No. 774,502. PATENTED NOV. 8, 1904.

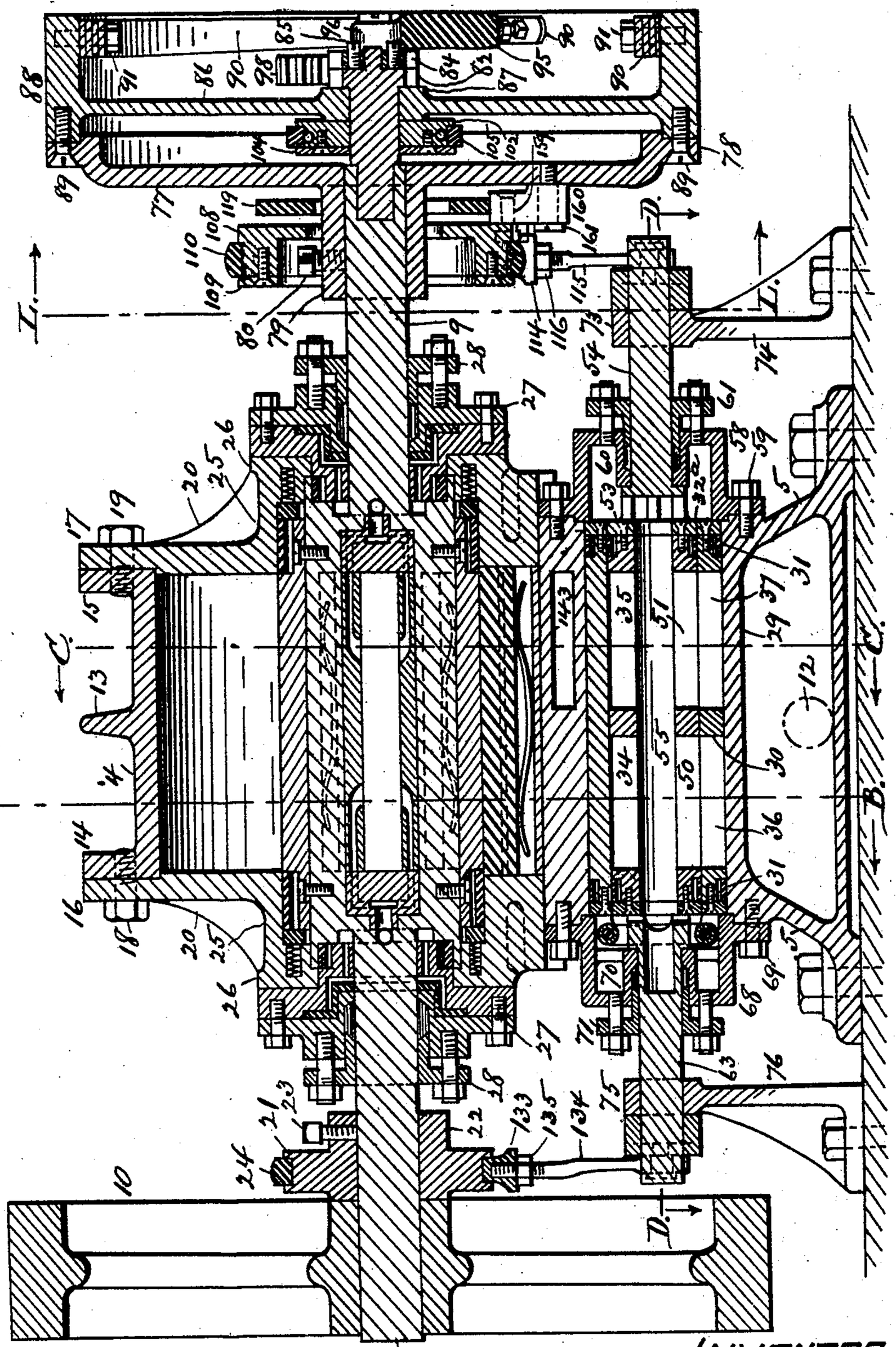
F. J. WATERS.

CUT-OFF VALVE FOR STEAM ENGINES.

APPLICATION FILED JUNE 3, 1903.

NO MODEL. 5 SHEETS—SHEET 1.

FIG. 1.



WITNESSES.

C. J. Flannigan.

Howard A. Lamprey

INVENTOR.

Frank J. Waters

by Warren R. Pierce

Attorney.

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NO MODEL. 5 SHEETS—SHEET 2.

FIG. 3.

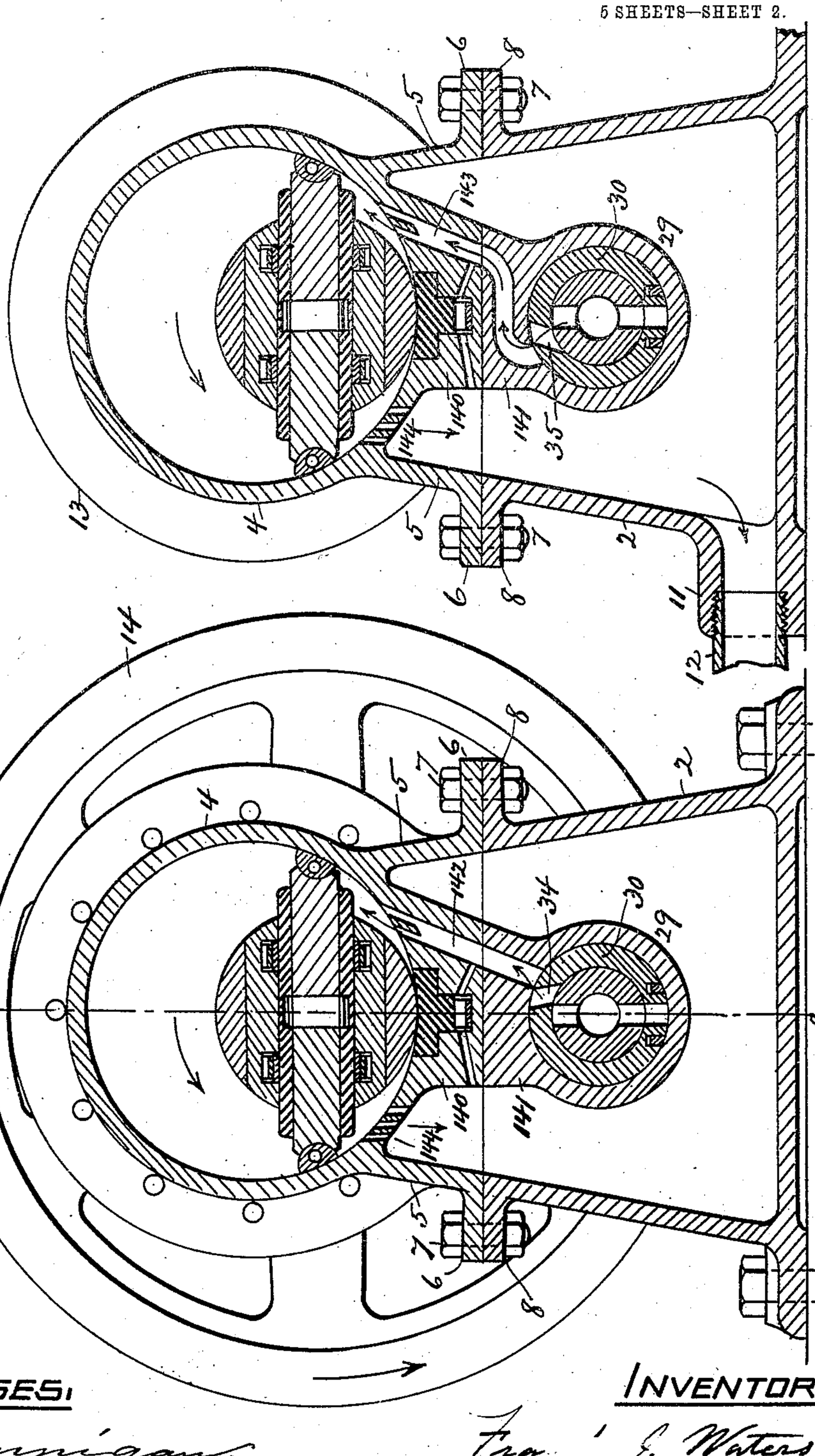

FIG. 2.

WITNESSES:

C. J. Flannigan.

Howard A. Lampfrey

INVENTOR.

Fred J. Waters

By Warren R. Pierce

Attorney.

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NO MODEL. 5 SHEETS—SHEET 3.

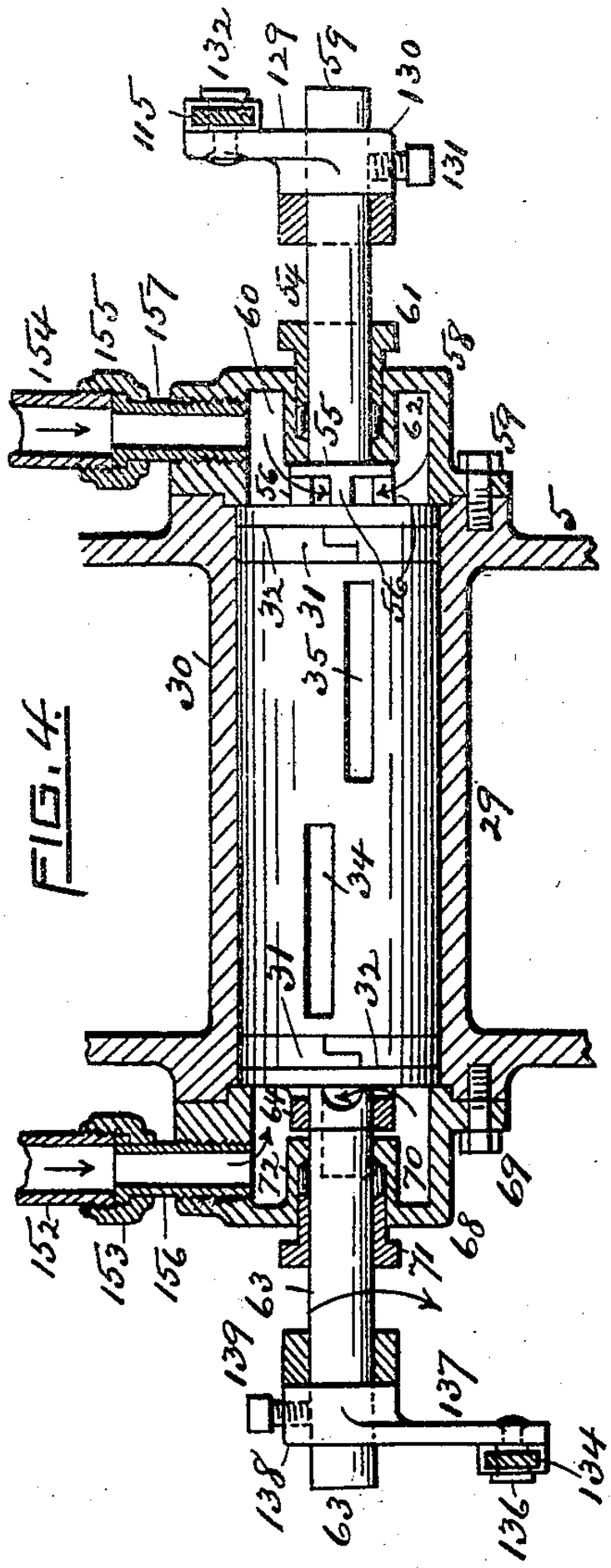

FIG. 4.

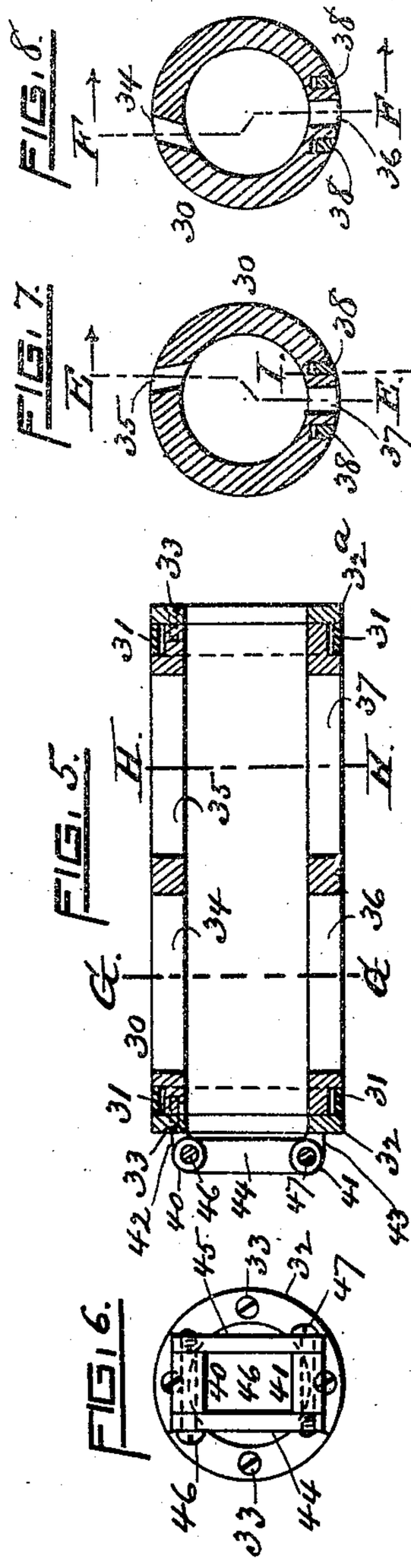

FIG. 5. FIG. 6.

FIG. 7.

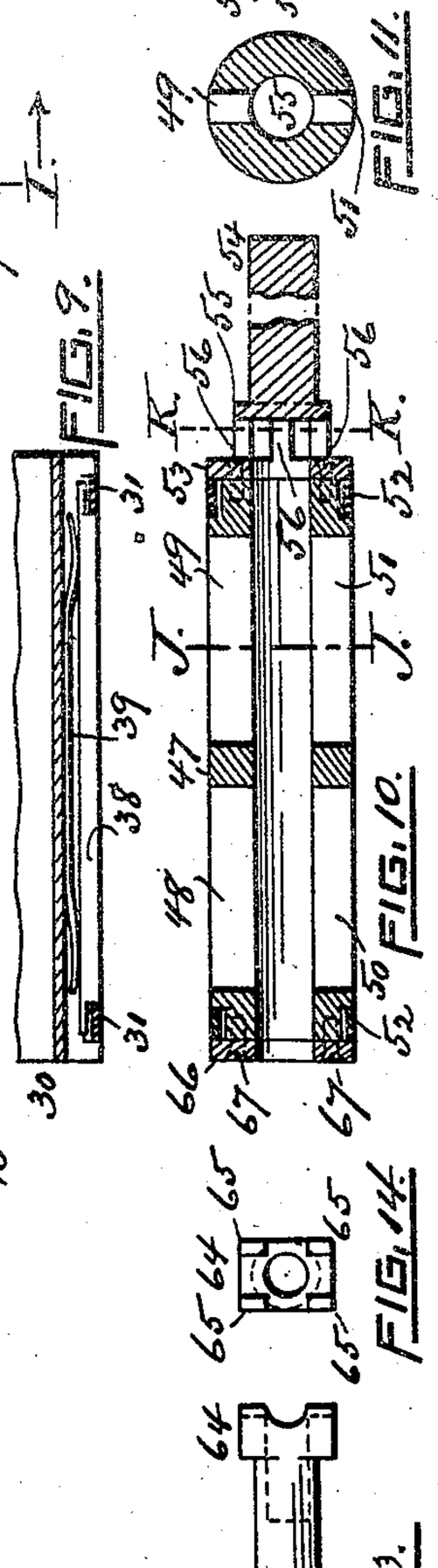

FIG. 9.

FIG. 10. FIG. 14.

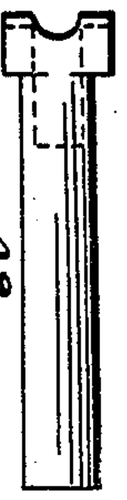

FIG. 13.

FIG. 11. FIG. 12.

WITNESSES,

C. F. Hannigan.

Howard A. Lahrey

INVENTOR,

Frank J. Waters

By Warren R. Pence

Attorney.

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F. J. WATERS.

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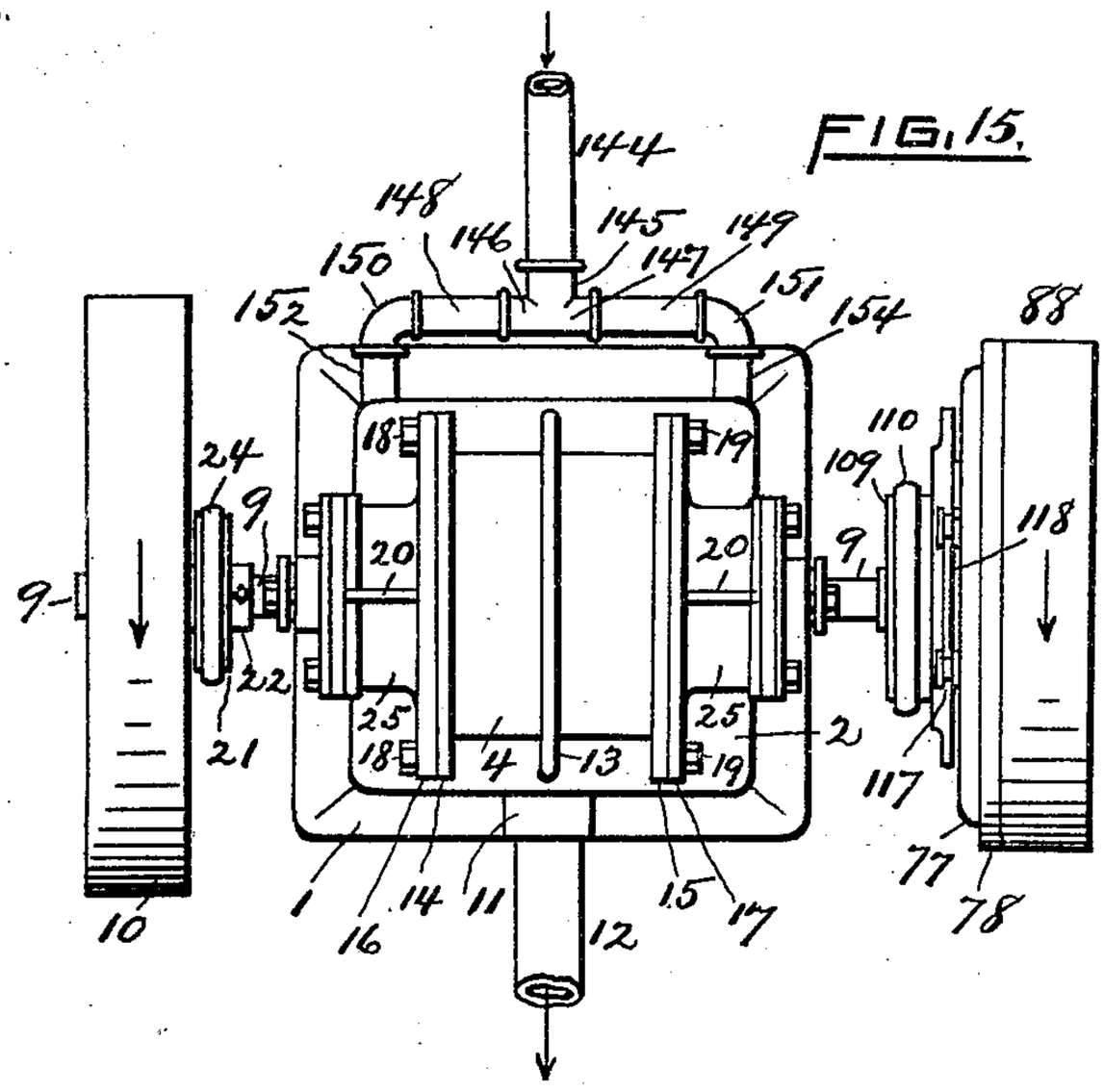
NO MODEL. 5 SHEETS—SHEET 4.

FIG. 15.



WITNESSES.

C. F. Flannigan.

Howard A. Lampfrey

INVENTOR.

Frank J. Waters

by Warren R. Perce

Attorney.

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APPLICATION FILED JUNE 3, 1903.

NO MODEL. 5 SHEETS—SHEET 5.

FIG. 16

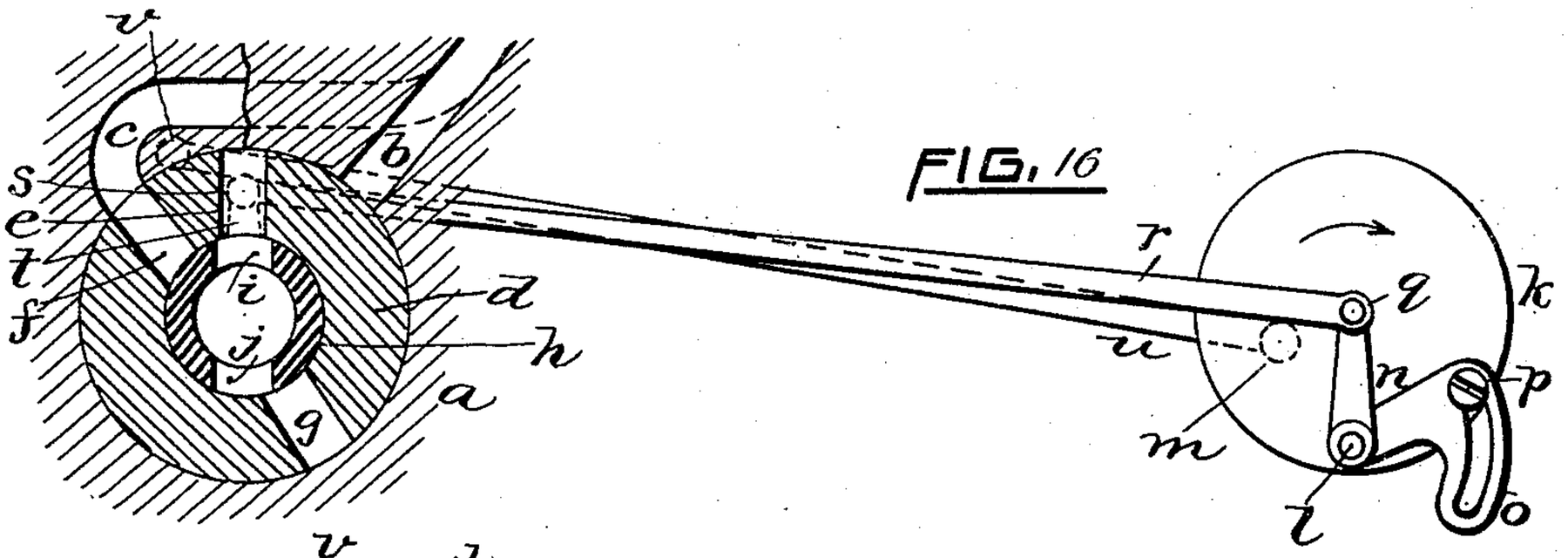


FIG. 17

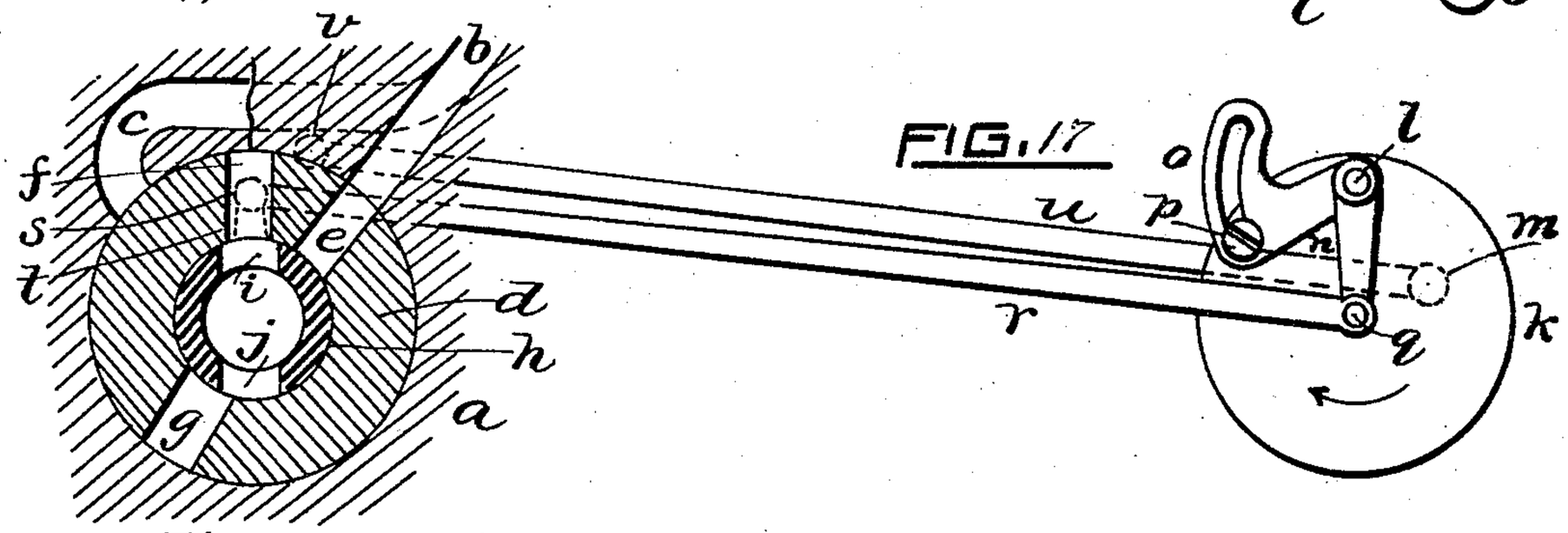


FIG. 18

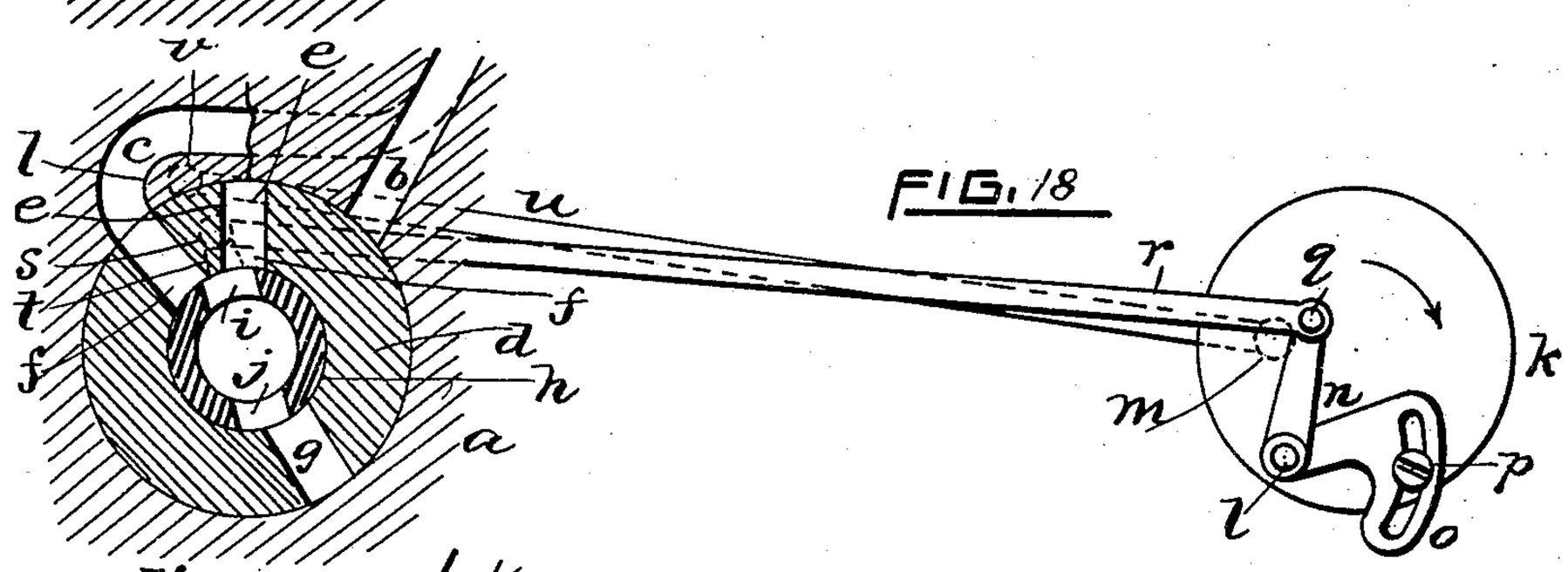
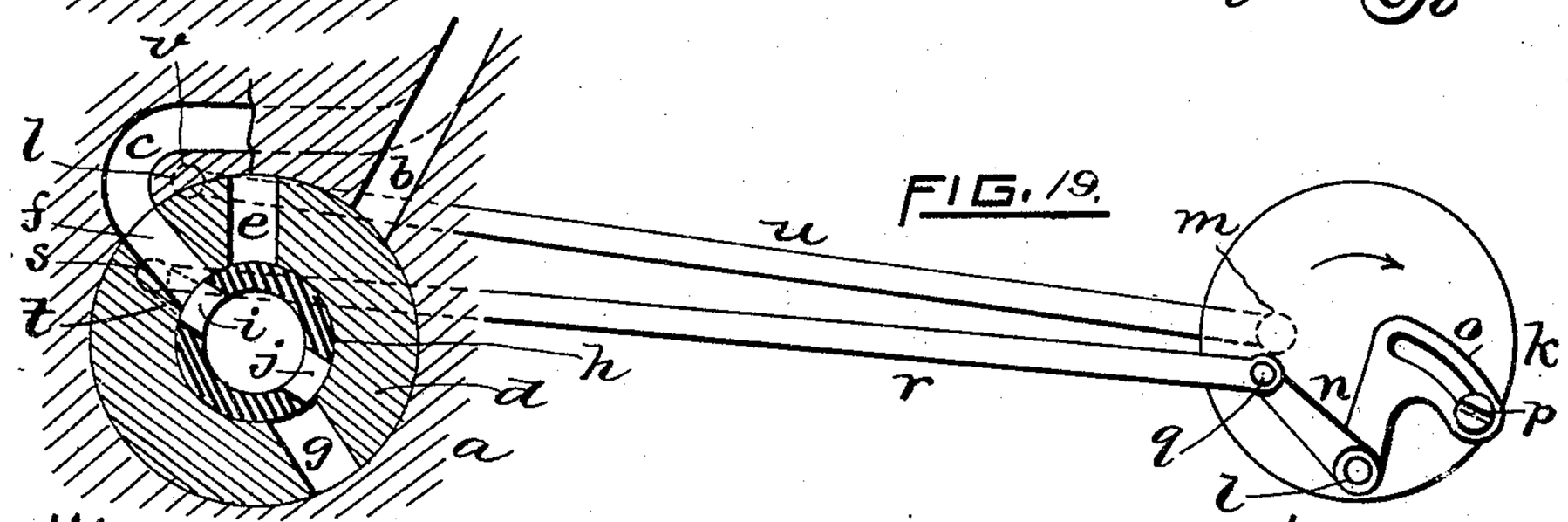


FIG. 19.



WITNESSES.

C. J. Hannigan.

Howard A. Lampfry

INVENTOR.

Frank J. Waters

by Warren R. Pierce

Attorney.

No. 774,502. Patented November 8, 1904.

UNITED STATES PATENT OFFICE.

FRANK J. WATERS, OF PROVIDENCE, RHODE ISLAND, ASSIGNOR, BY DIRECT AND MESNE ASSIGNMENTS, OF TWO-THIRDS TO WILLIS A. DREW, ARTHUR C. FARNHAM, AND ALFRED HARRISON, OF PROVIDENCE, RHODE ISLAND, JAMES GEE, OF CRANSTON, RHODE ISLAND, AND HENRY J. PAGE, OF WARWICK, RHODE ISLAND.

CUT-OFF VALVE FOR STEAM-ENGINES.

SPECIFICATION forming part of Letters Patent No. 774,502, dated November 8, 1904.

Application filed June 3, 1903. Serial No. 159,937. (No model.)

To all whom it may concern:

Be it known that I, FRANK J. WATERS, a citizen of the United States, residing at Providence, in the county of Providence and State of Rhode Island, have invented certain new and useful Improvements in Cut-Off Valves for Steam-Engines, of which the following is a specification, reference being had therein to the accompanying drawings.

Like characters indicate like parts.

Figure 1 is a central longitudinal section of a steam-engine containing my invention as seen on line A A of Fig. 2. Fig. 2 is a cross-section of the same as seen on line B B of Fig. 1. Fig. 3 is a cross-section of the same as seen on line C C of Fig. 1. Fig. 4 is a view of the oscillating valve of said engine, partly in plan and partly in section, as seen on line D D of Fig. 1. Fig. 5 is a sectional view of the same as seen on line E E of Fig. 7 and on line F F of Fig. 1. Fig. 6 is an end elevation of the valve illustrated in Fig. 6. Fig. 7 is a cross-section of the same as seen on line H H of Fig. 5. Fig. 8 is a cross-section of the same as seen on line G G of Fig. 5. Fig. 9 is a detail view in elevation of the spring packing-bar of said valve. Fig. 10 is a central longitudinal section of the cut-off valve. Fig. 11 is a cross-section of the same as seen on line J J of Fig. 10. Fig. 12 is an end elevation of said valve as seen on line K K of Fig. 10. Fig. 13 is an elevation of one of the shafts of said valve. Fig. 14 is an end elevation of the head of said shaft. Fig. 15 is a top plan of my improved steam-engine containing my inventions hereinafter described. This view is on a reduced scale. Figs. 16, 17, 18, and 19 are diagrams to illustrate the principle of steam induction and expansion which is involved in my invention, together with the valve movements for the same.

My invention relates to the cut-off valves of steam-engines; and it consists of the novel construction and combination of the several parts, as hereinafter described, and specifically set forth in the claims.

The cut-off valve herein described and claimed is moved and controlled automatically by a shifting eccentric valve-gear constituting a regulator for said cut-off valve, but which is to be made the subject-matter of a subsequent application by me for Letters Patent of the United States and the construction and operation of which I deem it necessary should be specified and explained in this specification.

In the drawings the exterior parts of the improved steam-engine to which my invention is applied are best shown in Fig. 23. The base of the engine is shown at 1, upon which rests an inclosed chamber or box 2. The base 1 is secured in position upon the floor or other support by the bolts 3. The cylinder 4 has a rectangular base 5, the flange 6 of which is fastened by bolts 7 to the flange 8 of the chamber 2. A main shaft 9 is rotatably mounted in the ends of the cylinder 4, and a fly-wheel 10 is splined or otherwise fastened thereon. The chamber 2 has a boss 11, provided with a circular opening in which the pipe 12 is fitted. The cylinder 4 has a central circumferential rib 13 and the end flanges 14 and 15. The rib 13 serves to strengthen and stiffen the cylinder, and the flanges 14 and 15 serve to support the cylinder-heads 16 and 17, fastened thereto, respectively, by the bolts 18 19. The cylinder-heads 16 and 17 have radial ribs 20 to strengthen the same.

On the main shaft 9, near the fly-wheel 10, is mounted an eccentric-disk 21, which has an integral hub 22. A set-screw 23, passing through the hub 22, has its inner end in contact with the main shaft 9 and fastens the eccentric-disk 21 in position. The periphery of the disk 21 is grooved, and a strap 24 is loosely mounted therein.

Each cylinder-head 16 17 has integral therewith the concentric sleeves or tubes 25 and the circular flange 26.

A stuffing-box 27 surrounds the main shaft 9 of the engine and is provided with the usual packing, which is compressed by a gland 28 in the well-known manner.

In the chamber 2 and integral therewith is a valve-seat 29, substantially tubular in form and shown in Figs. 1, 2, and 3. In the tubular valve-seat is mounted a tubular valve 30, capable of a limited oscillation therein. The construction of this valve 30 is shown in detail in Figs. 5, 6, 7, and 8, and it is illustrated in longitudinal section in Fig. 1 and in cross-section in Figs. 2 and 3. The ends of the tubular valve 30 are concentrically reduced in diameter. A split spring-ring 31 surrounds each reduced end of the valve 30 and constitutes a packing. A solid ring 32 is is fastened by screws 23 to one end of the valve 30 and serves to hold the split spring-ring 31 from outward lateral displacement, and another solid ring, 32^a, is fastened by screws 33 to the opposite end of the valve 30 to hold the split spring-ring 31 there from outward displacement. The valve 30 has four ports 34, 35, 36, and 37, the shape, relative size, and location of which are shown in Figs. 1, 2, 3, 5, 6, 7, and 8. The ports 34 and 35 are angularly directed, as shown in Figs. 7 and 8, and are not in alinement one with the other. The ports 36 and 37 are radially directed and are in alinement with each other. The valve 30 has at its bottom two parallel longitudinal grooves, in which, respectively, are packing-bars 38 of about the same width as said grooves, so as to move freely therein, but having a thickness from top to bottom less than the depth of said grooves, as seen in Figs. 7, 8, and 9. The outer edge of each packing-bar 38 is normally flush with the peripheral surface of the valve and is curved to correspond therewith, as illustrated in Figs. 7 and 8. In the space between the inner edge of each packing-bar 38 and the bottom of the groove in which it is seated is a bow-spring 39, as shown in Fig. 9. The ends of each packing-bar 38 have ears which hold said bar in position from outward displacement by projecting within the spring-rings 31, as seen in Fig. 9. The transverse splitting of the rings 31, as shown in Fig. 4, affords the requisite elasticity of action to adapt them to serve as steam-packings.

At one end of the valve 30 on the solid ring 32 there, as shown in Figs. 5 and 6, are two parallel tubes 40 41, having brackets 42 43, which are integral with or fastened to the ring 32. Two parallel bars 44 45 are fastened at the ends of said tubes by screws 46 47. The tubes 40 41 and bars 44 45 thus secured together offer a rectangular space 46, as seen in Fig. 6.

In the bore of the tubular valve 30 is seated the tubular cut-off valve 47, which has the four diametrically-arranged ports 48, 49, 50, and 51. The ends of the valve 47 are concentrically reduced in diameter to allow split springs 52 to be loosely mounted thereon, as seen in Fig. 10. The details of the construction of the cut-off valve 47 are shown in Figs. 10, 11, 12, 13, and 14, and it is shown in longitudinal section in Fig. 1 and in cross-section in Figs. 2 and 3. At one end of the valve 47 is a solid ring 53, (shown in Figs. 10 and 12,) having a central circular aperture 54 of the same diameter as the bore 55 of the cut-off valve 47. Said ring 53 is of such a diameter as to allow it to fit within the ring 32^a of the valve 30, as seen in Fig. 1. The ring 53 is integral with a valve-shaft 54, which has also an integral flange 55. Four equispaced integral bars 56 extend between the ring 53 and flange 55, as seen in Figs. 14 and 10. The ring 53 of the valve-shaft 54 is secured to the ends of the valve 47 by screws 57. A sleeve or cap 58 is fastened by bolts 59 to the chamber 5, as seen in Fig. 4, and has a stuffing-box 60, through which the shaft 54 passes. A gland 61 compresses the packing 62 in the stuffing-box 60, as shown in Figs. 1 and 4. At the opposite end of the cut-off valve 47 is the valve-shaft 63, having a head 64 rectangular in cross-section. It has a concentric circular socket, as indicated by dotted lines in Fig. 13 and by solid lines in Fig. 14. It has four projections 65 at the corners of said head, and the space between said projections is cut in a semicircular shape, as seen in Figs. 1, 4, and 13. The ends of said projections 65 rest against a ring 66, which serves to keep the adjacent ring 52 from lateral displacement and which is secured by screws 67 to the adjacent end of the valve 47. A sleeve-cap 68 is fastened by bolts 69 to the chamber 5, as seen in Fig. 4, and has a stuffing-box 70, through which the valve-shaft 63 passes. A gland 71 compresses the packing 72 in the stuffing-box 70, as shown in Fig. 4. The valve-shaft 54 is rotatably mounted in a bearing 73 upon the top of the standard 74, and the valve-shaft 63 is rotatably mounted in a bearing 75 upon the top of the standard 76.

In my pending application for Letters Patent, Serial No. 171,456, I have shown and described shifting eccentric valve-gear for imparting to the cut-off valve hereinbefore described oscillating movements to variable extents; but as these do not constitute a part of my present invention which is included in this application I do not here describe or specify the same.

On the outer end of the valve-shaft 54 is a crank-arm 129, having a hub 130. A set-screw 131, passing through the hub 130, fastens the crank-arm 129 to said shaft 54. The end of the crank-arm 129 is connected with the link-bar 115 by the screw-pivot 132.

From a projection 133 of the strap 24 (see Fig. 1) extends a link-bar 134, which is secured by screw-threads therein and held in place by a check-nut 135. The lower end of

the link-bar 134 is pivotally connected at 136 with a crank-arm 137, which is fastened by a hub 138 thereof on the outer end of the valve-shaft 63 and held in place by a check-nut 139, as seen in Figs. 1 and 4.

As seen in Figs. 2 and 3, there is a central block 140 integral with the cylinder 4 and in contact with an upward extension 141 of the valve-seat 29. A straight port 142 extends through the block 140 and the extension 141, as seen in Fig. 2, and an approximately **S**-shaped port 143 extends through said block and extension, as seen in Fig. 3. Exhaust-ports 144 extend through into the cylinder 4. The port 34 of the valve 30 can be made continuous with the port 142 by the oscillation of said valve, as hereinafter described, and the port 35 of said valve can in like manner be made continuous with the port 143.

The steam-inlet pipe is designated as 144 in Fig. 23. It enters a **T**-shaped pipe 145, from the branches 146 147 of which extend the pipes 148 149 to the elbows 150 151, respectively. From the elbow 150 a pipe 152 extends to a coupling 153, Fig. 4, and from the elbow 151 a pipe 154 extends to a coupling 155. A pipe 156 extends from the coupling 153 through an opening in the cap 68, and a pipe 157 extends from the coupling 155 through an opening in the cap 58.

In Figs. 1, 2, and 3 in the upper half thereof, respectively, is shown in the drawings the piston-hub on the main shaft 9 of the engine, the expansion piston-blades mounted in said hub, the several packing-bars and packing-rings relating to said piston hub and blades, and the various steam ports and passages by which the steam is carried to and introduced into the piston-hub.

Having thus described the several parts of my invention, I will now explain its operation.

The characteristic mechanical principle of my invention can be most simply explained at first by a reference to the series of diagrams constituting Figs. 16, 17, 18, and 19. In the diagrams shown in these figures, *a* represents a valve-seat having the straight port *b* and the **S**-shaped port *c*. An oscillating valve is represented by *d*, having the radial ports *e*, *f*, and *g*, and a cut-off valve is represented by *h*, having the radial ports *i* and *j*. A rotatable disk *k* has on one side a stud *l* and on the opposite side a stud *m*, located as shown. On the stud *l* is mounted a **V**-shaped lever *n*, at the end of one arm of which is a slotted arc-shaped projection *o*. A screw *p*, passing loosely through the slot of the projection *o*, enters the disk *k*. At the end of the other arm of the lever *n* it is pivotally connected at *q* with a link-bar *r* at one end of the latter. The link-bar *r* at the opposite end is pivotally connected at *s* to a radial earpiece *t*, which projects from the cut-off valve *h*. A link-bar *u* is pivotally mounted at one end upon the stud *m* of the disk *k* and at the opposite end is pivotally connected with an ear *v* upon the oscillating valve *d*. When the engine is starting and is working at low speed, the position of the parts (we will say) is that shown in Fig. 19. Here the port *i* of the cut-off valve *h* is coming into full continuity with the port *f* of the oscillating valve *d* and said port *f* of the oscillating valve *d* is in full continuity with the port *c* of the valve-seat *a*. When the slotted arm *o* is set in the position shown in Fig. 19, the oscillating valve *d* and the cut-off valve move from the position illustrated in said figure to a position where the ports *e* and *i* register with the port *b* of the valve-seat *a*. While this relative position of the parts continues the full flow of steam passes through said valves 47 and 30 into the cylinder 4 to operate the piston.

In Fig. 18 the projection *o* is set so that the screw *p* is half-way along the slot of said projection *o*. In this position the oscillating valve *d* oscillates as before, so that its port *f* first registers with the port *c* of the valve-seat *a* and then its port *e* registers with the port *b* of the valve-seat; but the oscillation of the cut-off valve *h* is half as much as it was in Fig. 19, with the consequence that only half the volume of steam passes from the cut-off valve *h* to the oscillating valve *d* and is then cut off, thus utilizing the expansive power of the steam during the last half of the stroke. In this relative position of the parts the cut-off valve is set somewhat ahead of the oscillating valve.

As more fully explained in my pending application for Letters Patent, Serial No. 171,456, and partially illustrated in Figs. 1 and 15, there is on that end of the main shaft 9 which is opposite to the fly-wheel 10 a large circular disk 88 and its connected parts, which may be comprehensively called the "regulator," but which need not here be particularly specified, except to state that it is provided with two spring-pressed weighted arms, by means of the centrifugal power of which variation of movement is given to the extent of oscillation of the cut-off valve 47; but said cut-off valve 47 has independent of this variable movement due to the centrifugal power of the weighted arms, as aforesaid, a constant oscillation derived from the link-bar 115 of the straps 110 of the eccentric 108 as the latter rotates with the disk 88 and its connected parts. When the engine is running at or below its fixed speed, the cut-off valve has an oscillation longer in extent (as measured by degrees) than that of the main (or rotary) valve. Therefore when the engine is running at or below its fixed speed the fullest possible amount of steam is supplied to the main or rotary valve and the cut-off valve has no throttling action whatever, but allows the full volume of steam to pass into said main or rotary valve.

In Figs. 16 and 17 the projection *o* is set so

that the screw *p* is at the inner end of the slot of the projection *o*. Here it is seen that the steam is entirely cut off, so that when the ports *c* and *f* register no steam can pass to them from the port *i* of the cut-off valve *h* and when the ports *b* and *e* register no steam can pass to them from the cut-off valve *h*. Moreover, in the position of the projection *o* in its relation to the screw *p* (shown in Figs. 16 and 17) the valves *d* and *h* move in directions opposite to each other.

I will now proceed to explain how the mechanism constituting my invention hereinbefore described effects similar valve movements when in operation.

The steam is admitted at boiler-pressure through the pipe 144 and thence passes through the T-shaped pipe 145, the pipes 148 149, elbows 150 151, and pipes 152 154, Fig. 15, and through the pipes 186 157. From the pipe 156 the steam passes into the cap 68 and thence through the semicircular steam passage-ways between the projections 65 of the head 64 of the valve-shaft 63. From the pipe 157 the steam passess into the cap 58 and thence through the rectangular steam passage-ways between the bars 56 of the flanges 53 55 of the valve-shaft 54, as seen in Fig. 4. Thence the steam passes into the bore of the cut-off valve 47 and thence through the ports 48 or 49 whenever allowed. The cut-off valve 47 is rotatably mounted in the bore of the tubular valve 30, and when the port 48 of the valve 47 opens into the port 34 of the valve 30 the steam can pass into said port 34, and when the port 49 of the valve 47 opens into the port 35 of the valve 30 the steam can pass into said port 35. When the ports 48 and 34 are continuous, more or less, with the port 142 or the ports 49 and 35 are continuous, more or less, with the port 143, the steam can pass into the cylinder 4 and move the piston therein, as is apparent from an inspection of Figs. 1, 2, and 3.

The rotation of the main shaft 9 causes a regular and constant rotation of the eccentric-disk 21 thereon, and said disk in its rotation communicates, by means of the strap 24 thereon and the link 134, a reciprocating oscillating movement to the crank 137, thus regularly rocking back and forth the valve-shaft 63. The rectangular head 64 of said shaft loosely entering the rectangular opening 46, which is between the bars 45 and tubes 40 on the end or ring 32 of the tubular valve 30, gives an oscillating movement to said tubular valve. The shafts 54 and 63 are thus rotated in the same direction until a high speed is developed; but after the high speed has been developed the shaft 54 is rotated in a direction opposite to that of the rotation of the shaft 63. The oscillation of the valve 30 is always at a rate synchronous with the rotation of the main shaft, and there is one reciprocation of said valve movement in each rotation of the main shaft, and said oscillation of the valve 30 is always to the same degree and extent; but the oscillation of the cut-off valve 47 is variable in the extent of its oscillation and synchronous with the expansive movements of the weights or balls of the regulator or shifting eccentric valve-gear shown and described in my said pending application for Letters Patent, Serial No. 171,456. It is thus seen that the cut-off valve is automatically controlled and is adapted to act under a variable load, causing the engine to run at a uniform speed notwithstanding a variation in load.

I have shown my improved cut-off valve as applied to a rotary steam-engine; but it is obvious that it is equally applicable to a reciprocating steam-engine, either by a duplication of parts or a rearrangement of the cylinder-ports.

The ports 36 and 37 of the valve 30 admit steam for the purpose of balancing said valve and may be called "balancing-ports." In like manner the cut-off valve 47 has balancing-ports 50 and 51.

It is obvious that instead of using parallel bars 44 45 and parallel tubes 40 41 to form the rectangular space or aperture 46 any rectangular case of whatever construction and however attached to the end of the valve 30 will serve the same purpose and be within the scope of my invention.

I am aware that it is not new to mount a tubular cut-off valve rotatably in a tubular rotary valve; but so far as I am informed such tubular cut-off valves have always been one of three kinds—first, a stationary tubular cut-off valve which is set to some desired position by hand or separately-operated mechanism and which maintains that position until it is set again to some other position by the operator or by said mechanism; second, a tubular cut-off valve which is turned by means of a governor or similar device to variable extents by centrifugal power or other automatic means, according to the speed of the engine, but which nevertheless remains stationary or in a temporarily-fixed position, while the speed of the engine continues unchanged, and, third, a tubular cut-off valve mounted in a tubular rotary valve and regularly oscillating or rotating at a uniform rate by means connecting it with the main shaft, but wholly without any reference whatever to variations in the load and wholly without any independent governor or controlling means. I am the first, so far as I am aware, to use a constantly-oscillating tubular cut-off valve mounted in a tubular rotary valve, the extent of whose oscillation, however, is automatically regulated by a governor or controlling device. My said construction especially adapts my cut-off valve for use in engines of high speeds. As in the diagrammatic views, Figs. 16 to 19, the inner valve is continually in oscillatory movement, but to variable extents,

in a tubular rotary valve, which is continually in oscillatory movement, but to a fixed extent, so the rotary valve and cut-off valve in my invention perform similar oscillatory movements and are thus distinguished from all other cut-off valves in the prior art.

I claim as a novel and useful invention and desire to secure by Letters Patent—

1. In a steam-engine, a cylinder having two inlet-ports, a tubular valve rotatably mounted and provided with two ports of equal width and length through one side thereof, which extend longitudinally of said valve but are separated by a partition and so arranged that one of said ports is slightly advanced peripherally beyond the other but are disposed in lines parallel to each other, said valve-ports being adapted respectively to register alternately with said cylinder-ports, a cut-off valve rotatably mounted in the first-named valve and having two ports of equal length and width through one side thereof extending longitudinally of said cut-off valve, separated by a partition and adapted respectively to register alternately with the ports of the first-named valve, means adapted to oscillate the first-named valve, and means adapted to oscillate the second-named valve, substantially as specified.

2. In a steam-engine, the combination of a rotatable tubular valve having ports, an end piece upon one end of said valve provided with a rectangular aperture, a valve-shaft having a rectangular head which is adapted to enter said aperture and there engage said valve and which is provided with a steam passage-way, a tubular cut-off valve having ports registrable with the first-named ports, and rotatably mounted in the first-named valve, a valve-shaft having a head which is provided with steam passage-ways and secured to that end of the cut-off valve, which is opposite to that end of the first-named valve where the first-named valve-shaft is engaged as aforesaid, said two valve-shafts extending in the same axial line, means adapted to oscillate the first-named valve-shaft, and means adapted to oscillate the second-named valve-shaft, substantially as described.

3. In a steam-engine having a main shaft, the combination of an outer tubular valve having an outlet-port on one side and a balancing-port on the opposite side, a tubular cut-off valve mounted loosely in the first-named valve and having a balancing-port on one side and an outlet-port on the opposite side which outlet-port is registrable with the outlet-port of the first-named valve, and separate means adapted to oscillate each of said valves once during each rotation of the main shaft, substantially as specified.

In testimony whereof I affix my signature in presence of two witnesses.

FRANK J. WATERS.

Witnesses:
WARREN R. PERCE,
HOWARD A. LAMPREY.