

No. 714,977.

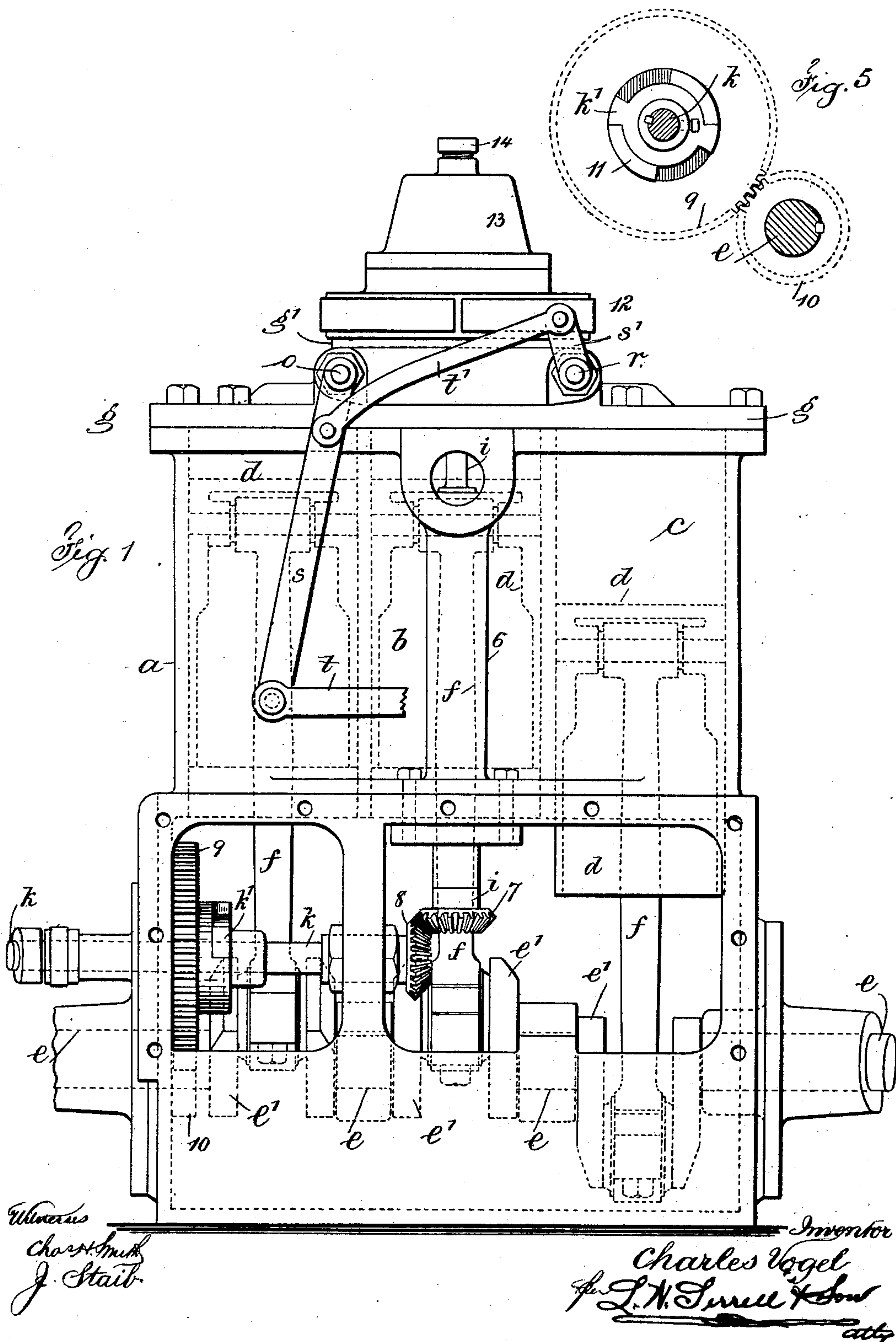
Patented Dec. 2, 1902.

C. VOGEL.
STEAM ENGINE.

(Application filed Feb. 10, 1902.)

(No Model.)

3 Sheets—Sheet 1.



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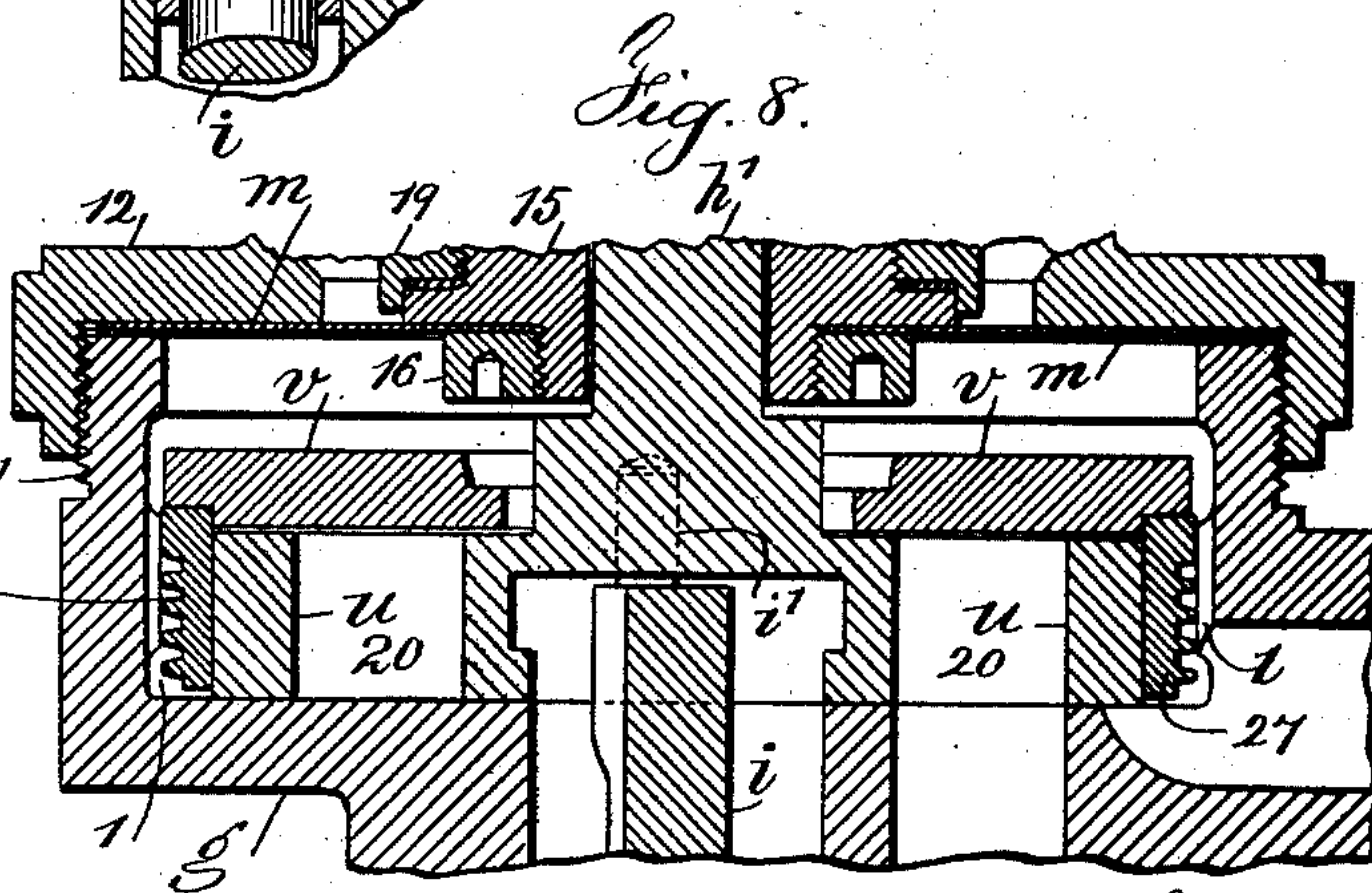
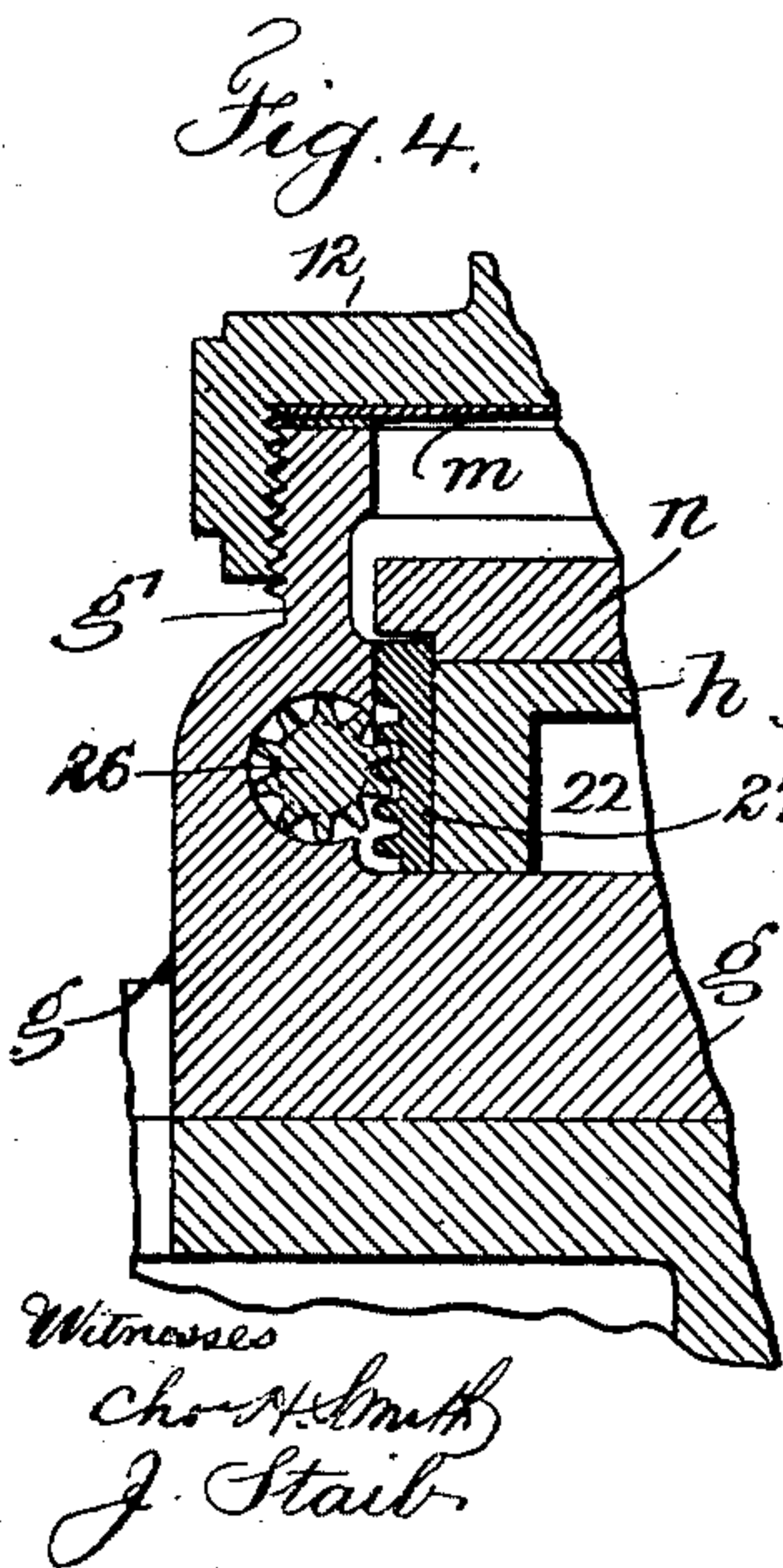
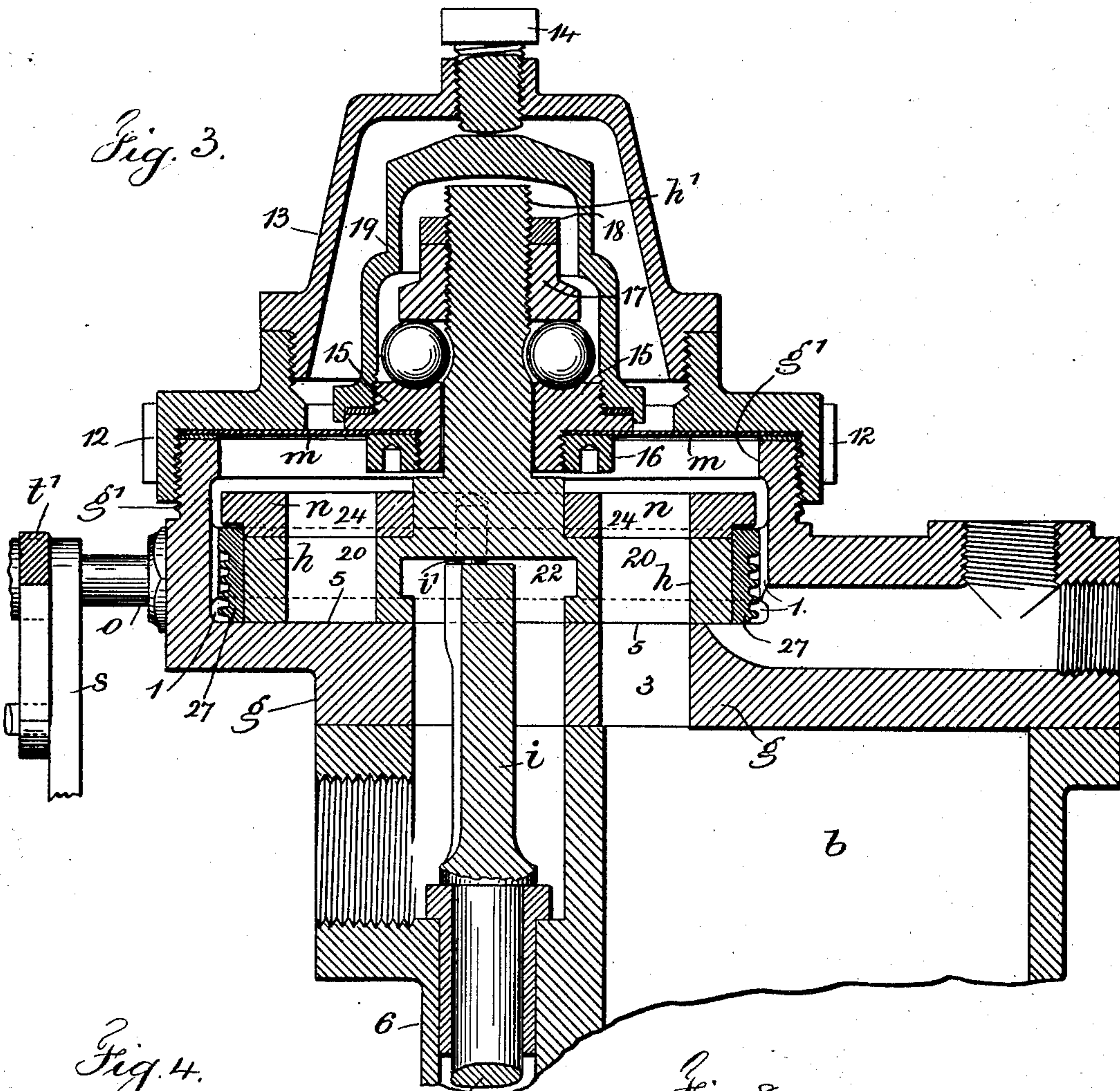
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3 Sheets—Sheet 3.



Inventor
Charles Vogel
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UNITED STATES PATENT OFFICE.

CHARLES VOGEL, OF FORT LEE, NEW JERSEY.

STEAM-ENGINE.

SPECIFICATION forming part of Letters Patent No. 714,977, dated December 2, 1902.

Application filed February 10, 1902. Serial No. 93,294. (No model.)

To all whom it may concern:

Be it known that I, CHARLES VOGEL, a citizen of the United States, residing at Fort Lee, in the county of Bergen and State of New Jersey, have invented an Improvement in Steam-Engines, of which the following is a specification.

My invention relates to improvements in steam-engines and valves therefor, such as have heretofore been employed by me, and especially to an improvement upon the device shown and described in Letters Patent granted to me April 11, 1893, No. 495,282. In the device shown in said patent there is a cut-off employed, but no means for moving the valve to reverse or change the direction of movement of the engine. The devices of the present improvement are applicable to stationary engines with or without the capacity for reversing the movement thereof, and also to engines employed for automobiles and yachts and similar devices requiring power and in which there is the capacity for quickly reversing the engine.

My present improvement relates, essentially, to means for changing the direction of motion or reversing the engine, to means for lifting the cut-off or disk so as to facilitate the starting of the engine, and to a balanced antifriction-valve structure. The main shaft of the engine or prime mover may be provided with a pulley and gear, a sprocket or suitable connection therefrom to the device to be actuated by said engine or prime mover, and this shaft is connected, preferably, by a gear to a gear upon an auxiliary shaft parallel therewith and which gear carries a clutch, the shaft also carrying a part of the clutch, so that to this shaft is imparted from the main shaft a rotation which through intermediate devices causes the rotation of the circular disk valve of the engine. If in starting the engine it happens that the ports in the engine-head and the ports in the valve do not aline and the engine cannot be started by simply opening the steam-supply, I provide devices for lifting the cut-off or disk, so that steam may be admitted between the juxtaposed surfaces of the cut-off or disk and valve to thereafter pass through the ports of the valve that may be open to the ports of the engine-cylinders for the admission of

steam in starting the engine, and the means for performing this operation may be actuated by the engine-governor or by a hand-operated lever or similar device, and I provide devices surrounding and connected to the valve-stem and at the side of the stem-chest opposite to the valve having an antifriction character and a surface for steam-pressure of appreciably less area than the surface of the valve or cut-off, so that the balance of pressure may be slightly in favor of keeping the valve to its seat, the structure employed being of such character that the valve may be readily turned regardless of the pressure thereon, all of which devices are hereinafter more particularly set forth.

In the drawings, Figure 1 is an elevation representing my improvement. Fig. 2 is a plan with the parts above the steam-chest rim removed and with the cut-off and the valve removed from the steam-chest. Fig. 3 is a vertical section through the valve, cut-off, and adjacent parts at the upper end of the steam-cylinders and at right angles to the elevation, Fig. 1. Fig. 4 is a vertical section of part of the devices shown in Fig. 3 and at right angles to the same. Fig. 5 is a cross-section through the main and adjacent parallel shafts, showing the clutch mechanism and the connecting-gears. Fig. 6 is a plan of the cut-off with parts of the valve showing beneath the same. Fig. 7 is an inverted plan of the disk valve with part of the cut-off shown back of the same. Fig. 8 is a partial vertical section in the same relation of parts as Fig. 3, but showing a modified structure. Fig. 9 is a plan of the disk valve of the modified structure, and Fig. 10 a plan of the cut-off of the modified structure. Figs. 3, 4, and 8 are on the same scale and upon a larger scale than the devices of the other figures for clearness in showing the details.

The three steam-cylinders *a b c* are preferably made integral and mounted upon a suitable base or frame. These steam-cylinders are each provided with a piston *d*, and connecting-rods *f* extend from the pistons *d* to cranks *e'*, formed upon the main shaft *e* at one hundred and twenty degrees apart. The main shaft *e* is in suitable bearings upon the said frame, and there is also in the said frame a bearing for the shaft *k*. I provide a head *g*,

common to all the cylinders, with which is formed a rim g' as a boundary to the steam-chest, and a valve-seat 5 in substantially the same plane as the top of the head g and in which head and through the valve-seat are ports 2 3 4 to the respective cylinders, the ports 2 and 3 being through inclined portions of the head and the port 3 directly to the cylinder beneath the same.

10 I employ a disk valve h of circular form and of even thickness, and the same is provided with a valve-stem h' . The valve h is formed with the necessary ports for the passage of steam and for the exhaust, and these ports are located in such relation to the ports 2 3 4 that steam will be admitted to the cylinders in succession and the exhaust will be opened at the end of the stroke of each piston, and I provide around the disk valve and in the interior surface of the part of the head forming the steam-chest annular and vertical steamways 1, the annular way being adjacent to the seat 5 and the vertical ways communicating therefrom to the steam-chest above the valve, the said head g being formed with an aperture, to which is connected the steam-pipe and with a passage therefrom to the steam-chest aperture.

I employ a valve-moving spindle i within the case 6, which is advantageously cast with the steam-cylinders and forms a passage for the exhaust, the said case being provided with a stuffing box and bearing, through which the said valve-moving spindle i passes. At the upper end of this spindle i there are pins i' , spaced apart and entering holes in the under surface of the disk valve h to connect the valve and spindle. The shaft k in bearings in the frame is parallel with the main shaft e , and I employ bevel-gears 7 and 8, one on the lower end of the valve-moving spindle i and the other on one end of the shaft k , and upon this shaft k is secured a clutch k' . There is a large gear 9 loose on the shaft k and a smaller gear 10 fixed on the main shaft e , and these gears are preferably in the proportion of two to one.

The hub 11 of the gear 9 is axially notched or recessed to receive parts of the clutch k' , the notches being substantially of the same width as the parts of the hub between the same, so that the said hub 11 is practically divided into two parts, thus providing for an appreciable amount of movement of the clutch with reference to the gear, and on the end of the shaft k is a hand-wheel l for turning the shaft, the clutch, the bevel-gears 7 8, and the valve-moving spindle i , and thereby the valve h , with which the spindle is engaged and hereinafter more particularly described.

The exterior of the rim g' is screw-threaded, and I provide an annular cover 12, screwing thereon, and an auxiliary cover 13, connected to the cover 12, and a set-screw 14 in the center of said covers, the position of which limits the endwise movements of parts hereinafter described, so as to prevent excessive steam

or other pressure moving the parts to such extent as to cause injury. The valve-stem h' projects up within these covers, and around said stem is a ball-race 15, having a curved seat for a row of antifriction-balls. (See Fig. 3.) The end of the stem is threaded, and screwing thereon is an adjustable ball-race 17, held by a lock-nut 18 and bearing upon the row of balls. A diaphragm m is provided with a central aperture for the lower portion of the ball-race 15, and the same is held in connection with said ball-race by a nut 16. The outer portion of said diaphragm m comes against the under surface of the cover 12 and in diameter agrees substantially with the rim g' , so that the edge of the diaphragm comes between the cover 12 and the upper surface of said rim, and said diaphragm is clamped by the screwing down of the cover 12 upon the rim g' , at which place there is preferably an intervening packing to form a steam-tight joint. I provide a cap 19 within said covers extending over the ball-races and row of balls and screwing down upon the ball-race 15 with an intervening packing and forming a steam-tight cap or closure.

The disk valve h (see especially Fig. 7) is provided with three radial adjacent ports in groups at opposite sides, and between these ports and also in the central portion of the said disk valve there is a chamber 22, formed in the under surface for the exhaust-steam from the steam-cylinders, communicating simultaneously with said cylinders and the exhaust-chamber in the case 6 with the rotation of the said disk valve. The ports 20 of these groups are the steam-ports in the rotation of the valve h in the direction of the arrow, and the ports 21 of these groups are the steam-ports during the reverse movement in the other direction, while the intermediate ports are only employed as possible steam-ports in starting the engine. A cut-off disk n of circular form and also of even thickness lies upon the disk valve h , and this is provided with slots at opposite points for the pins 23, rising from the valve h , and also with radial ports 24 and 25 in groups of two each at opposite sides of the center of said cut-off. The disk valve h and the cut-off n are thus connected and move together by virtue of the rotation of the valve-moving spindle i as actuated by the gears 7 and 8, shaft k , clutch k' , and gears 9 and 10 from the main shaft e , the said cut-off being carried around with the valve by the pins 23 and the relation of the valve and cut-off being maintained by the position of the pins 23 in the ends of the slots in the cut-off disk.

I provide parallel shafts o r in the head g at opposite sides of the steam-chest. (See especially Figs. 1, 2, 3, and 4.) The inner ends of these shafts are provided with or formed as pinions 26, open to the steam-chest. Consequently stuffing-boxes are provided where said shafts emerge from the head g . Upon the shaft o is a rocker-arm s , to the free

end of which is secured a connecting-rod *t*. On the shaft *r* is a short rocker-arm *s'*, and this rocker-arm *s'* is connected to the rocker-arm *s* by a link *t'*, and the pivotal center of the link *t'* with the rocker-arm *s* is of the same distance from the center of the shaft *o* as the length of the short rocker-arm *s'* from the center of the shaft *r* to the center of its pivotal connection with the link *t'*. Consequently when the connecting-rod *t* and the rocker-arm *s* are actuated a simultaneous movement of exactly the same extent is imparted to the shaft *r* as is imparted to the shaft *o*, but in the opposite direction. This connecting-rod *t* may, in a non-reversible engine, extend to connection with the governor, and in a reversible engine the same extends to the lever of automatic control or to a lever actuated by the motorman of an automobile or other device.

I provide a circular rack 27, surrounding the disk valve *h*, the same being slightly deeper than said disk valve and extending slightly above the same into the offset lower corner of the cut-off disk *n*, and the toothed surface of said circular rack meshes with the pinions 26 on the inner ends of the parallel shafts *o* *r*.

In the operation of the device the main shaft *e* actuates the gears 9 10, revolves the shaft *k*, the clutch *k'*, the bevel-gears 7 8, the valve-moving spindle *i*, and by the pins *i'* of said spindle rotates the disk valve *h* and the cut-off disk *n* together and at the same speed, and the reversal of the direction of movement is effected by the hand-wheel *l* turning the shaft *k*, swinging the clutch *k'* to a position opposite to that previously occupied by the clutch, and in so doing the spindle *i'* is turned, and the valve is moved independent of the cut-off disk, bringing the pins 23 to the opposite end of the slots in the cut-off disk, changing the relation of the ports in the disk to the ports in the valve and the relation of the ports in the valve to the ports 2 3 4 in the valve-seat, so that different ports aline from those that had previously alined in the direction of movement of the engine, and so effecting a reversal of the direction of rotation. The steam passes from the entrance in the head through the annular and vertical ways 1 up around the disk valve and cut-off disk to the space between the cut-off disk and the diaphragm. The area of pressure of the steam upon the diaphragm within the open center of the cover 12 is less than the area exposed to pressure of the cut-off disk. Consequently while there is an upward pressure against the diaphragm there is a greater downward pressure tending to keep the disk and valve in their respective places and the valve against its seat 5, these opposite pressures tending to separate the parts, as it were, are compensated, so far as the upward pressure is concerned, by the connection between the diaphragm and the valve-spindle, there being at this point a group of devices,

as hereinbefore described, effecting a rigid relation of the respective parts in which the row of antifriction-balls and the ball-races permit the valve and its stem to turn readily and freely regardless of the pressure being exerted.

In the relation of the cut-off disk and the disk valve, as shown in Figs. 6 and 7, the direction of rotation is indicated by the arrow, and it will appear that steam passes through the coinciding ports of the cut-off and valve progressively to the ports 2, 3, and 4 with the simultaneous rotation of the cut-off and valve and exhausts from the ports 2, 3, and 4 into the chamber 22 as the same comes over the said ports in the rotation of the valve and cut-off.

It will be further noticed that the ports 20 in the valve and 24 in the cut-off disk coincide and are of small area in proportion to the ports 2 3 4 in the valve-seat, thus not only regulating the amount of steam admitted, but requiring an appreciable travel of the said alining ports between the ports 2, 3, and 4 from the supply of one cylinder to the supply of the next, consequently shutting off the steam from the one and giving the same an opportunity to expand in doing its work prior to supplying steam to the adjacent cylinder, and so on progressively.

In effecting the reversal of the engine and by referring to Figs. 6 and 7 it will be noticed that the upper right-hand and lower left-hand ports 24 24 of the cut-off disk coincide with ports 20 20 of the disk valve, so that steam passes through these ports to enter the ports 2, 3, and 4 in the valve-seat, and that when the reversal is effected and the relation of the cut-off disk and disk valve altered these ports no longer aline, but instead the upper right-hand and lower left-hand ports 25 25 of the cut-off disk *n* then aline with the ports 21 21 in the groups of the disk valve *h*, thus admitting steam to a piston in a different position and progressively so with the rotation of the ports in effecting the reversal.

In stopping the engine it may happen that the coinciding ports of the disk and valve come intermediate to the ports 2, 3, and 4. Consequently in starting again steam cannot pass to either of the cylinders *a b c*, and to start without shifting the valve by hand and without changing the position of the motorman or engineer so as to reach the hand-wheel *l* and continue therefrom the rotation of the valve and cut-off disk the parallel shafts and devices connected therewith are provided, the movement of which raises the circular rack 27 and therefrom the cut-off disk *n*, separating the contacting faces of the cut-off disk and the disk valve, so that steam passing through the ports of the cut-off disk passes between the same and the valve and through any ports of the valve and alining ports 2 3 4 to a cylinder, so as to thereby start the movement of one or more of the pistons *d*. As soon as the start is effected the cut-off disk through the

intervention of the devices that raised the same is then lowered to its seat and contacts with the disk valve *h*, and the movements proceed as hereinbefore described. This movement is effected without changing the relation of the valve and cut-off.

The modified structure shown in Figs. 8 & 9 10 has special reference to a stationary engine without reversing means, and parts so far as they herein are similar to parts hereinbefore described bear the same letters of reference. In this modified form the disk valve *u* is provided with ports 28 and 29 at opposite sides of the center and which in area 15 substantially agree with the area of the ports 2, 3, and 4. *v* represents the cut-off disk, resting upon and supported by the circular rack 27, surrounding the disk valve *u* and in a state of rest maintained at a slight elevation above the upper surface of the disk valve *u*. The cut-off *v* surrounds the valve-spindle *u'*; but the open center thereof is of larger diameter than the valve-spindle, so that there is an appreciable annular space 25 between the valve-spindle and the center of the said cut-off disk. Consequently the steam in the steam-chest passes between the valve-spindle and the center of the cut-off *v* and between the adjacent surfaces of the cut-off 30 disk *v* and the upper surface of the disk valve *u* into the ports 28 and 29 in the operation of the engine.

The parts, as shown in the drawings, are in a state of rest. The cut-off disk *v* is maintained at the proper height, according to the load on the engine, and by the action of the governor upon the devices turning the shafts *o r* and pinions thereon, and so raising and lowering the circular rack 27 in proportion to 40 the speed, and so controlling the aperture for the passage of steam. This disk *v* is raised and lowered by means of the circular rack 27, shafts *o r*, rocker-arms *s s'*, link *t'*, and connecting-rod *t*, the same as hereinbefore described with reference to the cut-off disk *n*. 45 The disk valve *u*, as indicated in Fig. 9 by dotted lines, is provided with a chamber 22 in the under side for exhausting the steam, similar to that shown with reference to the 50 disk valve *h*.

I claim as my invention—

1. The combination in an engine with a main cylinder a disk valve having ports and means for imparting a rotary movement thereto and a steam-chest surrounding the valve, of a disk occupying a position above the disk valve, means for admitting steam past the disk and through the ports of the disk valve, and means for raising the said 60 disk above the valve to separate their juxtaposed faces and permit the entrance of steam between said faces to pass through any of the ports of the valve, substantially as and for the purposes set forth.

65 2. The combination in an engine with a main cylinder a disk valve having ports and means for imparting a rotary movement

thereto and a steam-chest surrounding the valve, of a disk occupying a position above the disk valve, means for admitting steam 70 past the disk and through the ports of the disk valve, and a rack device surrounding the valve and upon which said disk bears, pinions at opposite points of the said rack device and means for turning the said pinions 75 in opposite directions to simultaneously elevate the rack device at said opposite points to separate the juxtaposed faces of the disk and valve to permit the entrance of steam between the same, substantially as and for 80 the purposes set forth.

3. The combination in an engine with a main cylinder a disk valve having ports and means for imparting a rotary movement thereto and a steam-chest surrounding the 85 valve, of a disk occupying a position above the disk valve, means for admitting steam past the disk and through the ports of the disk valve, a circular rack surrounding the disk valve, within the steam-chest and slightly 90 deeper than the valve and upon which the said disk rests, parallel shafts and bearings therefor at opposite sides of said circular rack, pinions upon said shafts, within the steam-chest meshing with the rack at opposite 95 points, and devices connecting the said shafts, and means for actuating the same in opposite directions and to equal extent for simultaneously raising the circular rack and the disk to separate the juxtaposed surfaces 100 of the disk and valve, substantially as and for the purposes set forth.

4. The combination in an engine with a main cylinder a disk valve having ports and means for imparting a rotary movement there- 105 to and a steam-chest surrounding the valve, of a disk occupying a position above the disk valve, means for admitting steam past the disk and through the ports of the disk valve, a circular rack surrounding the disk valve 110 within the steam-chest and slightly deeper than the valve and upon which the said disk rests, parallel shafts and bearings therefor at opposite sides of said circular rack, pinions upon said shafts within the steam-chest mesh- 115 ing with the rack at opposite points, a rocker-arm connected to one of said parallel shafts and a connecting-rod therefrom, a short rocker-arm on the other parallel shaft, a link pivoted to the short rocker-arm at one end 120 and at the other end to the aforesaid rocker-arm and the length between pivot centers of the shaft and link over the short rocker-arm agreeing with the distance between the center of the other shaft and the pivotal connection of the said link with the aforesaid rocker- 125 arm so as to impart opposite movements of equal extent to the said parallel shafts and the pinions carried thereby, substantially as and for the purposes set forth. 130

5. In an engine, the combination with a main cylinder a disk valve having therein at opposite points groups of ports for steam and a steam-chest surrounding the valve, of a cut-

off disk above the same and having therein and at opposite points groups of ports for steam, means connecting the disk valve and the cut-off disk and determining the relations thereof, devices for rotating the disk valve and by the aforesaid means simultaneously rotating the cut-off disk, substantially as set forth.

6. In an engine, the combination with a main cylinder a disk valve having therein at opposite points groups of ports for steam and a steam-chest surrounding the valve, of a cut-off disk above the same and having therein and at opposite points groups of ports for steam, means connecting the disk valve and the cut-off disk and determining the relations thereof, devices for rotating the disk valve and by the aforesaid means simultaneously rotating the cut-off disk, and means for raising the cut-off disk above the disk valve and separating the juxtaposed surfaces thereof without disturbing the rotary relation of the disk and valve, substantially as set forth.

7. In an engine, the combination with a main cylinder a disk valve having therein at opposite points groups of ports for steam and a steam-chest surrounding the valve, of a cut-off disk above the same and having therein and at opposite points groups of ports for steam, means connecting the disk valve and the cut-off disk and determining the relations thereof, devices for rotating the disk valve and by the aforesaid means simultaneously rotating the cut-off disk, and means connected to the devices or means for simultaneously rotating the disk valve and cut-off disk and by which a reversal of the relation of the same is effected, substantially as set forth.

8. In an engine, the combination with a main cylinder a disk valve having therein at opposite points groups of ports for steam and a steam-chest surrounding the valve, of a cut-off disk above the same and having therein and at opposite points groups of ports for steam, means connecting the disk valve and the cut-off disk and determining the relations thereof, devices for rotating the disk valve and by the aforesaid means simultaneously rotating the cut-off disk, a circular rack surrounding the disk valve within the steam-chest and deeper than the said valve so as to set up into the offset edge of the cut-off disk, parallel shafts passing into the steam-chest at opposite sides of the circular rack, pinions connected with said shafts within the steam-chest and meshing with the circular rack, and means connecting said shafts and connected to one of said shafts whereby said shafts are simultaneously rotated in opposite direction to an equal amount and the circular rack is raised to elevate the cut-off disk above the disk valve and separate the juxtaposed surfaces thereof, substantially as and for the purposes set forth.

9. In an engine, the combination with a

main cylinder a circular disk valve having ports for steam, and a chamber in the under side for the exhaust and a steam-chest surrounding the valve, of a valve-moving spindle, pins on the upper ends thereof entering holes in the valve and connecting the parts, a main shaft and a shaft parallel thereto, gears connecting the shafts, a connection from the parallel shaft to the valve-moving spindle whereby the parts may be actuated by the main shaft and the connecting-gears, and a clutch fast upon the parallel shaft engaging the hub of the gear loose thereon, whereby the rotation of the circular disk valve is effected and its reversal may be effected by shifting the clutch by hand, substantially as set forth.

10. In an engine, the combination with a main cylinder a circular disk valve having ports for steam and a chamber in the under side for the exhaust and a steam-chest surrounding the valve, of a valve-moving spindle, pins on the upper ends thereof entering holes in the valve and connecting the parts, a cut-off disk above the circular disk valve also having ports for steam and slots at opposite points in the said cut-off disk, and pins in the circular valve passing up into said slots, a main shaft and a shaft parallel thereto, gears connecting the shafts, a connection from the parallel shaft to the valve-moving spindle whereby the parts may be actuated by the main shaft and the connecting-gears, and a clutch fast upon the parallel shaft engaging the hub of the gear loose thereon, whereby the rotation of the circular disk valve is effected and its reversal may be effected and the relation of the cut-off disk thereto altered by shifting the clutch by hand, substantially as set forth.

11. In an engine, the combination with a main cylinder a circular disk valve, its valve-stem, means for rotating the same, a steam-chest surrounding the valve, a disk or cut-off above the valve and a surrounding rim of the case forming a steam-chest, of a cover device secured to said rim, a diaphragm interposed between the rim and the cover device, and means substantially as shown and described and connected respectively to the diaphragm and the valve-stem and constituting an anti-friction and valve-balanced structure, substantially as set forth.

12. In an engine, the combination with a main cylinder a circular disk valve, its valve-stem, means for rotating the same, a steam-chest surrounding the valve, a disk or cut-off above the valve and a surrounding rim of the case forming a steam-chest, of a cover device secured to said rim, a diaphragm interposed between the rim and the cover device, a ball-race freely surrounding the valve-stem, means for connecting the same to the diaphragm, a row of anti-friction-balls surrounding the valve-stem and adjustable devices secured to the valve-stem and bearing

thereon, and means for insuring a steam-tight inclosure over the valve-stem, substantially as set forth.

13. In an engine, the combination with a
5 main cylinder a circular disk valve, its valve-stem, means for rotating the same, a steam-chest surrounding the valve, a disk or cut-off above the valve and a surrounding rim of the case forming a steam-chest, of a cover
10 device secured to said rim, a diaphragm interposed between the rim and the cover device, a ball-race freely surrounding the valve-stem, a nut connected to the ball-race and for clamping the inner portion of the diaphragm
15 in a fixed relation thereto, a row of anti-friction-balls surrounding the valve-stem, an adjustable nut forming a second ball-race surrounding the valve-stem and bearing on the row of balls, a clamping-nut therefor and a
20 cap covering the said parts to form a steam-tight valve-stem closure, substantially as set forth.

14. In an engine, the combination with a main cylinder a circular disk valve having
25 ports for steam, a valve and stem rising therefrom, means for rotating the valve and stem, a steam-chest surrounding the valve, a disk or cut-off superimposed upon the circular valve, a circular rim of the case receiving said parts and forming the boundary of the steam-chest, a cover device screwing thereon the internal diameter of which is of a predetermined size, a diaphragm lying
30 next to the under surface of the cover above the valve and cut-off and clamped between the cover and the rim of the steam-chest, a device surrounding the valve-stem and secured to the central portion of the diaphragm, the parts being so proportioned that the exposed
35 portion of the diaphragm within the cover is of less area than the exposed portion of the cut-off or disk, whereby the balance of pressure is in favor of maintaining the valve upon its seat, substantially as set forth.

45 15. In an engine, the combination with

three steam-cylinders, a valve-seat and three ports in said seat opening into said cylinders, of a circular disk valve having a chamber in the under side thereof for the exhaust and having through the same at opposite points
50 groups of three ports each for steam to pass through the valve, a steam-chest surrounding the valve, and an overlying cut-off disk having through the same at opposite points groups of two ports each for steam to pass
55 through the same, the said ports of the groups of the cut-off being separated at a greater distance apart than the entire space occupied by the groups of three ports of the disk valve, and means for rotating the said circular valve
60 and cut-off, substantially as set forth.

16. In an engine, the combination with three steam-cylinders, a valve-seat and three ports in said seat opening into said cylinders, of a circular disk valve having a chamber in
65 the under side thereof for the exhaust and having through the same at opposite points groups of three ports each for steam to pass through the valve, a steam-chest surrounding the valve, and an overlying cut-off disk
70 having through the same at opposite points groups of two ports each for steam to pass through the same, the said ports of the groups of the cut-off being separated at a greater distance apart than the entire space occupied
75 by the groups of three ports of the disk valve, means for rotating the said circular valve and cut-off, and pins passing up into slots formed in the cut-off whereby the disk valve may be shifted in relation to the cut-off, the length of
80 the slots being equal to the distance between centers of adjacent ports in the circular valve-disk, substantially as and for the purposes set forth.

Signed by me this 5th day of February, 1902. 85

CHARLES VOGEL.

Witnesses:

GEO. T. PINCKNEY,
S. T. HAVILAND.