No. 807,835. PATENTED DEC. 19, 1905.

D. W. LYON.

CRUDE OIL ENGINE.

APPLICATION FILED DEC. 5, 1904.

10 SHEETS—SHEET 1.

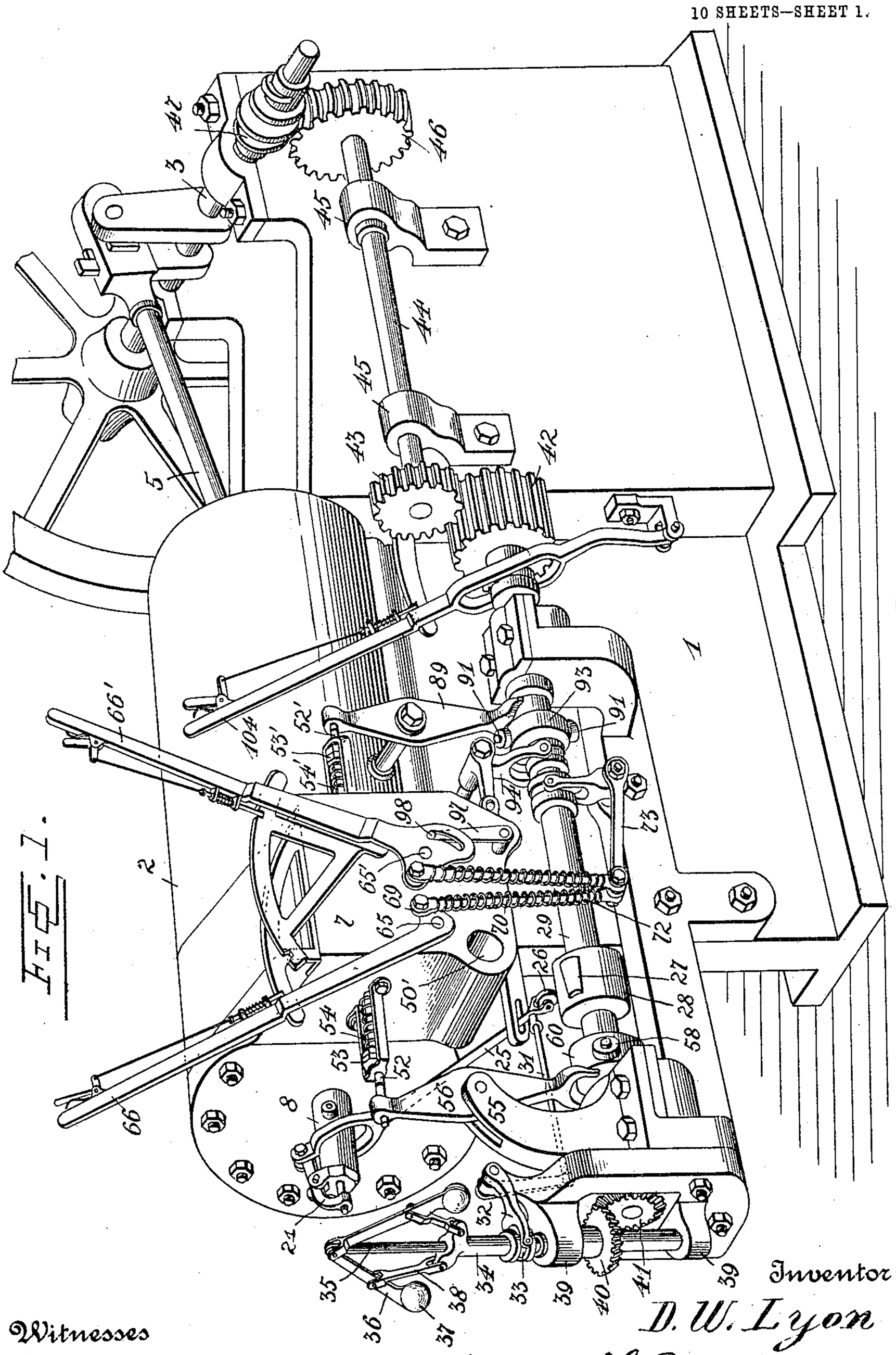



FIG. 1.

Witnesses

C. Munter

C. H. Griesbauer.

Inventor

D. W. Lyon

by A. Bowerson

Attorney

No. 807,835. PATENTED DEC. 19, 1905.

D. W. LYON.

CRUDE OIL ENGINE.

APPLICATION FILED DEC. 5, 1904.

10 SHEETS—SHEET 2.

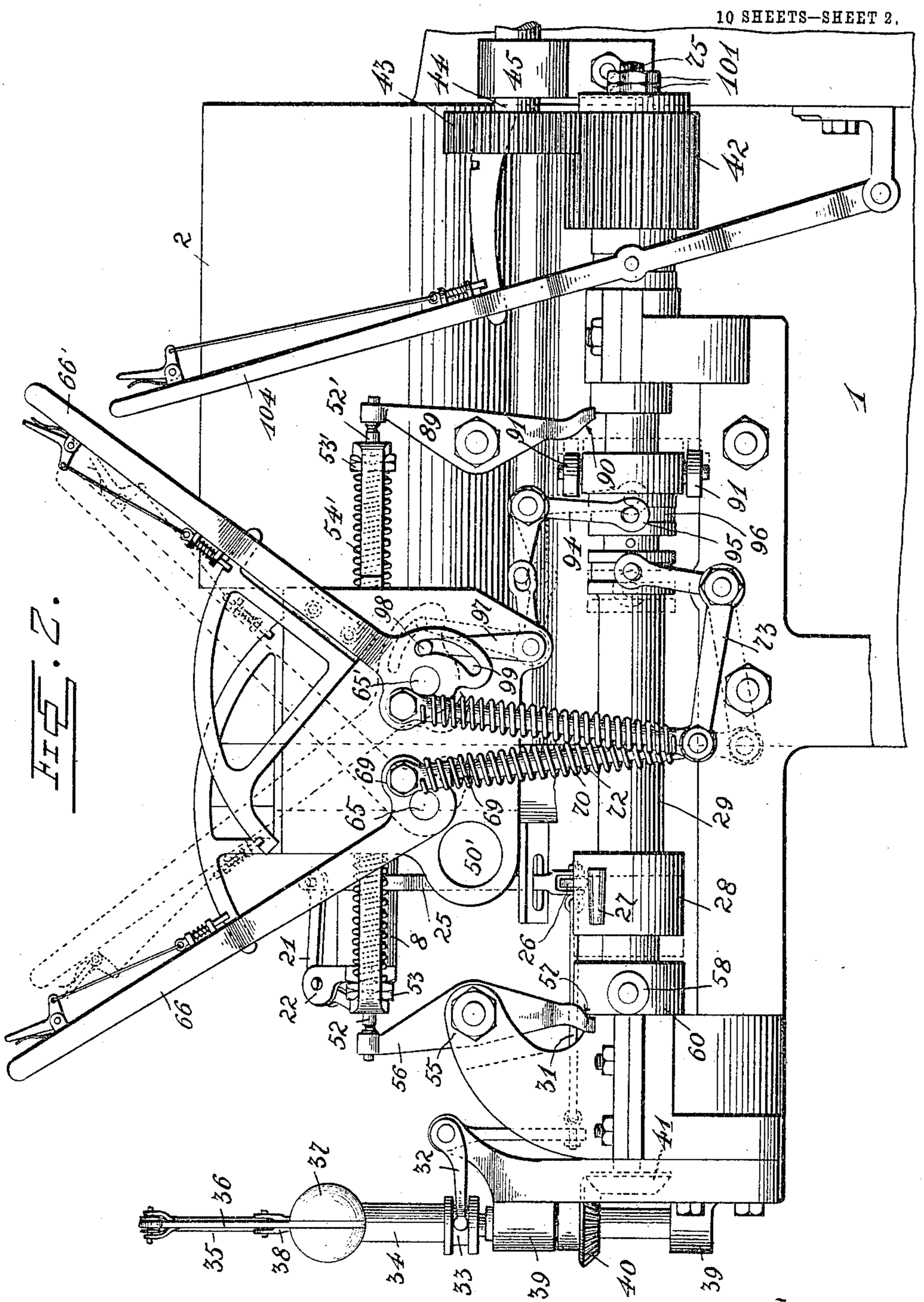



FIG. 2.

Witnesses
C. Munson
L. H. Griesbauer.

Inventor
D. W. Lyon
by H. Bowerson
Attorney

No. 807,835. PATENTED DEC. 19, 1905.

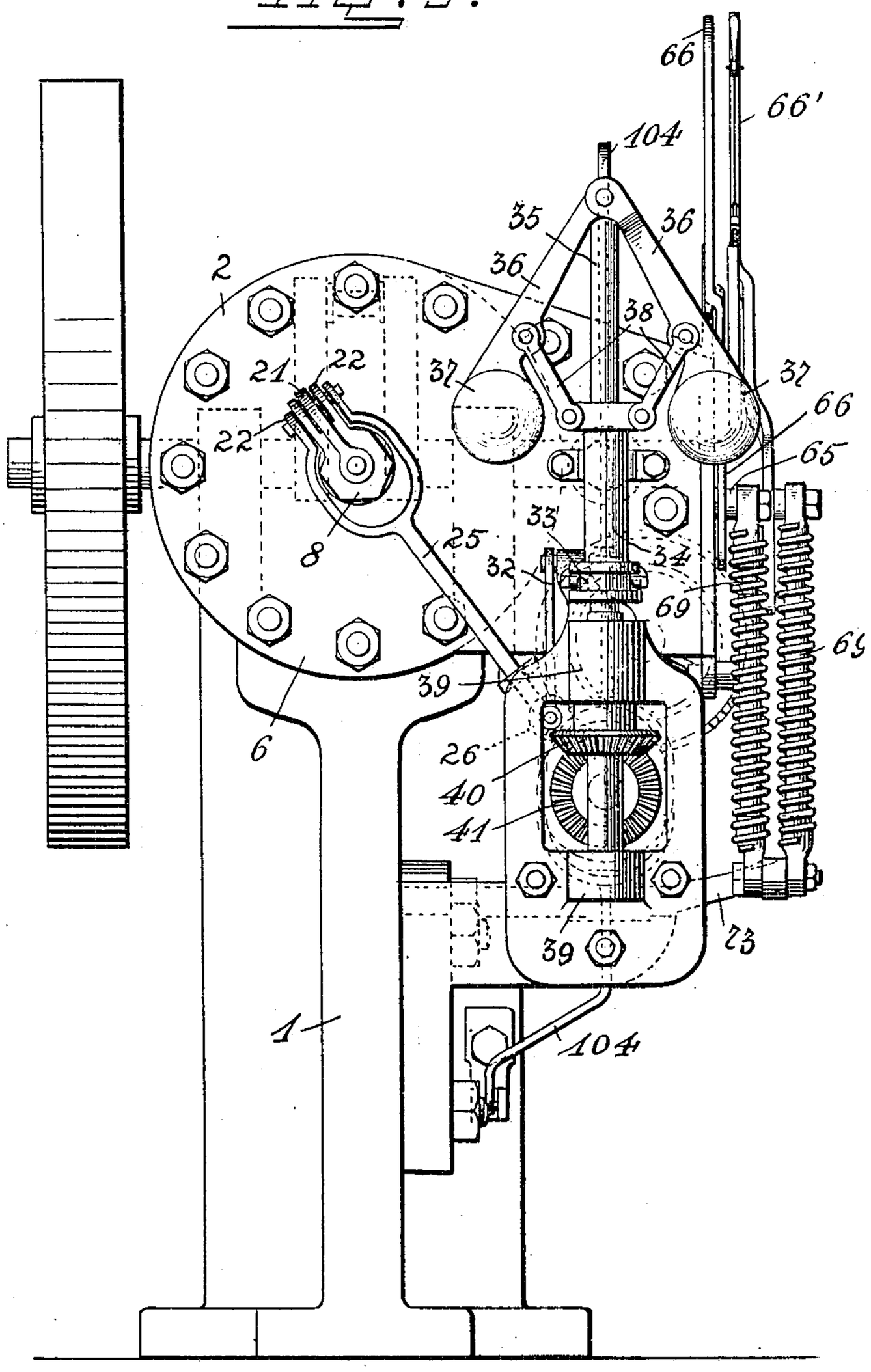
D. W. LYON.

CRUDE OIL ENGINE.

APPLICATION FILED DEC. 5, 1904.

10 SHEETS—SHEET 3.

Fig. 3.




Witnesses
C. Hunter
C. H. Griesbauer.

Inventor
D. W. Lyon
by H. B. Wilson
Attorney

No. 807,835. PATENTED DEC. 19, 1905.

D. W. LYON.

CRUDE OIL ENGINE.

APPLICATION FILED DEC. 5, 1904.

10 SHEETS—SHEET 4.

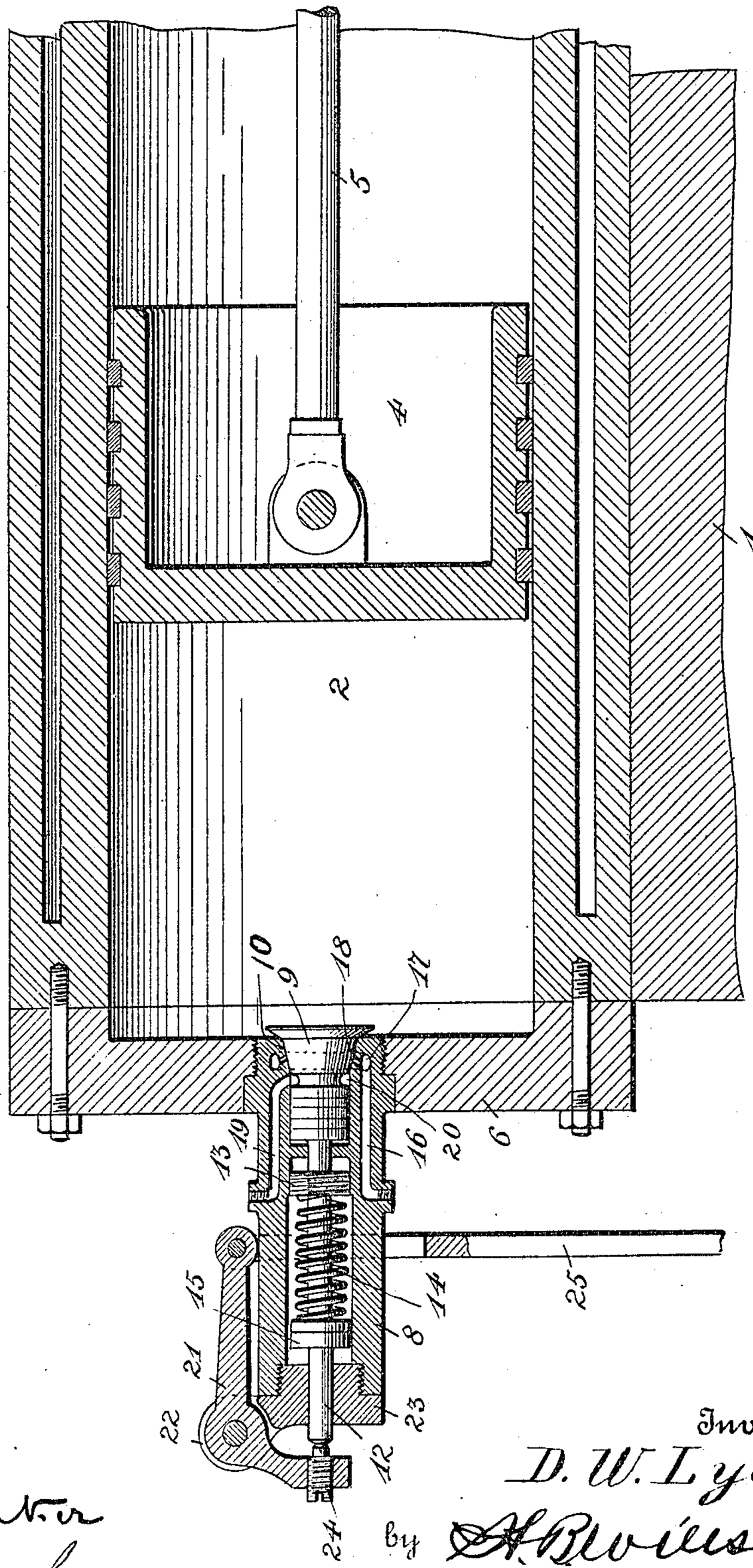



FIG. 4.

Witnesses
C. Munter
C. H. Griesbauer.

Inventor
D. W. Lyon
by A. Bovillson
Attorney

No. 807,835. PATENTED DEC. 19, 1905.

D. W. LYON.

CRUDE OIL ENGINE.

APPLICATION FILED DEC. 5, 1904.

10 SHEETS—SHEET 6.

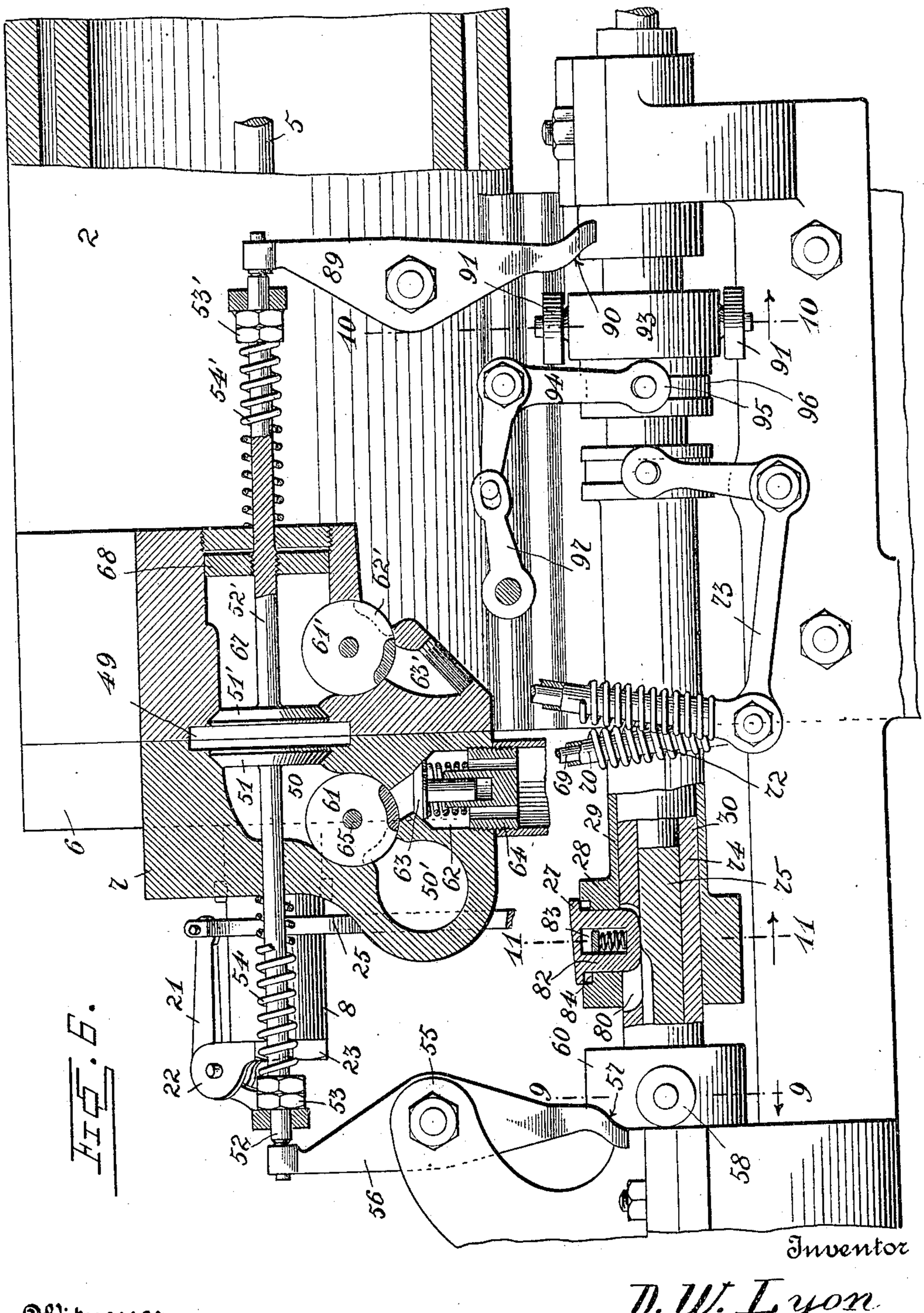


FIG. 6.

Witnesses
C. Munter
C. H. Griesbauer.

Inventor
D. W. Lyon
by H. Wilson
Attorney

No. 807,835. PATENTED DEC. 19, 1905.

D. W. LYON.

CRUDE OIL ENGINE.

APPLICATION FILED DEC. 5, 1904.

10 SHEETS—SHEET 5.

FIG. 5.

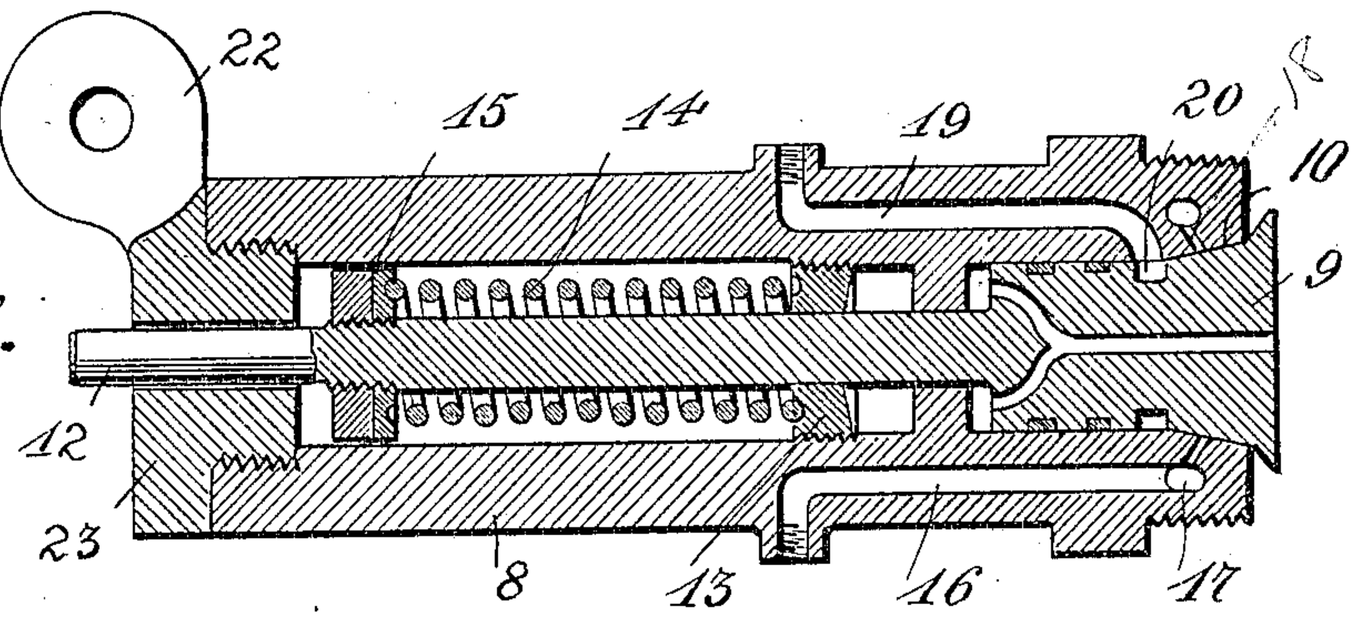



FIG. 12.

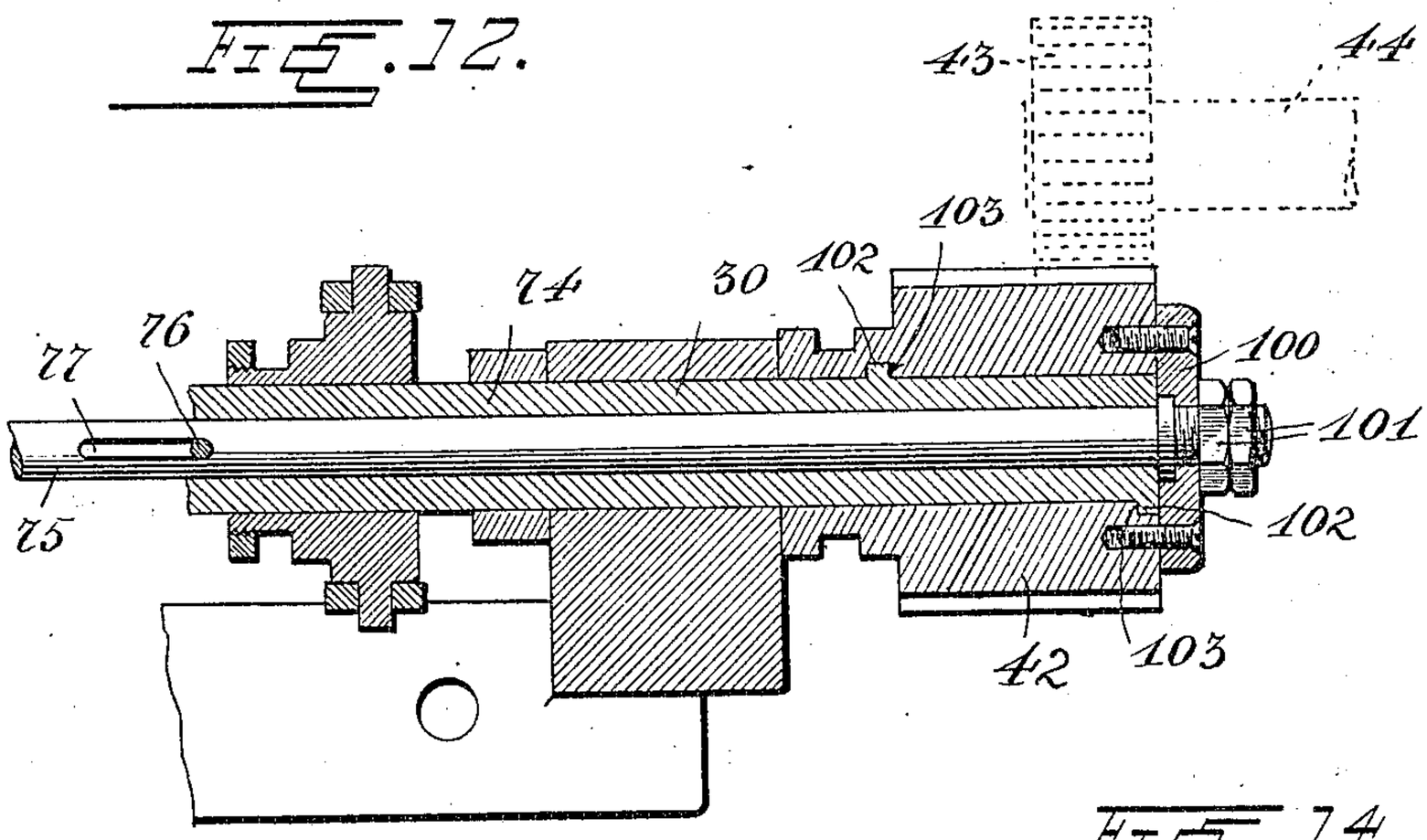



FIG. 13.

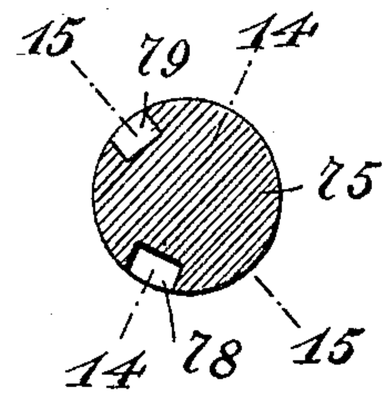



FIG. 14.

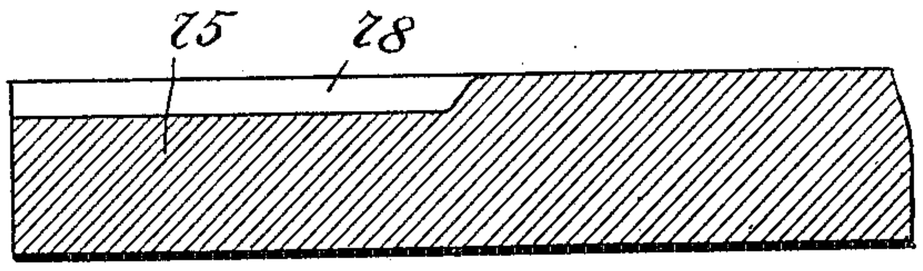
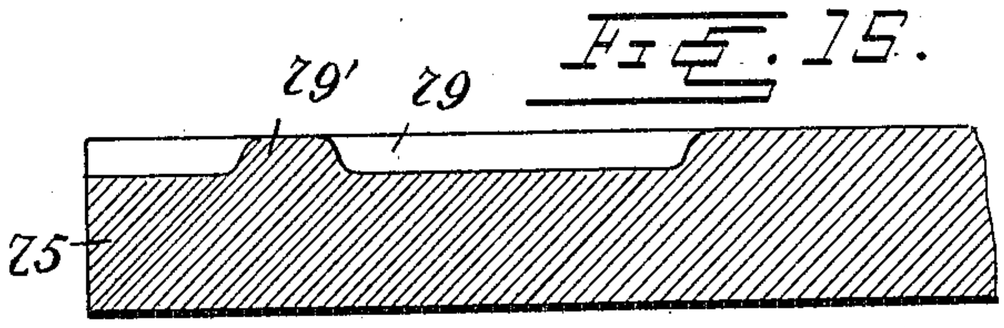



FIG. 15.




Witnesses
C. Hunter
C. H. Griesbauer.

Inventor
D. W. Lyon
by H. B. Wilson
Attorney

No. 807,835. PATENTED DEC. 19, 1905.

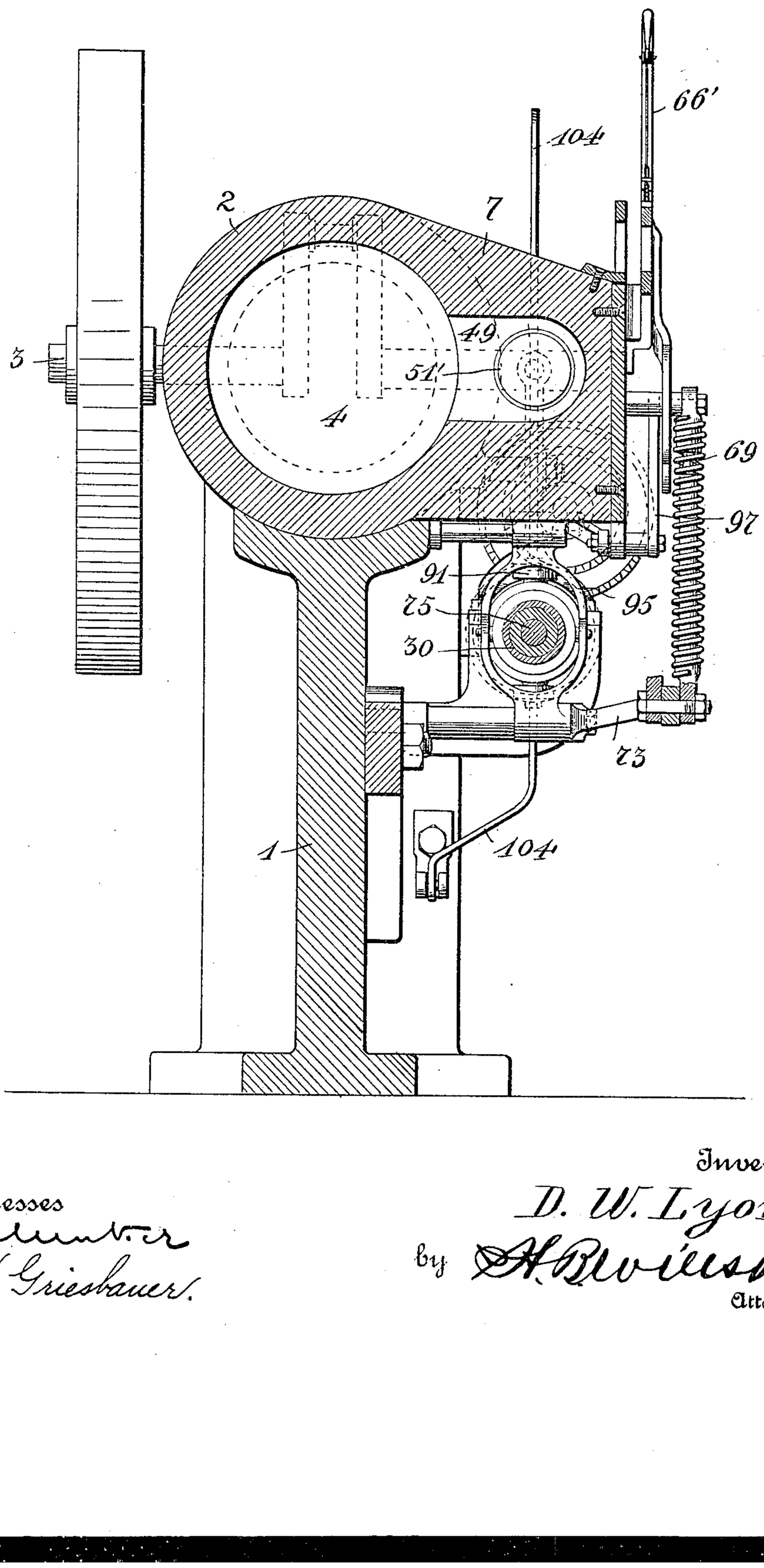
D. W. LYON.

CRUDE OIL ENGINE.

APPLICATION FILED DEC. 5, 1904.

10 SHEETS—SHEET 7.

Fig. 7.




Witnesses
C. Hunter
C. H. Griesbauer.

Inventor
D. W. Lyon
by H. Bowerson
Attorney

No. 807,835. PATENTED DEC. 19, 1905.

D. W. LYON.

CRUDE OIL ENGINE.

APPLICATION FILED DEC. 5, 1904.

10 SHEETS—SHEET 8.

FIG. 8.

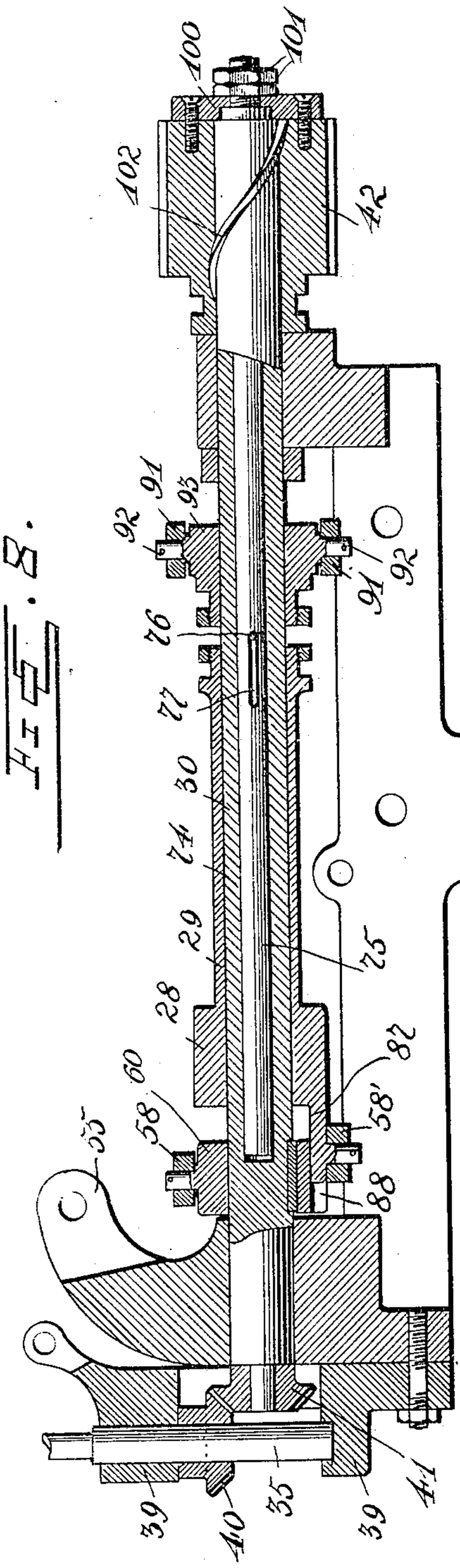



FIG. 10.

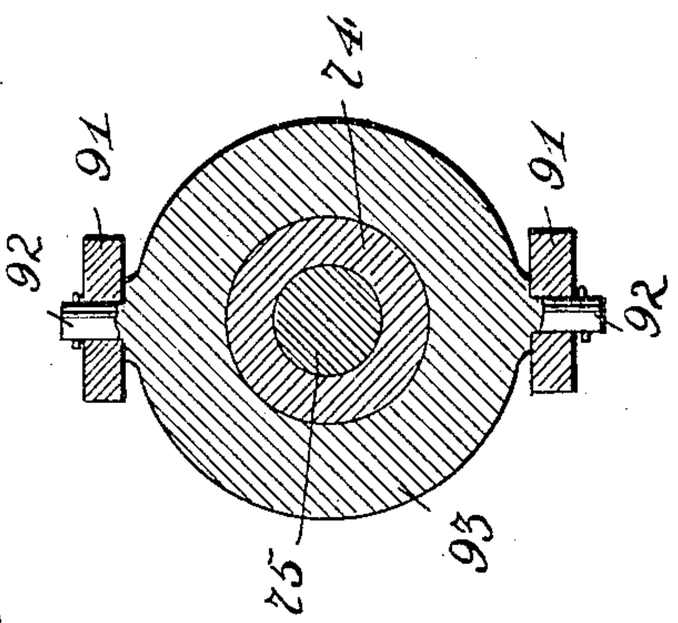



FIG. 11.

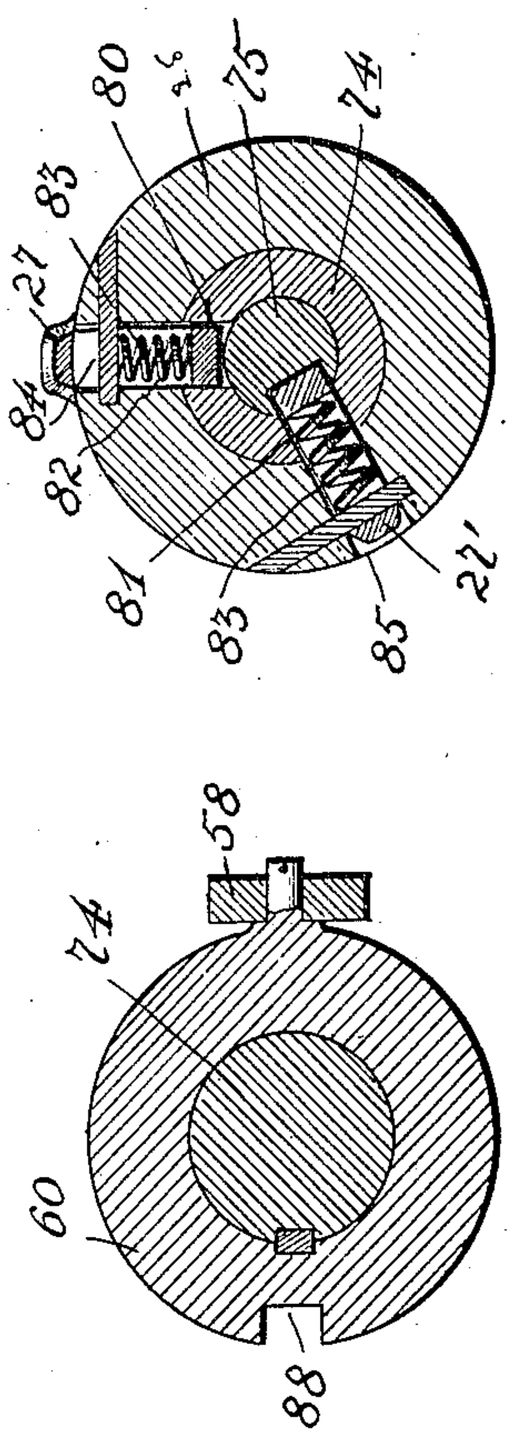



FIG. 9.




Witnesses

C. Hunter

C. H. Griesbauer.

Inventor

D. W. Lyon

by A. Bovillson

Attorney

No. 807,835. PATENTED DEC. 19, 1905.

D. W. LYON.

CRUDE OIL ENGINE.

APPLICATION FILED DEC. 5, 1904.

10 SHEETS—SHEET 9.

Fig. 16.

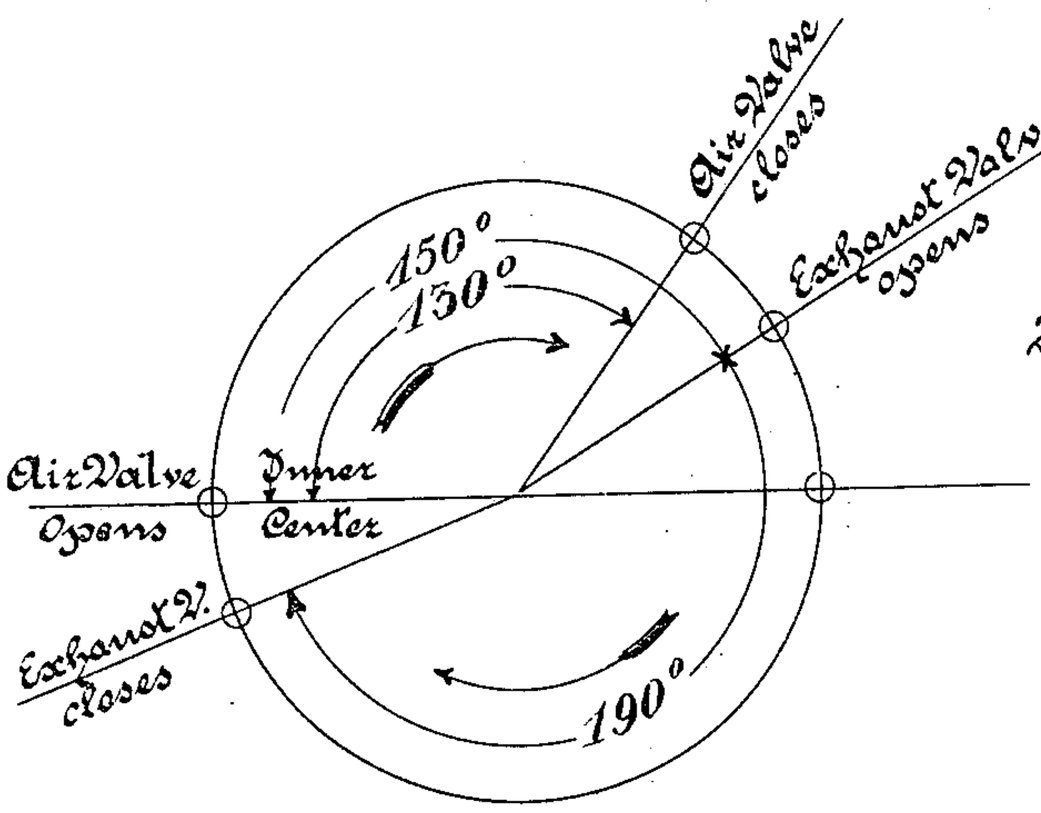



Fig. 18.

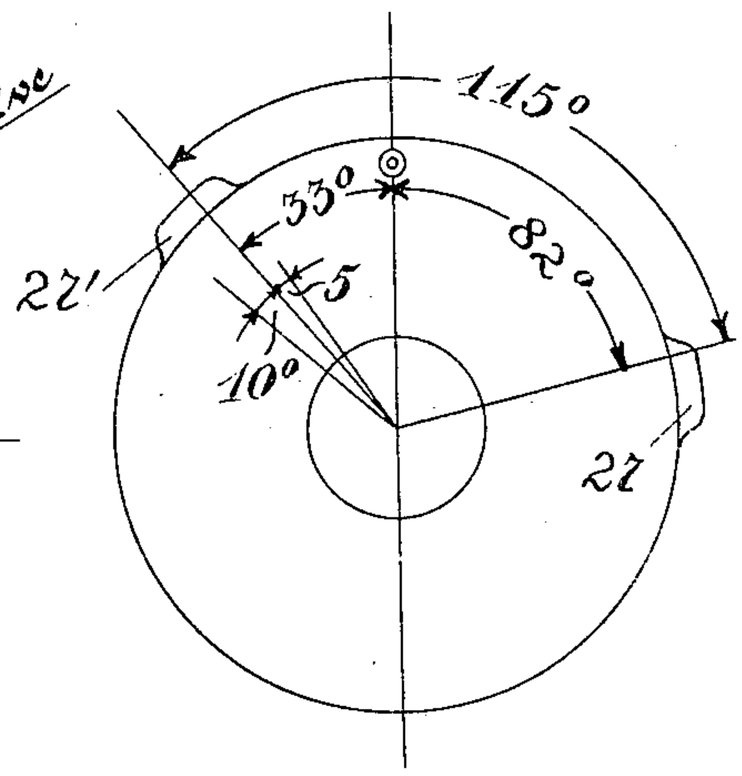



Fig. 17.

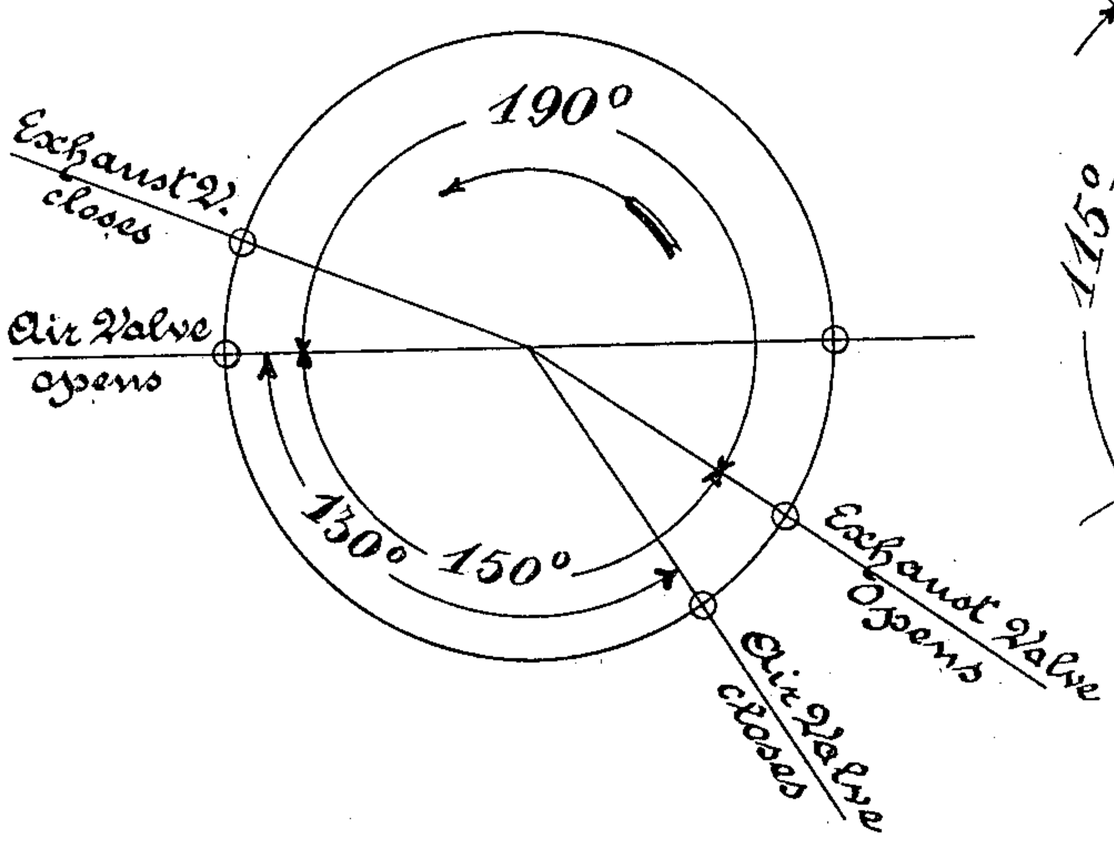
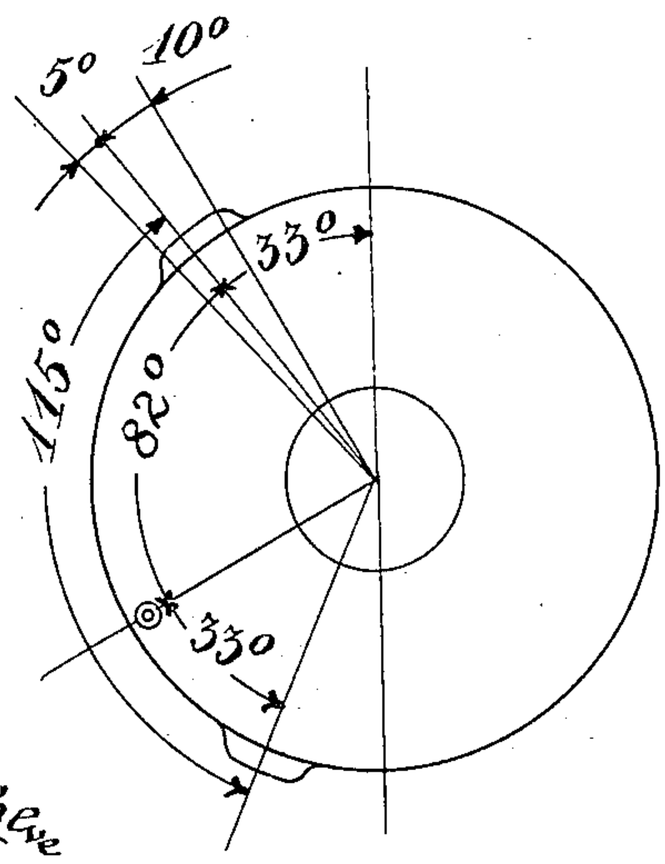



Fig. 19.




Witnesses
C. Mentzer
C. H. Griesbauer.

Inventor
D. W. Lyon
by H. Wilson
Attorney

No. 807,835. PATENTED DEC. 19, 1905.

D. W. LYON.

CRUDE OIL ENGINE.

APPLICATION FILED DEC. 5, 1904.

10 SHEETS—SHEET 10.

Fig. 20.

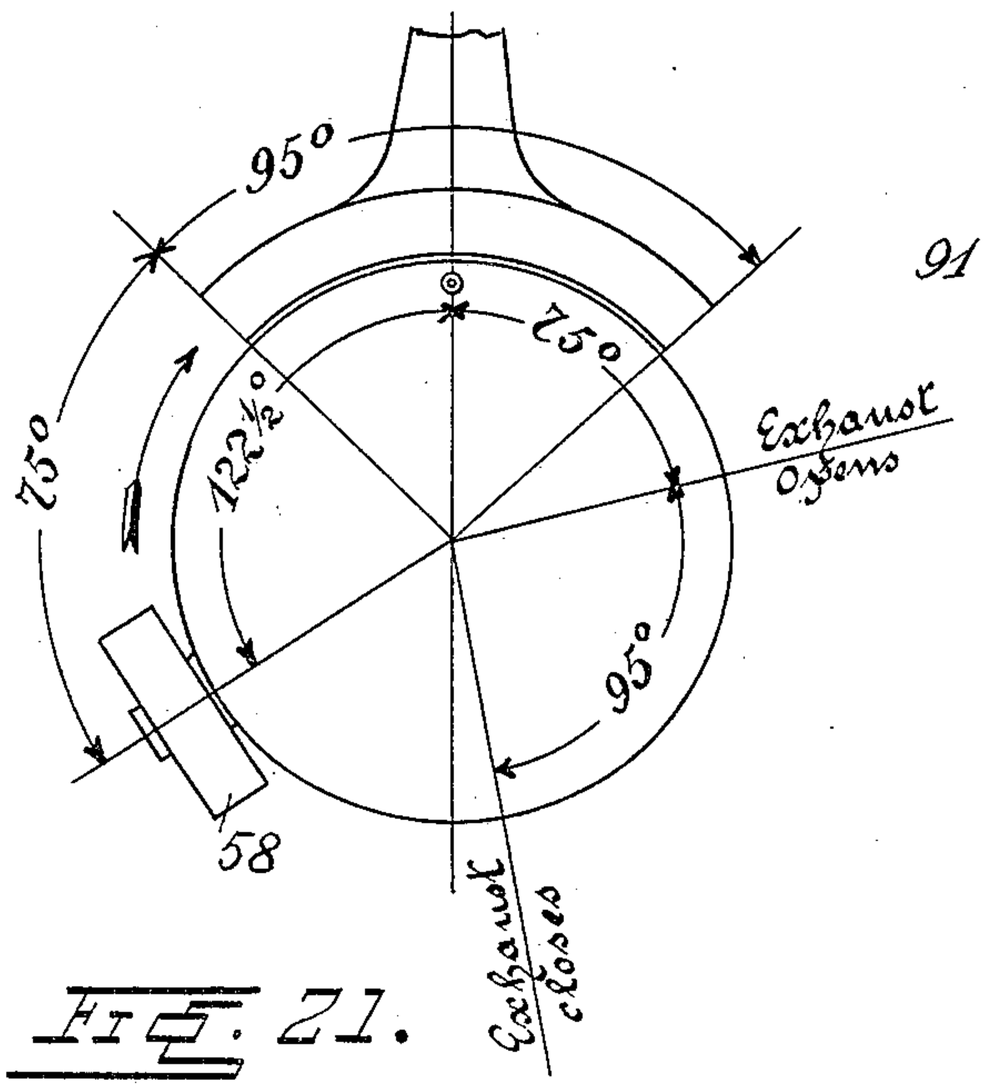



Fig. 21.

Fig. 22.

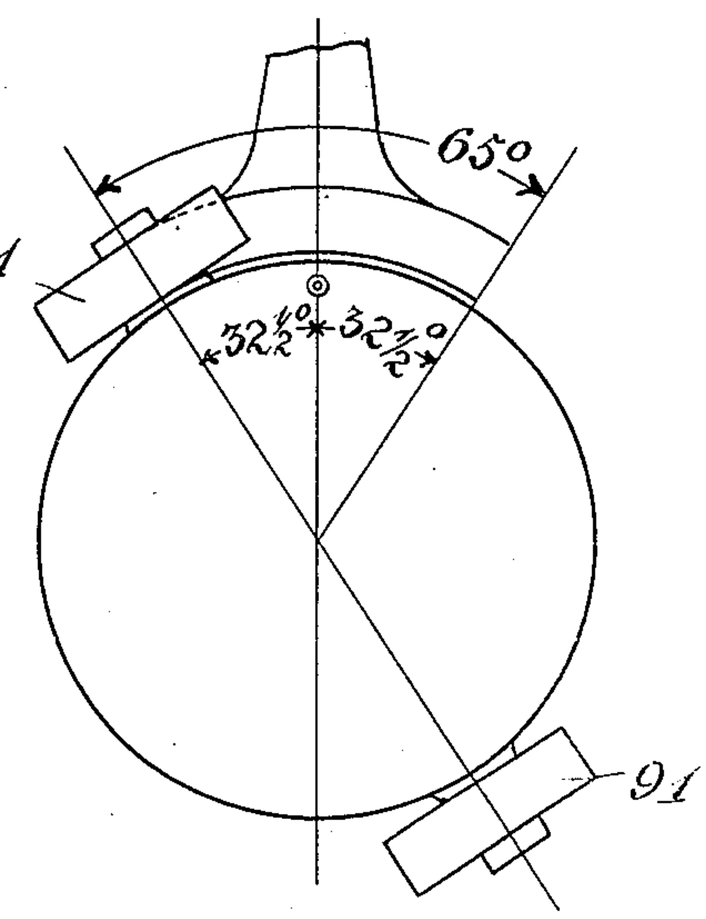
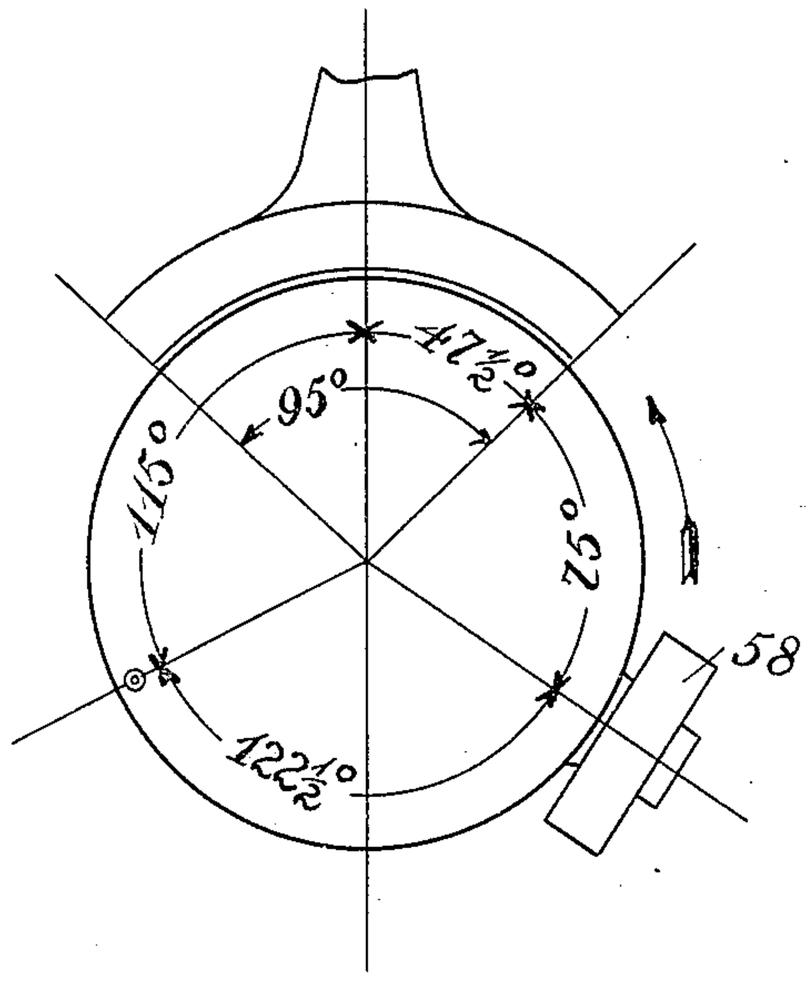
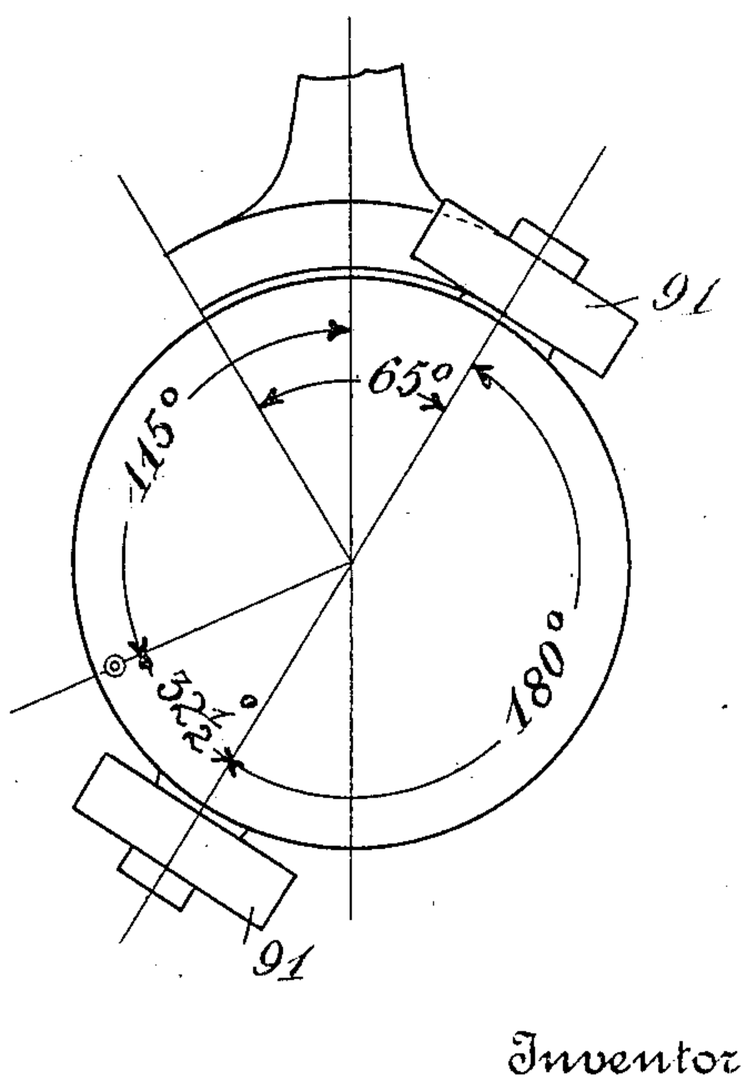



Fig. 23.




Witnesses
C. Hunter
C. H. Griesbauer.

Inventor
D. W. Lyon
by H. Brewson
Attorney

# UNITED STATES PATENT OFFICE.

DAVID WALTER LYON, OF SUTTERCREEK, CALIFORNIA.

## CRUDE-OIL ENGINE.

No. 807,835. Specification of Letters Patent. Patented Dec. 19, 1905.

Application filed December 5, 1904. Serial No. 235,566.

*To all whom it may concern:*

Be it known that I, DAVID WALTER LYON, a citizen of the United States, residing at Suttercreek, in the county of Amador and State of California, have invented certain new and useful Improvements in Crude-Oil Engines; and I do declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

This invention relates to improvements in crude-oil engines.

The object of the invention is to provide an engine of this character which may be easily and quickly transformed into an air-compressor or into a steam or compressed-air engine.

Another object is to provide means whereby the engine may be quickly reversed to cause the same to run in either direction.

A further object is to provide an improved oil-feed or fuel-valve which will be automatically operated at the proper time to inject oil into the engine-cylinder.

With these and other objects in view the invention consists of certain novel features of construction, combination, and arrangement of parts, as will be hereinafter described and claimed.

In the accompanying drawings, Figure 1 is a perspective view of the device arranged as a crude-oil engine. Fig. 2 is an enlarged side elevation of the engine-cylinder, a portion of the base, and the parts arranged thereon. Fig. 3 is an end elevation of the same. Fig. 4 is a longitudinal vertical sectional view through the cylinder and oil-feed valve of the engine. Fig. 5 is an enlarged detail sectional view through the oil-feed cylinder and valve. Fig. 6 is an enlarged detail vertical sectional view through the valve-chambers or steam-chest and a portion of the valve-gear shaft. Fig. 7 is a transverse vertical sectional view of the same. Fig. 8 is an enlarged detail sectional view through the valve-gear shaft, the parts of the same being arranged in different position from that shown in Fig. 6. Fig. 9 is a cross-sectional view of the same on the line 9 9 of Fig. 6. Fig. 10 is a similar view on the line 10 10 of Fig. 6. Fig. 11 is a similar view on the line 11 11 of Fig. 6. Fig. 12 is an enlarged detail vertical sectional view of the valve-gear shaft, showing the manner in which the parts are shifted to reverse the engine. Fig. 13 is an end view of the inner rod or bar of the valve-gear shaft. Fig. 14 is a fragmentary sectional view of the same on the line 14 14. Fig. 15 is a similar view on the line 15 15. Fig. 16 is a diagrammatic view illustrating the various positions of the crank with relation to the action of the exhaust and air valves when the engine is running over. Fig. 17 is a similar view showing the positions of said parts when the engine is running under. Figs. 18 and 19 are diagrammatic views showing the relative positions of the cam-segments for operating the oil-feed valve when the engine is running in one direction or the other. Figs. 20 and 21 are diagrammatic views showing the relative positions of the cam-rollers for actuating the exhaust-valve, and Figs. 22 and 23 are similar views showing the relative positions of the cam-rollers for actuating the air-valve.

In the embodiment of the invention I provide a suitable supporting-base 1, on one end of which is arranged an engine-cylinder 2 and on the opposite end is mounted a crank-shaft 3. Within the cylinder 2 is arranged a reciprocating piston 4, which is connected to the crank-shaft 3 by means of a piston-rod 5. The cylinder 2 is open at the crank-shaft end of the same and is closed at its opposite end by means of a head 6. On one side of the cylinder at the closed end of the same is arranged a combined valve-chamber and steam-chest 7.

In the cylinder-head 6 is formed a centrally-disposed opening in which is arranged a crude-oil-inlet-valve cylinder 8, in which is arranged an oil-inlet valve 9. The valve 9 is disposed within a seat 10, formed in the inner end of the valve-cylinder 8, and is provided with a stem 12, which extends through the cylinder 8 and projects slightly beyond the outer end of the same. The stem 12 is slidably mounted in a guide-collar 13, which is screwed into the valve-cylinder 8 and against which is adapted to bear the inner end of a coil-spring 14, arranged on the valve-stem 12. The opposite end of said spring is adapted to bear against a collar 15, which is screwed upon the valve-stem 12 and is adapted to slide within the valve-cylinder 8. The tension of the spring 14 is exerted to close the valve 9 and to normally hold the same in closed position.

In one side of the valve-cylinder 8 is formed an oil-inlet port 16, which communicates with an annular oil-chamber 17, formed in the in-

ner end of the valve-cylinder and surrounding the valve-seat 10. In the inner wall of the cylinder 8 is arranged a series of small radially-disposed passages 18, which afford communication between the annular chamber 17 and the interior of the valve-seat 10, whereby oil is admitted to the engine-cylinder when the valve 9 is opened. In the opposite side of the cylinder 8 is formed a compressed-air-inlet port 19, which communicates with an annular air-chamber 20, formed in the outer wall of the valve 9, whereby when said valve is opened the compressed air entering through the ports 19 will drive the oil which enters through the port 16 and the passages 18 into the engine-cylinder in the form of a fine spray. The spraying of the oil is facilitated by means of an annular flange or projection formed on the inner ends of the valve 9, against the inner inclined wall of which the oil is driven by the compressed air entering through the port 19 and chamber 20.

The valve 9 is opened by means of a bell-crank tappet-lever 21, which is pivotally mounted between parallel ears or lugs 22, formed on the end of a plug 23, which is adapted to be screwed into the end of the valve-cylinder 8 and through which the outer end of the valve-stem is adapted to slide. In the short arm of the lever 21 is arranged a tappet-pin 24, which is adapted to engage or strike the outer end of the valve-stem, thereby opening said valve. The longer arm of the tappet-lever 21 is pivotally connected to the upper forked end of a trip-arm 25, in the lower end of which is mounted a roller 26. This roller 26 is adapted to be engaged by one or the other of two cam-segments 27 or 27′, which are arranged in the cylindrical head 28 of a sleeve 29, mounted upon the valve-gear shaft 30, which is journaled in suitable bearings on the side of the engine-base. The segmental cams 27 and 27′ are preferably tapered in form and are adapted to be projected and retracted into and out of operative position by a suitable mechanism, hereinafter described.

To the lower end of the trip-arm 25 is pivotally connected the inner end of a link 31, the opposite end of which is connected to a suitably-mounted bell-crank lever 32. The short arm of the bell-crank lever 32 is forked and adapted to engage an annular groove 33, formed in a sleeve 34, which is slidably mounted upon a governor-shaft 35, to the upper end of which are pivotally connected the arms 36 of governor-balls 37. The upper end of the sleeve 34 is connected to the arms 36 by means of links 38, whereby the movement of the valve 9 will be automatically regulated and controlled by the governor of the engine.

The governer-shaft 35 is revolubly mounted in suitable bearing-brackets 39, which are secured to the base of the engine, and on said governor-shaft is fixed a beveled gear-pinion 40, which is adapted to mesh with a similar gear-pinion 41. Said gear-pinion 41 is fixed on the end of the valve-gear shaft 30, on the opposite end of which is slidably mounted a broad spur-gear pinion 42, which is in mesh with and is driven by a spur-gear pinion 43, fixed on the end of a driving-shaft 44, which is mounted in suitable bearing-brackets 45, arranged on the base of the engine. On the opposite end of the shaft 44 is fixedly mounted a worm-gear 46, which is engaged and driven by a worm 47, fixedly mounted upon the crank-shaft 3 of the engine. By this arrangement the motion of the crank-shaft is imparted to the valve-gear shaft and through the governor. As the speed of the engine increases the governor-shaft will be rapidly revolved, the centrifugal motion of the same forcing the balls 37 and arms 36 outwardly, thus drawing the sleeve 34 upwardly and rocking the lever 32, which causes the longer arm of the same, through the link 31, to draw the trip-arm toward the outer end of the head 28 in position to be engaged by the narrow portion of the segments 27 or 27′, so that when said arm is engaged by the narrow portions of the cam-segments the action of the tappet-lever controlled thereby will be short and quick, thus holding the valve 9 open to a very slight degree and to remain open for a very limited time, thereby permitting but a small amount of oil to be injected into the engine-cylinder, thus decreasing the force of the explosion occurring in said cylinders and reducing the speed of the engine. As the speed of the engine reduces the centrifugal motion of the governor will also be decreased, which will allow the balls 37 and arms 36 to drop, thus lowering the sleeve 34 and actuating the lever 32 to cause the trip-arm 25 to be moved back in position to be engaged by the larger portion of the cam-segments, which will cause the arm, through the tappet-lever 21, to hold the valve open a greater length of time and at an increased distance, thereby admitting more oil to the engine-cylinder. By this arrangement the movement of the engine will be automatically controlled to cause the same to run at a uniform speed.

In the engine-cylinder is formed an exhaust port or passage 49, which opens into the steam-chest or valve-chamber 7. With the port or passage 49 communicates an exhaust-passage 50, which communicates with a discharge-opening 50′, arranged in the lower portion of the chest 7. Between the exhaust-port 49 and the passage 50 is arranged an exhaust-valve 51, the stem 52 of which projects through the end of the chest 7 and has arranged on its outer end a collar 53, between which and the adjacent end of the chest is arranged a coil-spring 54.

Pivotally mounted in suitable bearing-brackets 55, which are arranged on the engine-base, is an exhaust tappet-arm 56, the upper arm of which is adapted to engage the outer end of the exhaust-valve stem 52. The

lower end of the arm 56 is forked, said forked ends being beveled on their lower ends, as shown at 57, and adapted to be engaged by a cam-roller 58, which is journaled on the side of a cylindrical head or collar 60. The cylindrical head or collar 60 is arranged on the valve-gear shaft 30, adjacent to the lower end of the tappet-arm 56, whereby when said valve-gear shaft is revolved the cam-roller 58 will be brought into engagement with the forked beveled lower ends of the exhaust tappet-arm 56, thereby rocking said arm, causing the same to open the exhaust-valve 51. Said valve is held open during the time the cam-roller is passing across the lower end of the tappet-arm and is automatically closed by the spring 54 as soon as the cam-roller has left the lower end of the tappet-arm.

In the passage 50 is arranged a rotary valve 61, which when turned in one direction will afford communication between the passage 50 and the discharge-opening 50′ and which when turned in the opposite direction will cut off the passage 50 from said opening and open the same into an air-discharging passage 62, which is normally closed by a spring-actuated check-valve 63. The valve 63 is mounted in an apertured plug 64, screwed into the lower end of the passage 62, and to the lower end of said plug is adapted to be screwed a suitable pipe or conductor which is adapted to communicate with an air receiver or tank. (Not shown.) The stem 65 of the valve 61 extends through the side of the chest 7, and to the same is connected an operating hand-lever 66, whereby the valve may be turned to open or close the air and exhaust passages hereinbefore described.

In the opposite side of the chest 7 from that containing the passage 50 is arranged a chamber 67, which communicates with the port 49. Between the exhaust-port 49 and the chamber 67 is arranged an air-valve 51′, provided with a stem 52′, which projects through an aperture formed in a plug which is screwed into the opposite end of the chest 7. On the outer end of the stem is arranged a collar 53′, between which and the plug in the end of the chest is arranged a coil-spring 54′, by which said valve is normally held in closed position. On the stem 52′ of the valve is arranged a disk 68, which is of greater diameter than the valve 51′, so that the pressure of air in the chamber 67 will cause the same to aid the spring 54′ in closing the valve 51′. In the lower portion of this end of the chest is arranged an air passage or port 62′ and a steam or compressed-air inlet port or passage 63′. Arranged in the chamber 67 of the chest is a rotary valve 61′, which is preferably of the Corliss type and corresponds to the valve 61 of the chamber 50 in the opposite side of the chest. The valve 61′ when turned in one direction will open the air-passage 62′ and close the steam port or passage 63′ and when turned in the opposite direction will close the steam-port 63′ and open the air-port 62′.

The stem of the valve 61′ is adapted to project through the side of the chest 7, and connected to the projecting end of the same is a hand operating-lever 66′, by which the valve may be turned to open or close the ports 62′ and 63′.

When using the device as a crude-oil engine, the valve 61′ is turned to open the air passage or port 62′ and to close the steam-passage 63′. The valve 51′ acts as a simple spring-valve and admits a full charge of air during the suction cycle of the piston, this air being drawn through the open air passage or port 62, formed in the chest 7. The air thus drawn in is compressed in the end of the cylinder upon the return stroke of the piston to one-thirtieth of its volume, thereby heating the same to such a degree that when oil is forced into the cylinder through the crude-oil valve 9, as hereinbefore described, said oil will be ignited by the heated air, thus causing an explosion which will drive the piston outwardly again, said piston being returned by the momentum or inertia of the fly-wheel, as will be understood.

Having thus described the arrangement and operation of the device when used as a crude-oil engine, I will now proceed to describe the arrangement and action of the same when used as an air-compressor. In changing the device from an oil-engine to an air-compressor the lever 66 is thrown forwardly to the position shown in dotted lines in Fig. 2 of the drawings, thereby turning the valve 61 to cause the same to close the exhaust-passage 50 from the exhaust-opening 50′ and to connect the air-passage 62 with the passage 50, so that air can pass through the check-valve 63 from the exhaust-port of the engine-cylinder, from which it is conducted to the air-receiver, as hereinbefore described.

On the lower end of the hand-lever 66 is formed an eccentric projection, to which is pivotally connected the upper end of a connecting rod or link 69. The rod or link 69 consists of a tubular sleeve 70, in which is arranged a rod 71, said rod and tube being yieldingly connected by means of a coil-spring 72, which is arranged around the tube or sleeve 70. The upper end of the rod 71 is pivotally connected to the eccentric projection on the lower end of the lever 66, and the opposite end of the tubular sleeve 70 is pivotally connected to the outer end of a forked bell-crank lever 73. The forked arm of the bell-crank lever 73 is adapted to have a loose pivotal engagement with the inner end of the sleeve 29, which is slidably mounted upon the valve-gear shaft 30, whereby when said hand-lever is thrown to the dotted-line position said bell-crank lever may be actuated to slide the sleeve 29 and the segment-carrying head 28 along said valve-

gear shaft and into engagement with the head 60 on said shaft.

The valve-gear shaft 30 is formed in two telescoping sections. The outer section of the same is in the form of a cylindrical tube 74, which is open at its forward end and closed at the opposite end. The inner section of the shaft is in the form of a cylindrical rod or bar 75, which is adapted to slide within the tube 74. Said sliding telescoping movement of the rod is limited by means of a pin 76, which passes through said outer section 74 and through a slot 77, formed in the inner section or bar 75. On the inner end of the inner section or bar 75 are formed two longitudinally-disposed grooves or recesses 78 and 79, which are adapted to be brought into alinement with slots 80 and 81, formed in the outer tubular section of the shaft.

The segments 27 and 27′, which are carried by the head 28 on the end of the sleeve 29, have formed on their inner side apertured shanks 82, which are adapted to project through radially-disposed passages formed in the head 28 and through the slots 80 and 81, formed in the tubular section 74 of the valve-gear shaft, whereby when either the outer tubular section 74 or the sleeve 29 is moved to the proper position to bring the slots 80 or 81 into alinement with either of the grooves 78 or 79 formed in the end of the inner bar or section of the valve-gear shaft said cam-segments will be forced inwardly by means of a coil-spring 83. The coil-spring 83 is arranged in the aperture formed in the shanks of said cam-segments, thereby drawing said cam-segments into seats or recesses 84 and 85, formed in the head 28, thus causing the outer surface of said cam-segments to lie flush with the surface of said head, by which arrangement said cam-segments are brought to an inoperative position, so that the same will not engage the trip-arm 25 of the oil-inlet valve, thus cutting off the oil-supply from the engine. When the sleeve 29 has been shifted by the hand-lever 66 to bring the head 28 into engagement with the head 60, as hereinbefore described, the inner ends of the shanks on the cam-segments 27 and 27′ will be moved through the slots 80 and 81 until the same reaches a position over the groove 78 and 79, formed in the end of the bars 75 of the valve-gear shaft. At this point the springs 83 will force the ends of the shanks into said grooves, thereby retracting the cam-segments into the recesses 84 and 85 and causing the same to lie flush with the outer surface of the head 28, and thus preventing the same from engaging the end of the trip-arm 25, which will prevent the operation of the oil-inlet valve, as hereinbefore described, thus enabling the device to be used as an air-compressor, and when so used the crank-shaft may be operated by any suitable driving mechanism to actuate the piston 4 in the engine-cylinder.

When using the device as an air-compressor, the exhaust-valve 51 will be actuated in the same manner as described in connection with the oil-engine, except that in addition to the cam-roller 58, which operates the exhaust tappet-arm 56, a second cam-roller 58′ will be employed. Said roller is journaled on the outer side of a lug or projection 87, formed on the outer end of the head 28, the lug or projection 87 being adapted to engage a groove or channel 88, formed in the side of the head or collar 60 in the opposite side of the same from the cam-roller 58, when said head 28 and sleeve 29 are shifted by the hand-lever 66, as hereinbefore described. By bringing the second cam-roller 58′ into position to engage the tappet-arm 56 the exhaust-valve 51 will be opened twice as often as when actuated by a single cam-roller, thus permitting the air to be rapidly discharged from the air-compressor cylinder into the chamber 50, from whence it passes through the port or passage 62, forcing the check-valve 63 open and passing through the apertured plug 64 into the pipe, by which it is conducted to a suitable receiving-tank.

Having thus described the arrangement and operation of the device when used as an air-compressor, I will now proceed to describe the operation and arrangement of the same when used as a compressed-air or steam engine. In transforming the device into a steam or compressed-air engine the hand-lever 66′ is actuated to turn the valve 61′ into position to close the air port or passage 62′ and to open the steam or compressed-air passage 62′, with which is adapted to be connected a pipe leading from a steam-generator or compressed-air tank. (Not shown.) The steam or compressed air will enter through the passage 63′ into the chamber 67, and in order to admit the same through the port 49 into the engine-cylinder at the proper time suitable means are provided for actuating the air-valve 51′ to admit the air or steam to said cylinder. The mechanism actuating said valve is here shown as consisting of a tappet-arm 89, which is pivotally mounted upon the side of the engine-cylinder, the lower end of the arm being forked or bifurcated. Said forked or bifurcated ends are beveled, as shown at 90. The lower forked end of the tappet-arm 89 is adapted to be engaged by cam-rollers 91, which are pivotally mounted upon laterally-projecting studs 92, which are arranged on opposite sides of a collar 93, said collar being slidably mounted upon and rotated by the valve-gear shaft 30. The collar 93 is adapted to be shifted upon the valve-gear shaft to bring the rollers in position to engage the end of the tappet-arm by means of a bell-crank lever 94, the forked lower arm 95 of which is pivotally connected to a loose ring or band 96. This ring or band 96 is engaged with an annular groove or channel formed in the collar 93. The opposite or upper arm of the bell-crank lever 94 is piv-

otally connected to a bell-crank lever 97, which is pivotally mounted upon the engine-cylinder, the opposite arm of said lever having formed thereon a laterally-projecting pin or stud 98. Said pin or stud 98 is adapted to engage a cam-slot 99, formed in an eccentrically-disposed projection on the lower end of the hand-lever 66′, whereby when said lever is operated to cause the valve 61′ to open the steam-inlet port or passage 63′ the bell-crank lever 97 will be actuated to cause the bell-crank lever 94 to shift said collar 93, thereby bringing the cam-rollers 91 into position to engage the tappet-arm, thus causing said tappet-arm to open the valve at every revolution of the crank-pin as the same passes over the center and to hold said valve open until the crank-pin passes over one hundred and thirty degrees of its cycle. After the cam-rollers pass the end of the tappet-arm 89 the valve 51′ will be automatically closed by the spring 54′ and the pressure of air upon the balancing-disk 68, which is arranged upon the valve-stem 52′ within the chamber 67. The steam or compressed air entering the engine-cylinder through the port 49 will drive the piston outwardly, said piston being moved inwardly again by the momentum or inertia of the fly-wheel. The compressed air or steam is exhausted upon the return of the piston through the port 49, said exhaust being controlled by the exhaust-valve 51 in the same manner as described with the device when used as a crude-oil engine.

When the engine is running on steam or compressed air, the sleeve 29, carrying the segments which operate the oil-valve, will be shifted by the hand-levers 66′ through a connecting-link 69′, which is similar in construction to the link 69 and is connected to an eccentric projection on the lower end of the lever 66′ and to the forked bell-crank lever 73 in the same manner as described in connection with the lever 66, thereby moving the oil-valve-operating mechanism out of operative position.

One of the main features of this engine is its reversing-valve mechanism, by means of which the engine may be started in either direction, said mechanism consisting in providing the broad or elongated gear 42, with which the pinion 43 on the short driving-shaft 44 is in mesh. Said elongated gear is slidably mounted on the outer tubular portion 74 of the valve-gear shaft and connected at its outer end to the inner telescoping rod or bar 75 of the shaft by means of an apertured plate or disk 100, through which the reduced end of the rod is adapted to pass, and on the projecting end of said rod are screwed clamping-nuts 101, thereby connecting said rod to the disk. On the tube 74 is formed a helical thread 102, which is adapted to be engaged by a similar thread 103, formed in the inner wall of the elongated gear-wheel 42, whereby when said gear is shifted on said tube 74 in one direction or the other the latter will be turned. This movement of the tube 74 will also turn the heads or collars 60 and 93, which carry the exhaust and air valve operating rollers, thereby causing said rollers to engage the valve-operating tappet-arms at one or the other side of the same, which will cause the valves to open at the proper time to cause the engine to run over or under, as the case may be. The position of said rollers is shown diagrammatically in Figs. 13 and 20 of the drawings. By referring to Fig. 20 it will be seen that the cam-roller is exactly one hundred and twenty-two and one-half degrees from zero-point and seventy-five degrees from the exhaust-valve tappet-arm. The arc of contact of the roller with the tappet being ninety-five degrees, it is plain that as the engine turns over the cam-rollers will perform their proper functions at the right time of the piston's stroke. By reference to Fig. 21 it will be seen that should the valve-gear shaft be turned back one hundred and fifteen degrees, so that a line passing through its zero-point to its central axis would form an angle of one hundred and fifteen degrees with a line passing through the zero-point of the driving-pinion to its axis, it would place the cam-rollers in position to open the valves at the proper time when the engine is running under. This action would affect both the air and exhaust valves alike and is accomplished by sliding the elongated gear 42 outwardly on the end of the tubular portion of the valve-gear shaft, as hereinbefore described. The elongated gear 42 is adapted to be shifted on said tubular portion of the shaft by means of a shifting-lever 104, which is pivotally connected to the engine-cylinder, as shown. As the gear 42 is shifted upon the tubular portion 74 of the valve-gear shaft, the telescoping rod or bar 75 will be drawn outwardly, thereby bringing the recesses or grooves 78 and 79, formed in the inner end of the same, into position to cause the oil-valve-operating segments to be projected or retracted to rock the tappet-lever 21 and open the oil-valve at the proper time with regard to the direction in which the engine is running. By reference to Fig. 18 of the drawings it will be seen that the striking-points of the valve-operating segments are placed at one hundred and fifteen degrees from each other. When the rod or bar 75 is pulled outwardly by the movement of the gear-wheel 42, the segment 27, which operates the oil-valve when the engine is running over, it will be caused to drop down flush with the surface of the head 28, the shank of said segment being forced through a slot 80, formed in the tubular sections of the valve-gear shaft and into the groove 78 in the end of the rod 75, which has been brought into alinement with said slot through the shifting of said rod. Simultaneously with the dropping of the seg-

ment 27 through the movement of the rod 75 the segment 27′, which operates the oil-valve when the engine is running under, will be forced outwardly into operative position by means of a projection 79′, formed in the groove or channel 79 of the valve-gear rod 75. This action of the valve-gear rod causes the proper segment to be projected into operative position at the correct time to cause the oil-valve to be opened at the proper time with respect to the direction in which the engine is running.

Having thus described my invention, what I claim as new, and desire to secure by Letters Patent, is—

1. In an engine of the character described, the combination with a cylinder, of a reciprocating piston mounted therein, a fuel-valve arranged in one end of said cylinder, said valve having a flaring end to serve as a deflector for the fuel, a valve-seat for said valve provided with a series of radially-arranged jets or apertures for injecting the fuel in a spray into the cylinder when the valve is opened, and means whereby said engine may be changed from an oil-engine to an air-compressor, or to a steam or compressed-air engine, substantially as described.

2. In an engine of the character described, the combination with a cylinder, a reciprocating piston mounted therein, a fuel-valve arranged in one end of said cylinder, said valve having a flaring inner end, a valve-seat for said valve having an annular series of fuel-jets, a valve-chest arranged on one side of said cylinder, air inlet and exhaust valves arranged in said chest, and means whereby said engine may be changed from a crude-oil engine to an air-compressor, or to a steam or compressed-air engine, substantially as described.

3. In an engine of the character described, the combination with a cylinder, of a reciprocating piston mounted therein, a fuel-valve arranged in one end of said cylinder, said valve provided with a fuel-deflector on the inner end thereof, a valve-seat having an annular series of jets or openings, a valve-chest arranged on one side of said cylinder, air inlet and exhaust valves arranged in said chest, a revolubly-mounted valve-gear shaft, mechanism actuated by said shaft for controlling said valves, means to primarily adjust said valves whereby said engine may be transformed from a crude-oil engine to an air-compressor, or to a steam or compressed-air engine, and means whereby the valve-controlling mechanism actuated by said shaft may be arranged to drive said engine in either direction when running as an oil, a steam or a compressed-air engine, substantially as described.

4. In an engine of the character described, the combination with a cylinder, of a reciprocating piston mounted therein, a fuel-valve arranged in one end of said cylinder, said valve being provided with a deflector-flange, a valve-seat for said valve, said valve-seat being provided with an annular series of fuel jets or openings, means whereby said valve is operated at the proper time with respect to the direction in which said engine is running, an air-inlet valve, an exhaust-valve, and means for operating said valve, substantially as described.

5. In an engine of the character described, the combination with a cylinder, of a reciprocating piston mounted therein, a governor-controlled fuel-valve arranged in one end of said cylinder, a deflector-flange on said valve, a valve-seat provided with a series of fuel-jets, a revolubly-mounted valve-gear shaft, means carried by said shaft whereby said valve is operated, an air-valve adapted to be opened by the suction-stroke of said piston, an exhaust-valve, and means carried by said valve-gear shaft whereby said exhaust-valve is operated, substantially as described.

6. An engine provided with a piston-cylinder and piston therein, a valve to admit fuel to said cylinder, said valve having a deflector-flange, a valve-seat provided with an annular series of fuel-jets, means for throwing said valve into and out of operation, an inlet-valve, a duct leading to the cylinder and controlled by the inlet-valve, an air-duct and a duct for compressed fluid leading to the first-mentioned duct, means to establish communication between either the air-duct or the fluid-duct and the first-mentioned duct, an exhaust-valve, an exhaust-duct controlled thereby, said exhaust-duct having a plurality of discharge-ports, a valve in one of said ports, and means to establish communication between said exhaust-duct and either of said ports, whereby said engine may be used either as an internal-combustion engine, a steam or compressed-fluid engine, or a fluid-compressor at will, substantially as described.

In testimony whereof I have hereunto set my hand in presence of two subscribing witnesses.

DAVID WALTER LYON.

Witnesses:
THOMAS J. BENNETTS,
FRED WERNER.