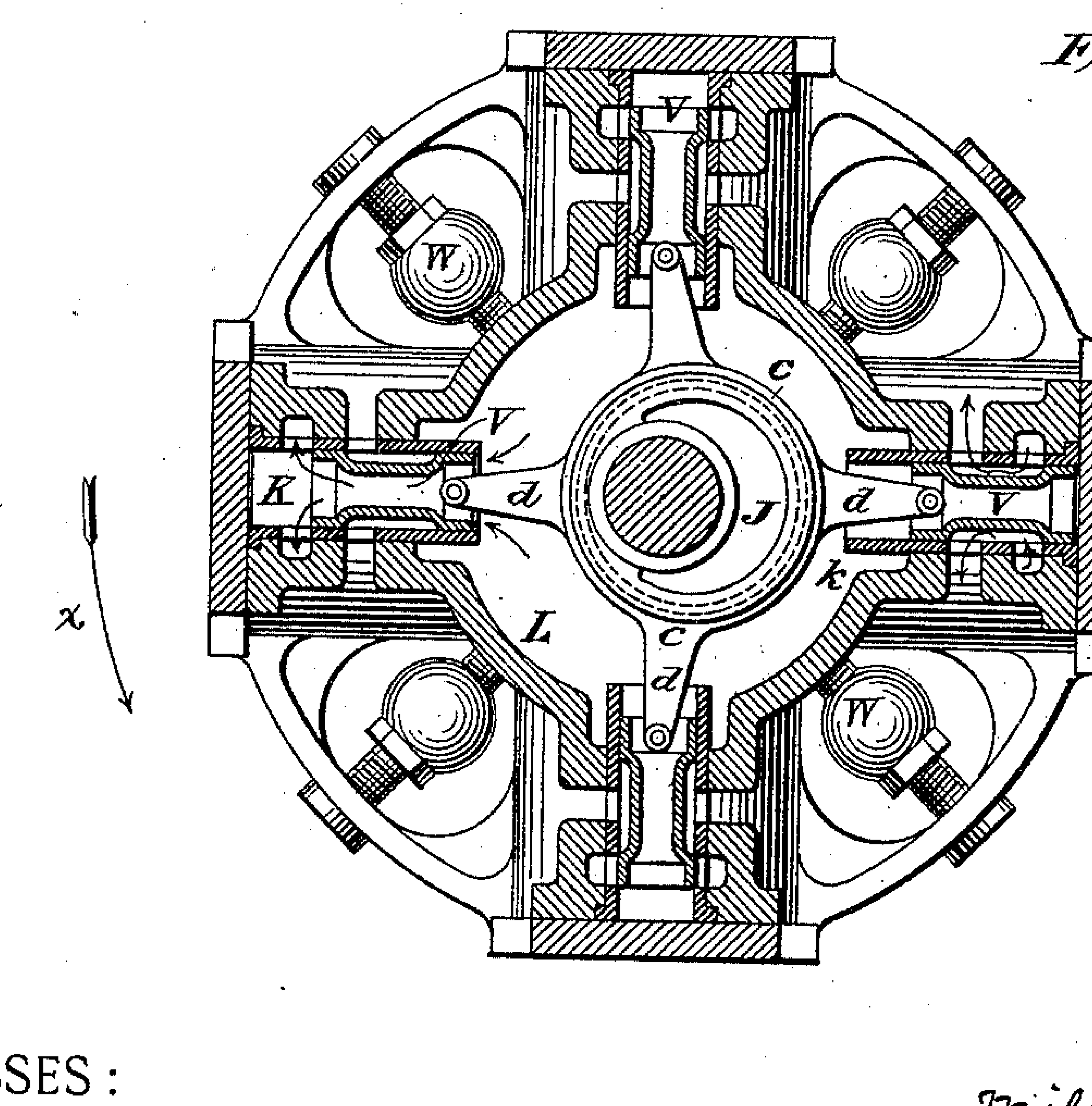

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Fig. 5.

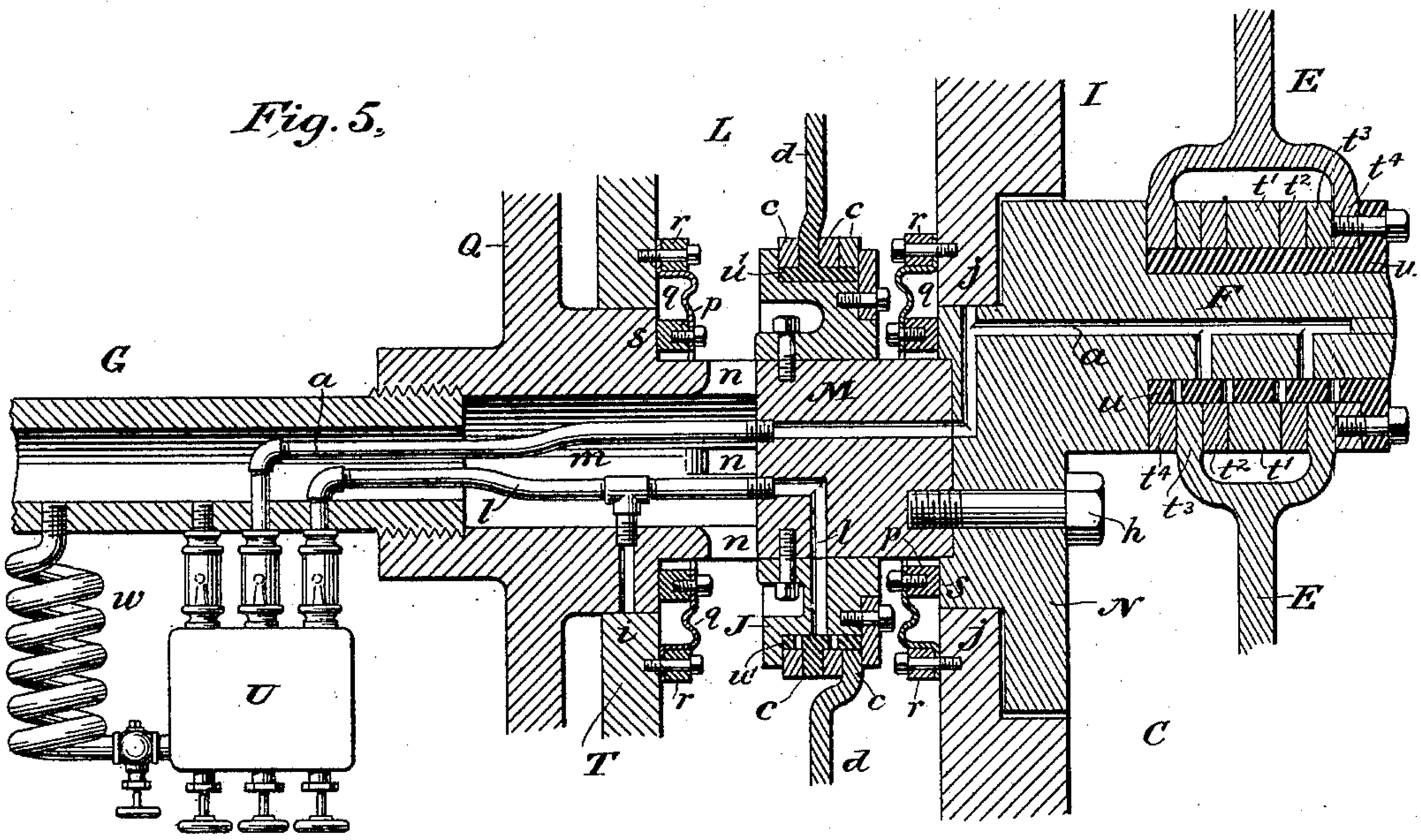

Fig. 6.

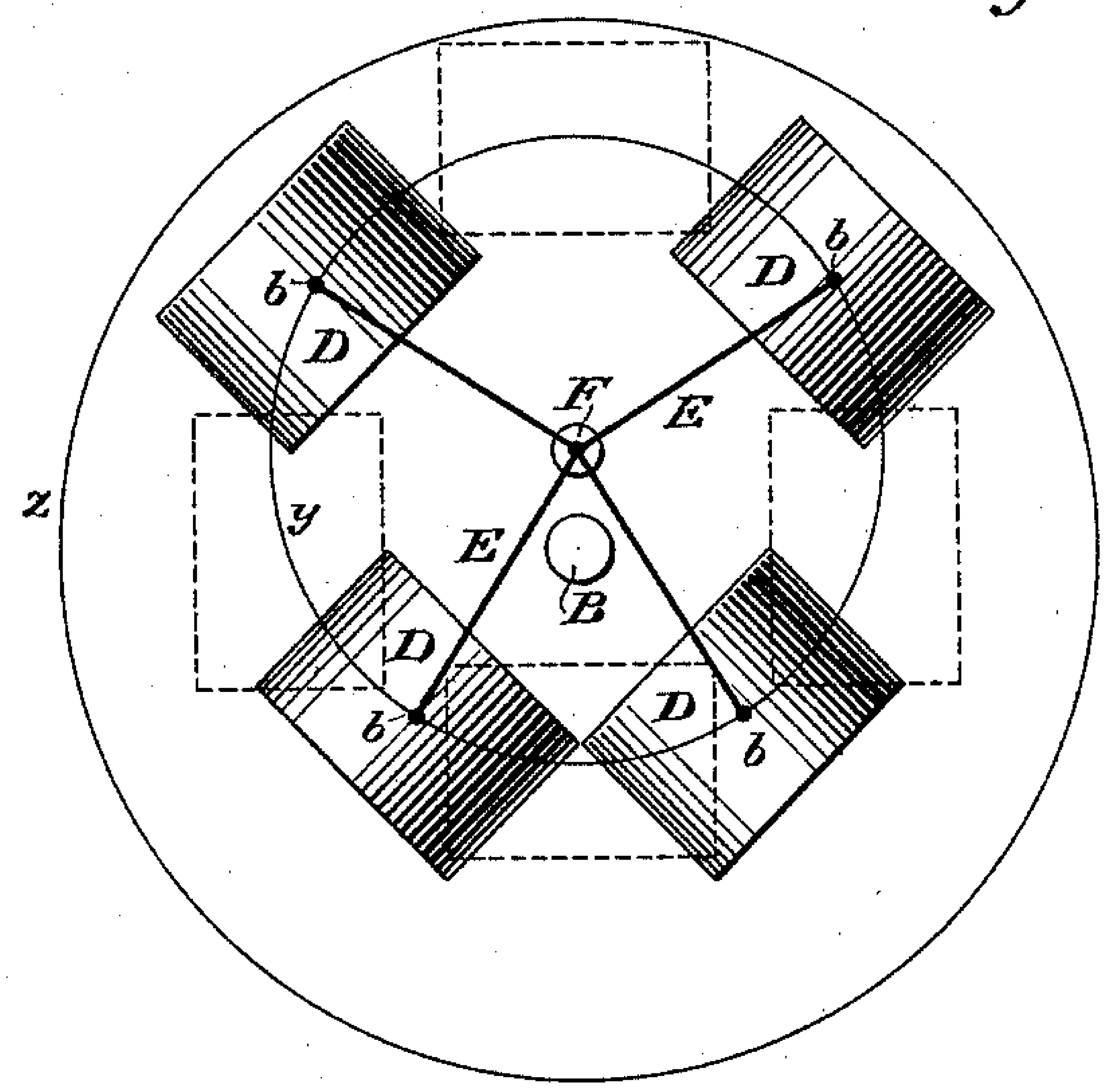

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Fig. 7.

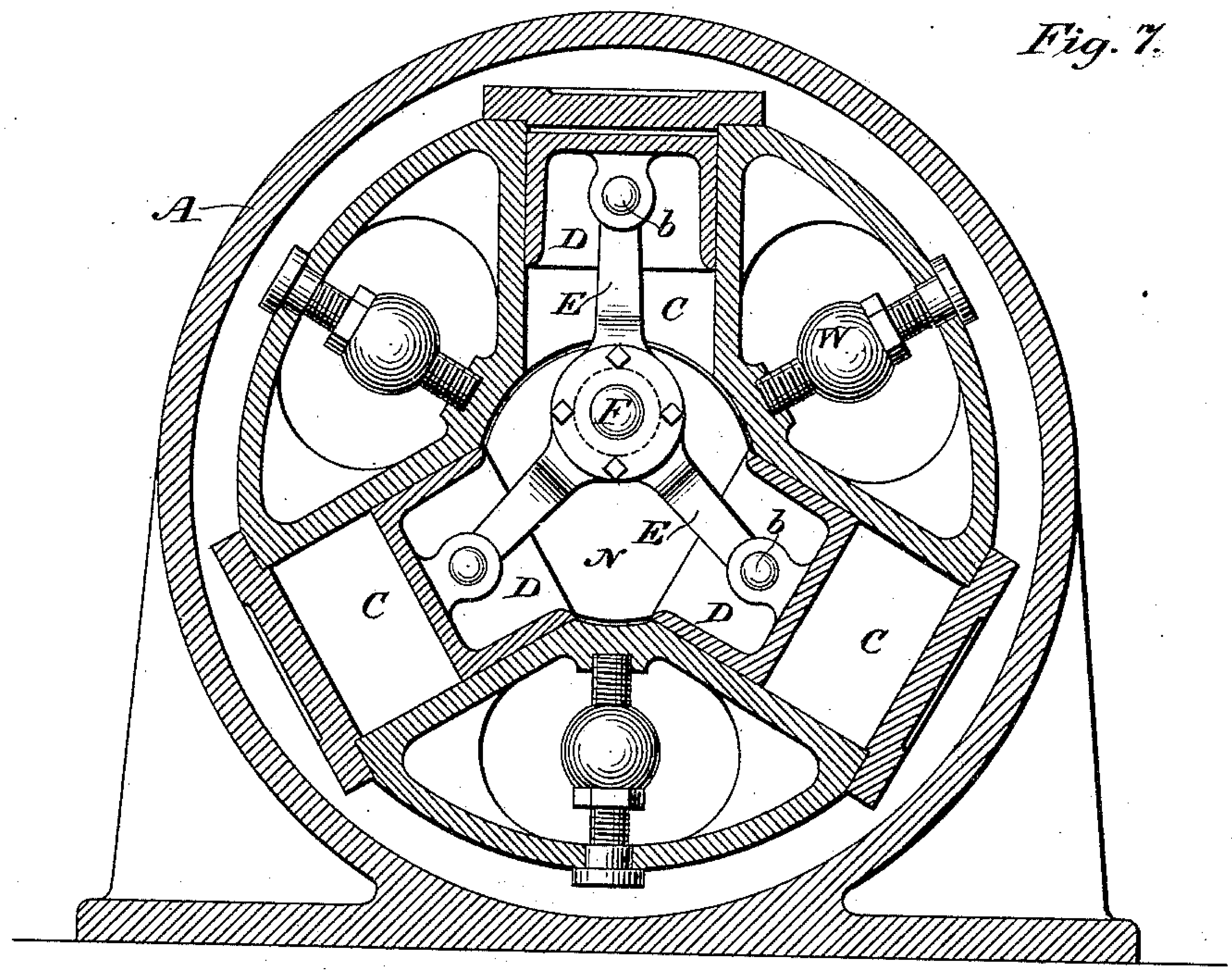
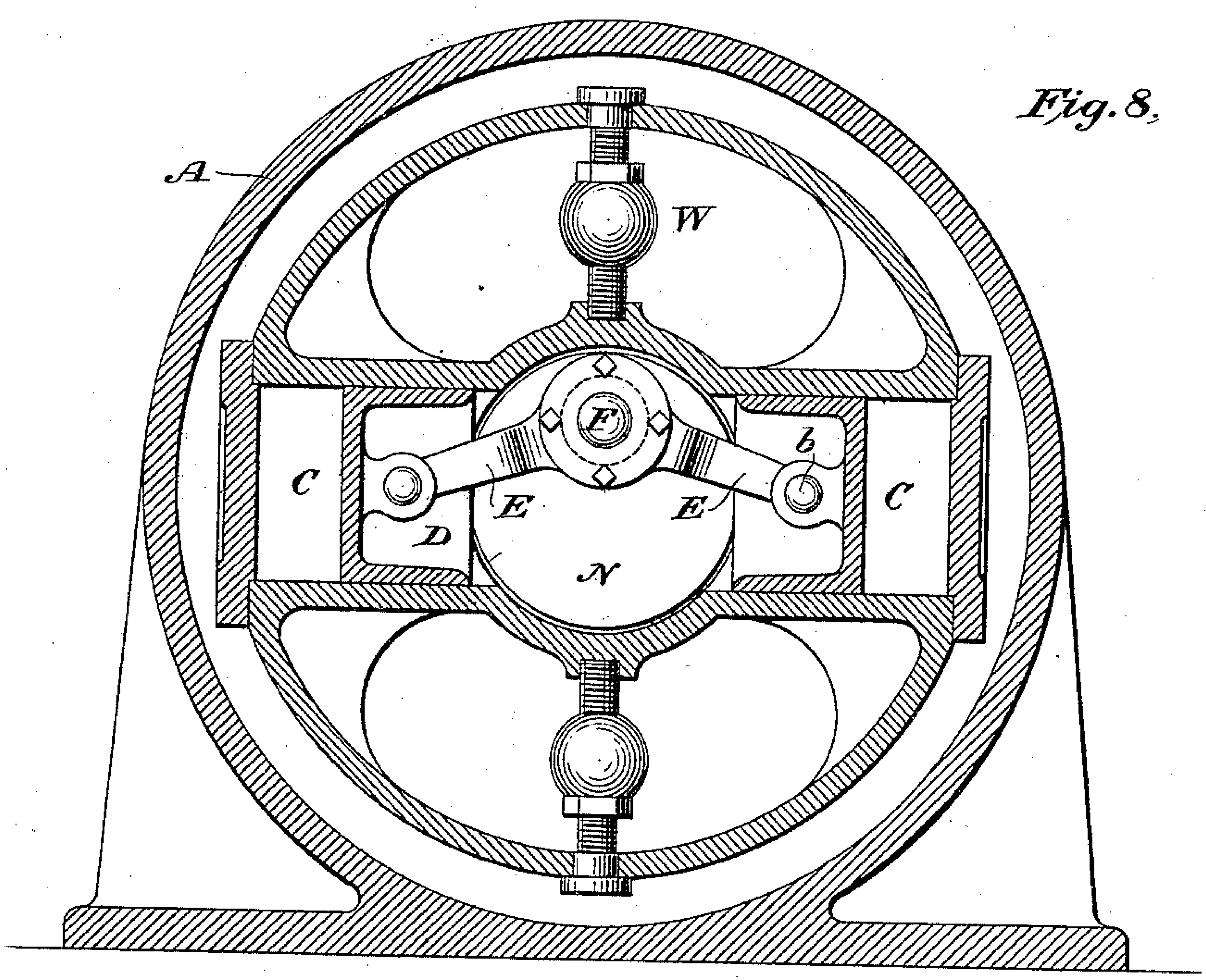


Fig. 8.



WITNESSES:

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Carrie E. Ashley

INVENTOR:

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UNITED STATES PATENT OFFICE.

MILAN W. HALL, OF BROOKLYN, NEW YORK.

STEAM-ENGINE.

SPECIFICATION forming part of Letters Patent No. 409,234, dated August 20, 1889.

Application filed January 24, 1888. Serial No. 261,787. (No model.)

To all whom it may concern:

Be it known that I, MILAN W. HALL, a citizen of the United States, residing at Brooklyn, in the county of Kings and State of New York, have invented certain new and useful Improvements in Steam-Engines, of which the following is a specification.

My invention relates to steam-engines or other analogous motor-engines, and is also applicable to pumps, water-meters, and other machines operating on analogous principles.

My invention relates to that type of engines known as "revolving-cylinder engines," or those constructed with a plurality of cylinders arranged radially around a common axis on which they are mounted to revolve, and having their pistons connected by pitmen, or otherwise, to a stationary crank eccentric to said axis. The advantage of engines of this type is that all reciprocating movements are eliminated, the movements of all the parts being directed in circular paths, so that the loss of power which in reciprocating engines is consumed in alternately imparting momentum to the moving parts and overcoming this momentum in stopping them is avoided. Engines of this type are consequently well adapted for running at a high speed, being free from the pounding and vibrations due to the stopping and starting of the reciprocating parts, and requiring no steam-cushions to receive the impact of the pistons.

The particular construction of such revolving-cylinder engines which most resembles my present invention, and upon which the latter is most directly an improvement, may be described as follows: Two or more cylinders, usually four, are fixed rigidly together by casting them in one piece, or otherwise, their axes being arranged on equidistant radii around the axis of rotation, their axes being all in one plane perpendicular to said axis of rotation. These cylinders are mounted on a radial shaft, and in each cylinder is placed a single-acting piston of the bucket-plunger type, which pistons are connected by means of pitmen to one common crank or stud which is arranged eccentrically to the axis of rotation, and is fixed in place so as to remain stationary. Each of the cylinders is provided with a valve-chest arranged parallel with it, and in the several valve-chests balanced piston-valves are arranged to work, all of the valves being connected through eccentric rods and straps to one common eccentric, which is also arranged stationary and in a fixed relation to said stationary crank. The valves thus act with reference to their respective cylinders in the same manner as the valves of reciprocating engines. The pistons, being all connected to the stationary crank, remain at all times equally distant from the eccentric axis thereof, and hence the action of the steam causes the cylinders to revolve upon the axis of the shaft on which they are mounted, a result which is due to the reaction of the pistons in pressing through their pitmen upon the crank. The movement of the pistons relatively to the cylinders is reciprocatory, but relatively to a stationary part the pistons rotate in a circular path eccentric to the path traversed by the rotary cylinders. Thus there is, during the running of the engine, no change in the direction of motion of any of the parts, and hence no necessity for overcoming momentum in stopping or inertia in starting them, so that an engine of this type should be capable of running at a much higher speed than a reciprocating engine. The revolving cylinders are inclosed in an exterior stationary casing into which the exhaust-steam is admitted from the cylinder.

Revolving-cylinder engines as heretofore made have attained but little practical success, owing to certain defects in their construction. It is the object of my invention to overcome these defects and produce an engine of this type which shall be practical and economical in its operation, in order that it may be available as a high-speed engine for driving dynamos, centrifugal machines, &c., by direct connection therewith.

My invention introduces some important structural improvements and provides means for insuring the perfect balance of the revolving parts by correcting any inequality of balance that may occur in the casting or otherwise.

In the accompanying drawings, Figure 1 is an end elevation of a construction of engine embodying my invention, the outer casing and shaft being in vertical section cut in the plane of the line 1 1 in Fig. 2. Fig. 2 is a vertical axial section cut in the plane of th line 2 2 in Fig. 1. Fig. 3 is a vertical transverse section cut through the axes of the steam-cylinders, as denoted by the line 3 3 in Fig. 2. Fig. 4 is a vertical transverse section cut through the axes of the valve-chests and looking in the opposite direction from Fig. 3, as denoted by the line 4 4 in Fig. 2. Fig. 5 is a fragmentary section of a portion of Fig. 2, showing the details of the valve-connections, steam-packings, and lubrication on a larger scale. Fig. 6 is a diagram illustrating the revolving movement of the pistons around the crank center. Fig. 7 is a vertical section corresponding to Fig. 3, and showing a modified construction wherein the engine has three cylinders instead of four; and Fig. 8 is a similar section illustrating an engine having two cylinders.

Referring first to Figs. 1 to 4, let A designate the outer case inclosing the working parts of the engine; B, the rotary shaft; C C, the cylinders, of which four are employed in this construction; D D, the pistons working in these cylinders; E E, the pitmen or connecting-rods of the respective pistons, and F the crank, which in this construction is stationary.

G is the steam-inlet pipe, and H the exhaust-pipe.

The four cylinders C C are connected fixedly together, preferably by being all formed in one casting, lettered I. The cylinders are connected to the shaft B and rotate therewith. The crank F is held stationary by being fastened in any suitable manner to the outer case A or to any other stationary part. The four pitmen E E all engage the one crank-stud F and radiate therefrom to the points at which they are pivoted to the pistons.

In Fig. 3 the upper and lower pistons are shown at the end of their stroke and the right and left hand pistons are shown at mid-stroke. If the rotation be assumed to be in the direction of the arrow x, the right-hand piston is for the moment the only effective one. Steam is entering the right-hand cylinder C through the steam-port e, and is exerting a pressure tending to force the piston to the left and the cylinder-head to the right. The latter pressure being resisted, the reaction in the opposite direction is transmitted through the pitman to the crank F, as indicated by the arrow, and by reason of the inclination or throw of this pitman a lateral pressure is exerted against the cylinder C, which forces it to rotate in the direction of the arrow x, thereby carrying around the entire system of cylinders and pistons. As the center is passed, the next successive piston (being the upper one in Fig. 3) commences to act, and during the ensuing quarter-revolution the two pistons are acting in co-operation, the mechanical advantage of the preceding one, however, diminishing as that of the succeeding one increases. In short, the action is the reverse of that of an engine with four radial equidistant stationary cylinders with their pistons all coupled to a rotary crank revolving around the common center. The four pistons are each single-acting, so that their action against the crank is a pushing action and continues during only one-half of the revolution. This has the advantage of avoiding the necessity of piston-rods and stuffing-boxes between the pistons and the crank. The action of the four pistons is successive, and the thrust exerted through the respective pitmen against the crank increases and diminishes in such relation as to result in a very nearly uniform thrust or back-pressure upon the crank-stud, and consequently in a similarly uniform forward impetus applied to the cylinders.

It will be seen that although the pistons reciprocate relatively to the cylinders, yet their actual movement is a rotary one around the crank F. As the cylinders revolve, the pistons revolve with them around the crank F as a center, and consequently in very nearly circular paths, the path of the centers of the pitmen-joints b b being exactly circular. The axes of the pitmen-joints b b are preferably arranged in the center of gravity of the pistons, in order that the latter may be exactly balanced in their movement around the center F. The pistons D D, considered relatively to the crank-center F, have an oscillatory movement on the centers b b as they whirl around the crank-center, which oscillation is equal in degree to the angular throw of the pitmen, but which, occurring coincidently with the revolution around the crank-center, results merely in the extreme outer and inner portions of the pistons most remote from the centers b traveling in curves slightly varying from the true circle traversed by the centers b.

In order to clearly illustrate the path traversed by the pistons and its relation to the rotary paths of the cylinders, I have introduced the diagram, Fig. 6, where the pistons are shown in elevation in the position which they occupy when the cylinders have advanced one-eighth of a revolution beyond the position shown in Fig. 3. The circle y denotes the path traversed by the pitmen-joint centers b b, and the circle z denotes the paths traversed by the outer ends of the cylinders.

Inasmuch as the pistons in revolving around the crank-center necessarily move in and out along radii from the axis of the shaft B around which the cylinders revolve, they necessarily draw closer together as they approach the shaft-axis and separate as they recede therefrom. This action results in a slight acceleration in speed of the pistons during one half of each revolution, and a corresponding retardation during the remaining half. These accelerations and retardations occur gradually and without shock or vibration, and also without any loss or waste of power, because they are induced through the relative movement of the cylinders and pistons so that the acceleration caused by the cylinders on one side, and which might tend slightly to retard their rotation, is balanced by the retardation caused by the cylinders on the other side, which tends to accelerate the speed of the cylinders. Furthermore, it will be observed that the acceleration of speed of the pistons is coincident with the transmission of power through them and their pitmen against the crank, and their retardation is coincident with the exhausting of the steam from behind them, circumstances which tend still further to neutralize any effect which might otherwise result from the slight variation in the movement of the pistons from a uniformly-speeded rotation.

The effect of centrifugal force upon the pistons tending to throw them away from the crank center is more than neutralized during the active half-revolution of each piston by the pressure of live steam against its outer side, and during the inactive half-revolution the outward tendency of the piston is useful in expelling the exhaust-steam from the cylinder.

I will now proceed to describe more in detail the constructive features introduced by my invention.

The valve-gear is characterized by the employment of a stationary eccentric J, embraced by four eccentric-straps *c c*, which are connected by eccentric-rods *d d* to the four steam-valves V V, which move radially in valve-chests K K, communicating with the respective cylinders. The cylinder-casting I is formed with a concentric steam chest or chamber L, in which the eccentric J and the eccentric straps and rods are inclosed. The valve-chests K K radiate from this chamber L coincidently with the radial arrangement of the cylinders, as shown in Fig. 4. By preference each valve-chest K is lined with a bushing *k*, in which the ports are formed. In the construction shown this bushing is cylindrical, and forms a close-working fit with the cylindrical or piston valve V. Each valve V is essentially a single-acting D slide-valve developed cylindrically around an axis parallel with its direction of radial motion, so that it becomes a double piston-valve with a contraction or neck between the pistons forming the steam-passage *g* for connecting the cylinder-port with the exhaust-port, and with a steam-passage formed through the valve from end to end. Each valve-chest is formed with a cylinder-port *e*, leading to the outer end of the respective cylinder C, and with an exhaust-port *f* opening outwardly to the exterior of the casting I. When the valve V is drawn by the eccentric toward the center of rotation, its outer end uncovers the cylinder-port *e*, as shown at the left hand in Fig. 4, and steam passes from the steam-chest L through the hollow valve and passes by the port *e* into the cylinder. At the same time the diametrically-opposite valve is thrust away from the center of rotation, as shown at the right in Fig. 4, so that the steam-passage *g* between the pistons affords communication between the cylinder-port *e* and the exhaust-port *f*, whereupon the steam passes from the cylinder C to the exterior and freely escapes. When the valve V is in an intermediate position, as shown at the top and bottom in Fig. 4, and as shown in Fig. 2, its outer piston, which is of the same length as the width of the cylinder-port *e*, stands directly over and closes that port. By this construction of tubular double piston-valves the live steam is caused to press equally against both ends of each valve, whereby the valves are balanced and all undue friction is avoided. The action of centrifugal force establishes a continual tensile strain upon the eccentric-rods *d d*, which enables these rods to be constructed of very light material without liability of their buckling, as would be the case where they are subject to thrusting-strains.

It will be understood that with the valve-gear shown, or with any other type of valve-gear that may be devised, the setting of the eccentric relatively to the crank-stud in order to give a lead to the valves, and the extent of lap which the valves have relatively to their ports, will be governed by the same rules as with reciprocating engines.

The crank F and eccentric J are, in the construction shown, both mounted upon and fixed rigidly to a shaft M, which is arranged fixedly with its axis coinciding with that of the shaft B. The crank F is formed on a crank-disk N, which is fastened by bolts *h h* or otherwise to the end of the stationary shaft M. The four cylinders C C are cast together, with an intervening chamber P at the center, in which the disk N, crank F, and pitmen E E are arranged. This chamber P extends to the left in Fig. 2 sufficiently beyond the cylinders C C to admit the thickness of the disk N between, as shown, and this recessed portion of the cylinder-casting is formed out of contact with the disk, in order that it may freely rotate. The disk N is constructed with a hub which projects through the wall of the casting I to the steam-chamber L. The concentric opening in the casting I, through which this hub passes, is made a bearing-fit therewith at *j*, in order that the cylinder-casting in its rotation shall turn on this hub as on a journal. On the opposite side of the steam-chamber L the casting I is formed or provided with another bearing at *i*, which turns on a portion of the shaft M as on a journal. The shaft B is formed or constructed with a disk B′ on its end, which disk is bolted to the cylinder-casting I and forms a cover for closing the chamber P between the cylinders. Thus the cylinder-casting I is rotatively mounted on the bearings *i* and *j*, and by means of the bearings in which the shaft B turns.

The engine is constructed with an outer inclosing-case A, within which the moving parts are placed, and which is made steam-tight, by preference. This case is cast with a base A′, and is formed on one side with a removable cover Q and on the other side with a removable cover or plate R. The shaft M is fastened to or formed integrally with the cover Q, and the bearing R′ for the shaft B is fastened to or formed integrally with the cover R. The opening or seat against which the cover Q fits is large enough to admit the passage of the cylinders, whereby they may be inserted within the case A. The seat or opening in the case A, which is closed by the cover R, is large enough to admit the insertion of the disk B′ on the shaft B, so that to get access to the chamber P it is only necessary to remove the cover R and disk B′.

The steam-pipe G is screwed into the center of the cover Q and communicates with the steam-chest L through the medium of a hollow or bore *m* in the shaft M and lateral openings *n n* therein, as shown in Fig. 2. The space within the casing A exterior to the cylinder-casting constitutes an exhaust-space, into which the exhaust-steam is admitted from the ports *f f*, and from which it escapes by the exhaust-pipe H, which may be applied at any convenient point.

The steam-chest L is packed, in order to prevent escape of steam through the bearings *i* and *j* by means of diaphragm packings as best shown in Fig. 5. These packings consist each of a ring *p*, a diaphragm *q*, and a ring *r*. The smaller ring *p* is brazed or otherwise fastened with a steam-tight joint to the inner margin of the annular diaphragm *q*, and the outer margin of the diaphragm is fastened against the inner wall of the steam-chamber L through the medium of the ring *r*, which is placed against it, and screws or bolts which are passed through this ring and screw into the wall of the chamber. Thus the packing turns with the cylinder-casting. The inner ring *p* bears against the stationary surface or face *s* just inside of the bearing-joint *i* or *j*, so that this joint comes between the two rings, and leakage of steam through this joint is prevented by the ring *p* being pressed against the face *s* by the steam-pressure within the steam-chamber L acting against the diaphragm *q*. The tightness of the packing is thus proportional to the pressure of the steam, and any wear between the ring *p* and the face *s* is taken up by the yielding of the diaphragm.

In order to enable the packings to be applied within the chamber L, the latter is constructed with an annular cover or plate T, which, when removed, affords an opening large enough to insert the packings, and also enables the eccentric to be entered. The inner packing (shown at the right) in Fig. 2 is first inserted and fastened in place, and the outer packing is applied to the cover T, which is put in place on the shaft M, after which the shaft is thrust into the steam-chamber until the cover T comes into place, whereupon the latter is fastened to the cylinder-casting by screws inserted through a hand-hole, closed by a cap Q′. The crank-disk N is inserted into the chamber P from the opposite side, and afterward bolted to the end of the shaft M. The chamber P is subsequently closed by screwing on the disk B′, after which the cylinders are thrust into the casing A from the left, the shaft B being passed into the bearing R′ and the cover Q being screwed to the case. A belt-pulley S may subsequently be fastened on the projecting end of the shaft, if desired.

It is not necessary that the cylinder-casting I be made all in one piece. For convenience of construction it may be preferable to make it of several pieces, which will be fitted together and united subsequently in such manner as to be substantially integral.

The construction by which the four pitmen E E embrace the one crank-stud F is a novel one. Each pitman is formed with an eye for engaging the crank, these eyes being differently formed in the four pitmen. The middle one has a single eye. (Shown at t' in Fig. 5.) This eye is embraced between two eyes t^2 t^2, formed on the forked end of another of the pitmen. Outside of these come eyes t^3 t^3, formed on the forked end of a third pitman. The fourth pitman has its forked ends formed with eyes t^4 t^4, still farther apart, and which embrace the eyes of all the other pitmen between them. Thus the thrust of each of the pitmen is so divided or balanced as to be substantially in the center of the crank-pin. The pitmen-eyes do not engage the crank-pin directly, but engage a bushing *u*, which fits over the crank-pin and which is united to one of the pitmen by a flange on its outer end, through which screws are passed into one of the eyes t^4, as shown in Fig. 2, so that this bushing is caused to turn on the crank-stud coincidently with the pitman having the widest branched end. The eyes of the other pitmen turn upon this sleeve with an oscillatory motion equal in extent to the angular deflection of the pitmen. This construction makes a better connection than if each of the pitmen separately grasped the crank-stud, since the wear due to their oscillatory movement comes upon the bushing *u* instead of upon the crank-pin, and since their thrust is distributed through the bushing over the entire surface of the crank-pin. Furthermore, the centrifugal tendency of the pistons is equalized in its effect upon the crank, since their outward pull is directed against the bushing, against which those on opposite sides pull in opposite directions, and consequently only the resultant pressures due to the action of the steam upon the pistons are transmitted to the crank-stud.

A similar construction is applied to the eccentric-straps *c c*. One of these straps is formed integrally with a bushing *u′*, of a width equal to that of the working-face of the eccentric, and the other three eccentric-straps play upon the exterior of this bushing, oscillating thereagainst according to the angular play of the eccentric-rods. This construction has the same advantage as that just described with reference to the crank-stud connection.

Figs. 2 and 5 show means for lubricating the engine. v in Fig. 2 is an ordinary oil-cup for lubricating the bearing of the shaft B. For lubricating the internal bearings which are subject to steam-pressure, I provide a lubricator U, of ordinary construction, wherein by the condensation of steam admitted from the steam-pipe G the oil is forced up through a sight-feed and conducted through suitable ducts to the respective bearings. The lubricator U is connected to the steam-pipe G by a coiled pipe w, which affords an extensive radiating-surface in order to cool and condense the steam, the water of condensation from which enters the bottom of the oil-chamber, as is usual in lubricating devices of this character, and forces the oil out from the upper part of said chamber through the sight-feed. I employ three sight-feeds, the one of which at the left opens directly into the steam-pipe G, in order to supply oil to the valves and pistons, the middle one of which connects with a pipe or duct a, which lubricates the crank-stud and the bearing j, and the right-hand one of which connects with a pipe or duct l, which lubricates the eccentric and the bearing i. As shown in Fig. 5, the duct a consists of a small pipe connecting at one end with the sight-feed, and at the other end to the solid portion of the shaft M, and a bore or channel extending thence through the shaft M and through the crank-disk N into the crank-stud F, in which it branches laterally and terminates at the bearing-surface of this stud, another branch leading to the bearing j. The sleeve u has perforations through it to conduct the oil to the bearing-surfaces of the pitmen-eyes. The duct l consists of a small pipe, connecting at one end with the right-hand sight-feed and at the other end to the solid portion of the shaft M, and a bore or channel extending thence into the shaft and laterally to and into the eccentric J, and terminating at the bearing-face thereof. The sleeve u' has oil-perforations through it to conduct the oil to the bearing-surfaces of the eccentric-straps. The duct-pipe l has a branch leading to the bearing i. Thus the oil is supplied to all the bearing-surfaces, and its supply is under control through the medium of the usual adjusting-screws of the sight-feeds.

The cylinder-casting I is made, preferably, with tie portions or braces I′, extending from the outer end of each cylinder to the outer ends of the adjacent cylinders, in order to stiffen and strengthen the structure. This casting should be perfectly balanced, in order that the rotation of the engine may be unaccompanied by vibration and free from centrifugal strain upon the bearings. Inasmuch as it is difficult to maintain a perfect balance of weight in the construction and finishing of a casting, I provide means by which the parts may be balanced in the subsequent putting together of the engine. For this purpose I provide four or other suitable number of radial screws J′, on which are placed counter-weights W W, which may be adjusted inwardly or outwardly upon the screws and fastened in place thereon by set-nuts, as shown. By the proper adjustment of these weights a perfect balance of the engine may be secured.

I have not illustrated any reversing-gear for my engine, as engines of this character will not ordinarily need to be reversible, and as any ordinary or known constructions of reversing-gear may be readily applied to it by simple mechanical adaptation and without necessarily involving the exercise of invention, or the engine may be reversed by reversing the direction of the flow of steam through it—that is to say, by causing the steam to enter at the pipe H and to escape at the pipe G—the means for accomplishing which are so obvious as to require no description.

My improved engine may have more or less than four cylinders and pistons. In Fig. 7 I have shown an engine constructed with three cylinders radiating equidistantly from the center of rotation, and in Fig. 8 I have shown an engine having only two cylinders arranged on diametrically-opposite sides of the center of rotation. This latter construction, however, I do not recommend, as the balance of the pistons will not be as perfect as in a three or four cylinder engine, and for the further reason that if the pistons are single-acting two dead-points are formed.

My improved engine may be modified in various ways without departing from its essential features—as, for example, by the substitution of other well-known types of valve-operating mechanisms or valve-gears for the particular valve-gear which I have shown. Any known type of automatic variable cut-off, or other type of governor, may also be applied to it.

I claim as my invention the hereinbefore-described improvements in steam or other engines and other analogous machines, defined, respectively, as follows, substantially as hereinbefore specified, namely:

1. An engine constructed with a plurality of cylinders arranged radially around a common axis, with an equal number of valve-chests having ports communicating with said cylinders, and with a concentric revolving steam-chest between said valve-chests, in combination with an axial rotative shaft on which said cylinders and valve-chests are mounted, a crank arranged eccentrically to said axis, pistons in said cylinders, pitmen engaging said crank and connecting with said pistons, valves in said valve-chests, a valve-gear for moving said valves, and a steam-inlet communicating with said concentric steam-chest.

2. An engine constructed with a plurality of cylinders arranged radially around a common axis, and with an equal number of radially-arranged valve-chests having ports communicating with said cylinders, and a concentric revolving steam-chest between and communicating with said valve-chests, in combination with an axial rotative shaft on which said cylinders and valve-chests are mounted, pistons in said cylinders, pitmen engaging said crank and connecting with said pistons, balanced tubular piston-valves in said valve-chest, whereby the steam passes from said steam-chest through said valves to the cylinder-ports, and a valve-gear in said steam-chests for moving said valves.

3. In an engine, the combination of an inclosing-case, a stationary shaft, and a crank formed on said shaft, with a rotary shaft in line with the axis of said stationary shaft, a plurality of radially-arranged cylinders fixed to said rotative shaft and having a bearing upon said stationary shaft and formed with valve-chests having ports communicating with the cylinders, and a steam-chest concentrically embracing said stationary shaft, a steam-inlet passage through said stationary shaft opening into said steam-chest, valves in said valve-chests, and a valve-gear in said steam-chest for moving said valves.

4. In an engine, the combination of an inclosing-case, a stationary shaft, a crank formed on said shaft, and a steam-inlet passage through said shaft, with a rotary shaft in line with the axis of said stationary shaft, a plurality of radially-arranged cylinders fixed to said rotative shaft and formed with a steam-chest concentrically embracing and bearing on said stationary shaft, and into which said steam-inlet passage opens, pistons in said cylinders, pitmen engaging said stationary crank and connecting with said pistons, and packings applied at the bearing-joints between said steam-chest and stationary shaft to prevent escape of steam from said chest through said joints.

5. In a revolving-cylinder steam-engine, the combination of a relatively rotary shaft and steam-chamber, the one having rotative bearings upon the other and the one part formed with a face substantially perpendicular to the axis of rotation, with a packing for said bearings, consisting of a ring arranged concentrically against said perpendicular face, and an annular diaphragm fastened to said ring at one margin, bridging the bearing-joint to be packed, and fastened at its opposite margin to the other part, whereby the steam-pressure against said ring and diaphragm acts to press said ring against said perpendicular face.

6. In an engine, the combination of an inclosing-case constructed with a removable cover, and with a stationary shaft fixed to said cover, and a crank formed on said shaft, a rotary shaft in line with said stationary shaft, a plurality of radially-arranged cylinders fixed to said rotary shaft, pistons in said cylinders, and pitmen engaging said stationary crank and connecting with said pistons.

7. In an engine, the combination of a stationary shaft and a crank formed thereon, a rotary shaft in line with the axis of said stationary shaft, a plurality of radially-arranged cylinders fixed to said rotative shaft and formed with a steam-chest concentrically embracing and bearing on said stationary shaft, pistons in said cylinders, pitmen engaging said stationary crank and connecting with said pistons, a stationary eccentric fixed on said stationary shaft, valves for admitting steam from said steam-chest to said cylinders, and eccentric straps and rods connecting to said valves.

8. An engine constructed with a plurality of radially-arranged cylinders mounted to rotate around an axis, in combination with pistons in said cylinders, a crank arranged eccentrically to said axis, mechanical connections between said crank and said pistons, and one or more adjustable counter-weights applied to said cylinders, whereby the latter may be adjusted to a correct balance around the axis of rotation.

9. An engine constructed with a plurality of radially-arranged cylinders mounted to rotate around an axis, in combination with radial screws attached to said cylinders and adjustable counter-weights mounted on said screws and adjustable toward and from the axis of rotation.

In witness whereof I have hereunto signed my name in the presence of two subscribing witnesses.

MILAN W. HALL.

Witnesses:
ARTHUR C. FRASER,
GEORGE H. FRASER.