(No Model.)

4 Sheets—Sheet 1.

L. C. WORRON.

MULTI-CYLINDER ENGINE.

No. 501,983. Patented July 25, 1893.

FIG 2.

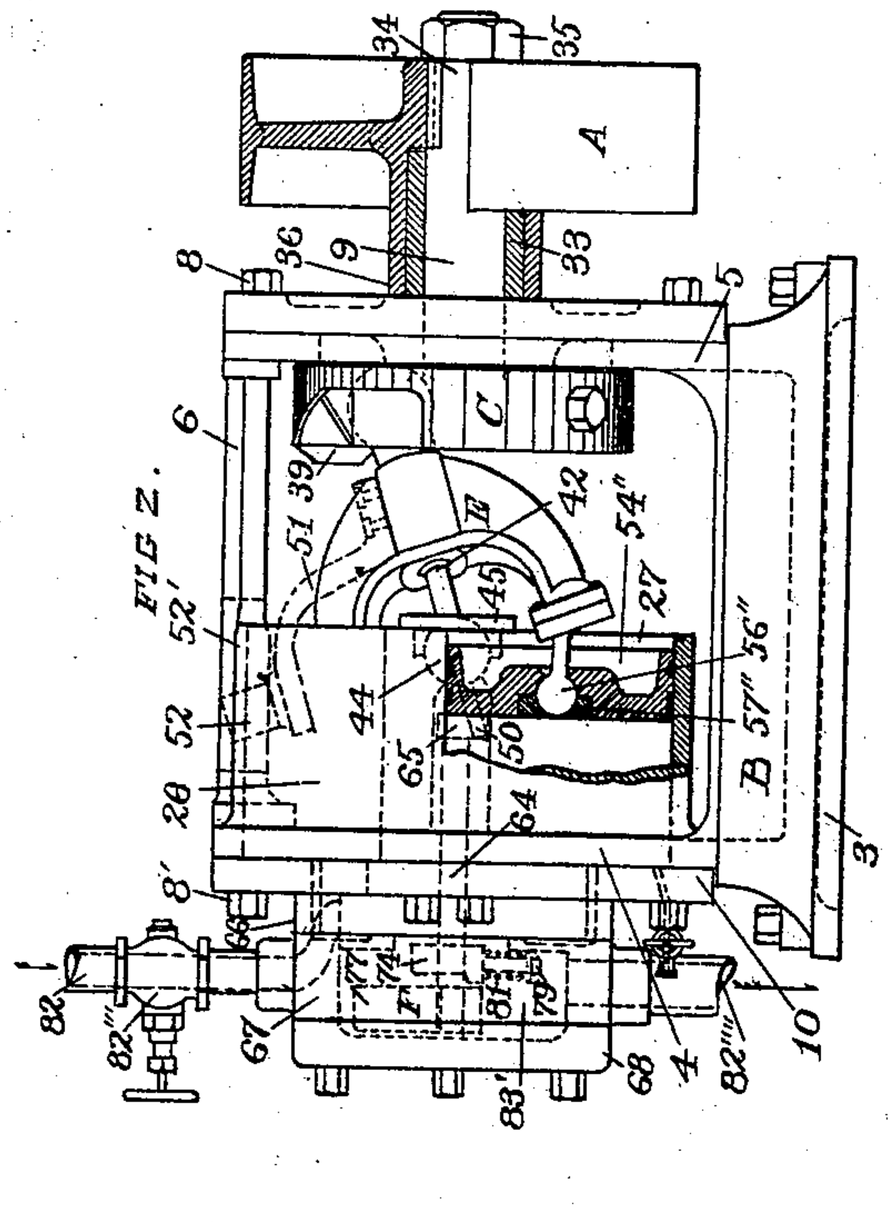

FIG 1.

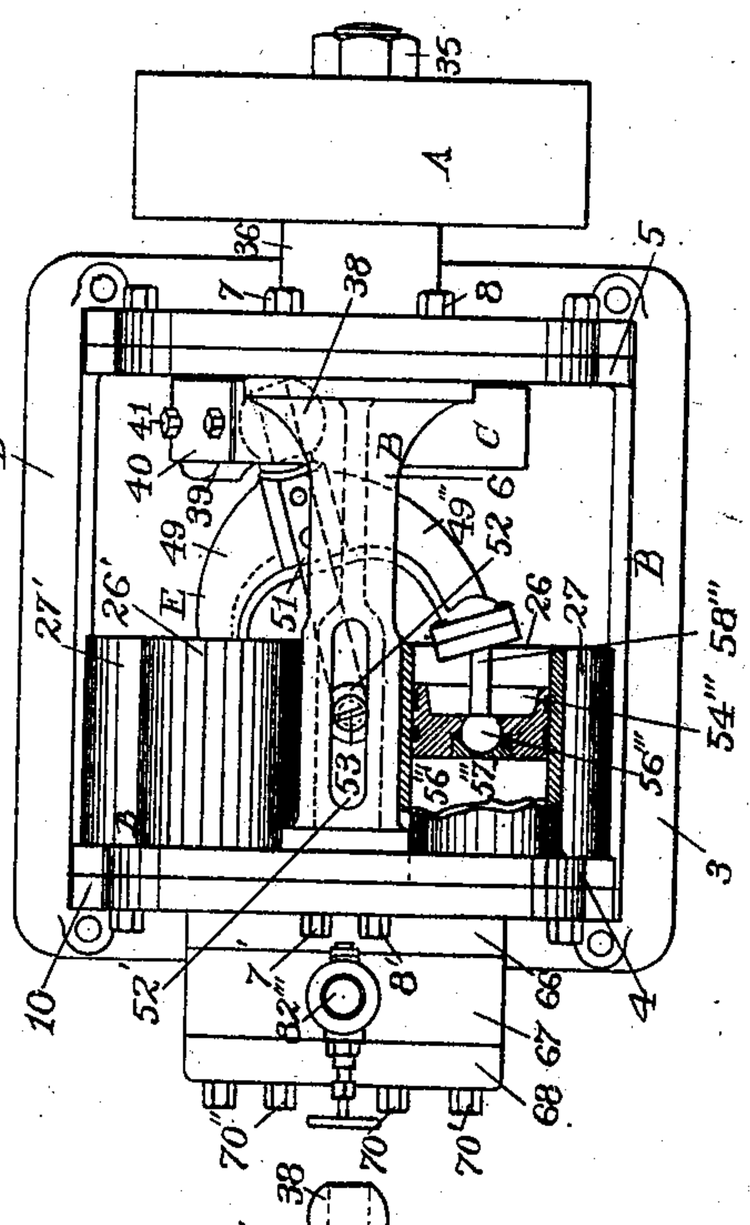

FIG 3.

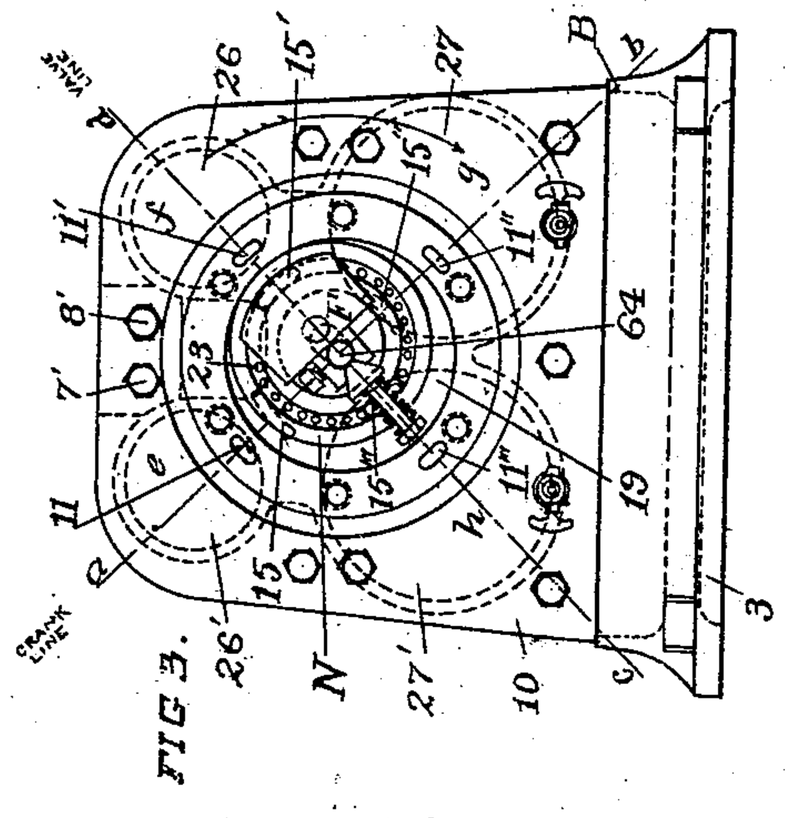

FIG 4.

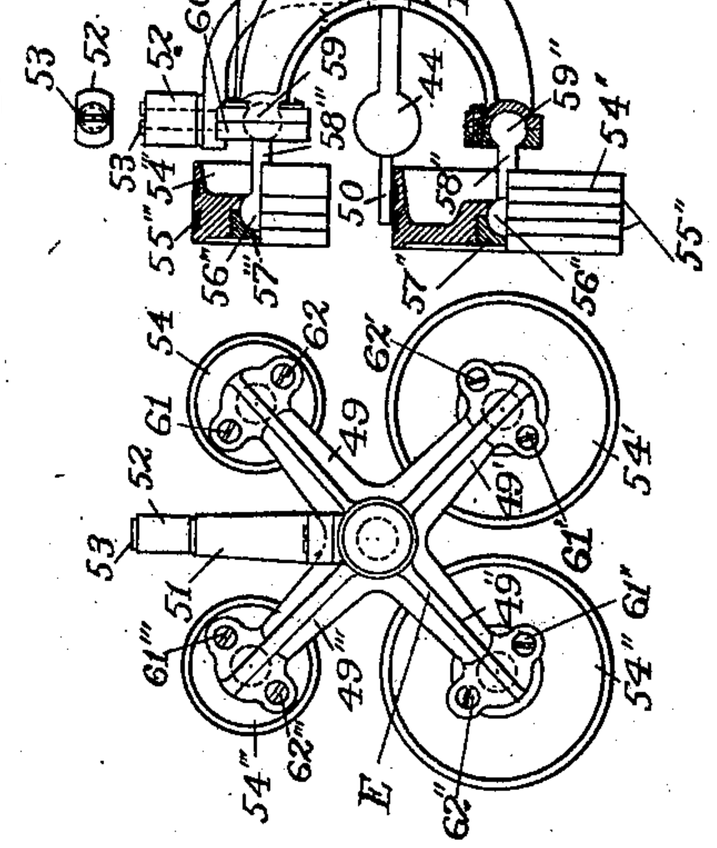

FIG 5.

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(No Model.)

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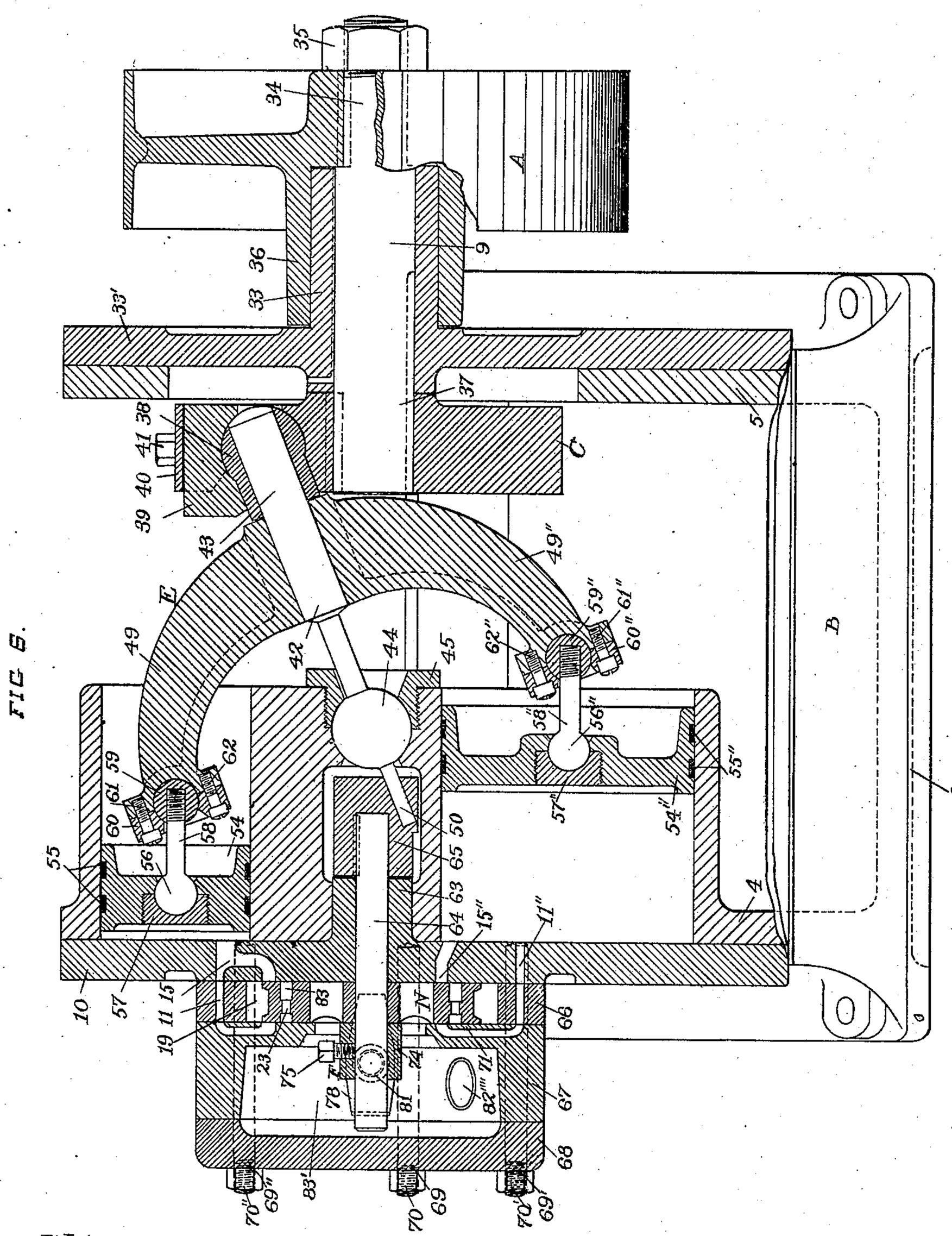
FIG 5.



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4 Sheets—Sheet 3.

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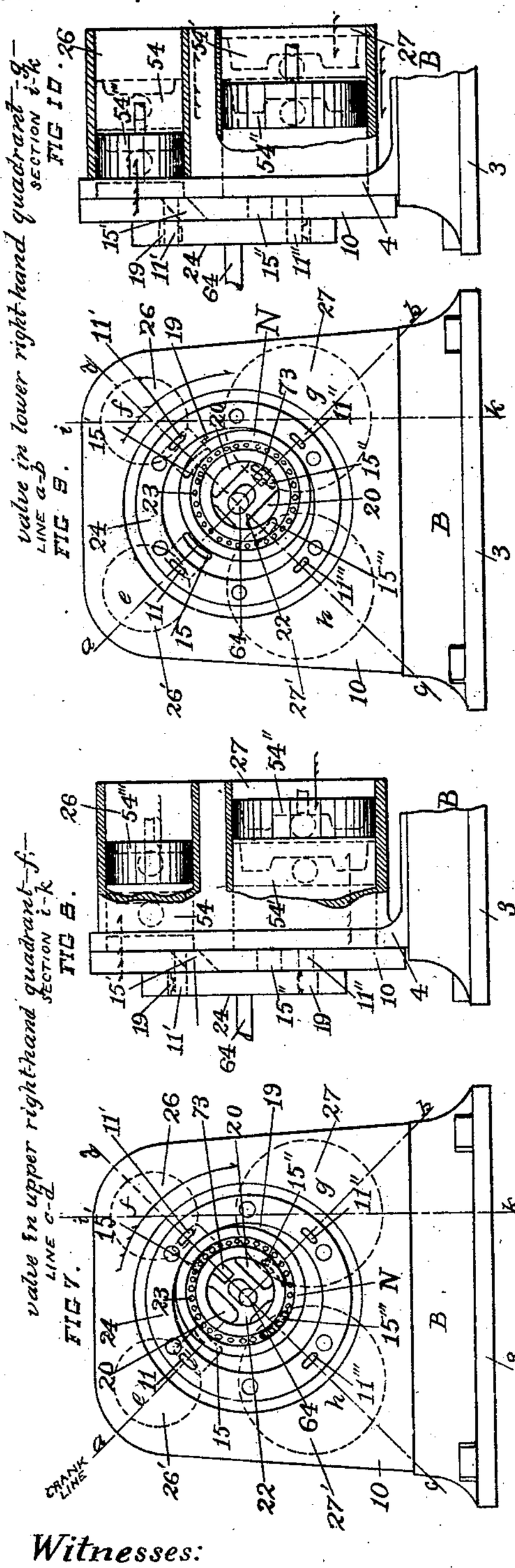
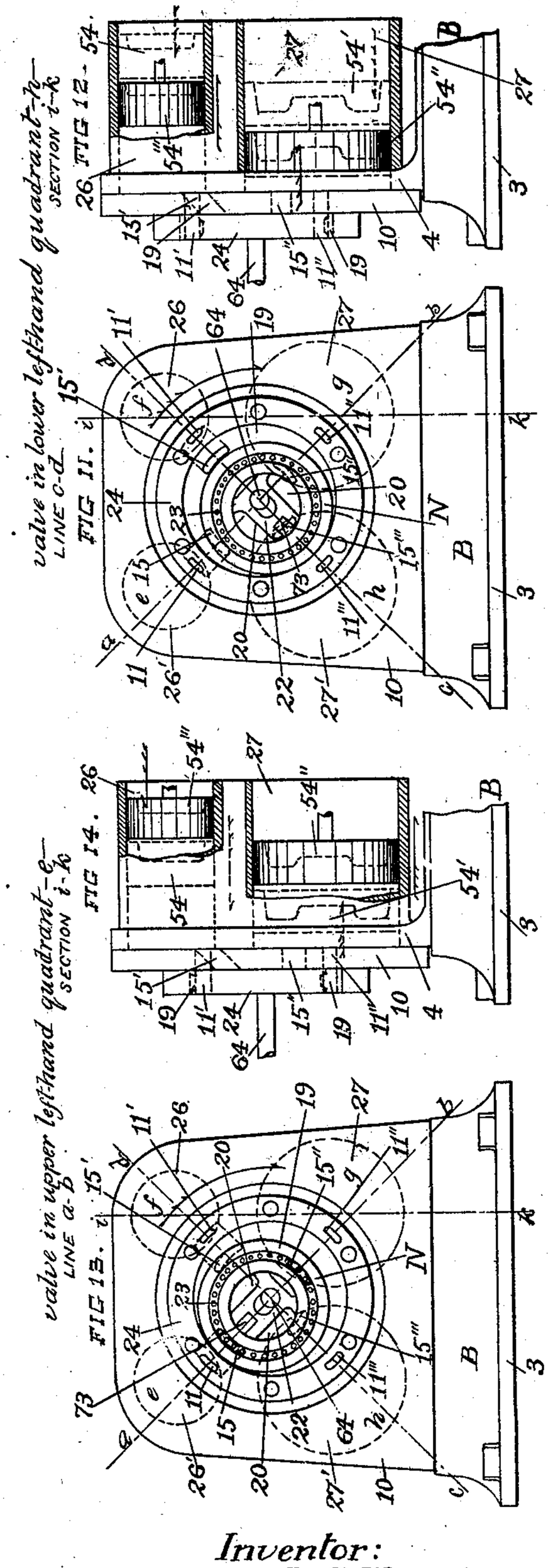
MULTI-CYLINDER ENGINE.

No. 501,983.

Patented July 25, 1893.





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4 Sheets—Sheet 4.

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MULTI-CYLINDER ENGINE.

No. 501,983. Patented July 25, 1893.

FIG 16.

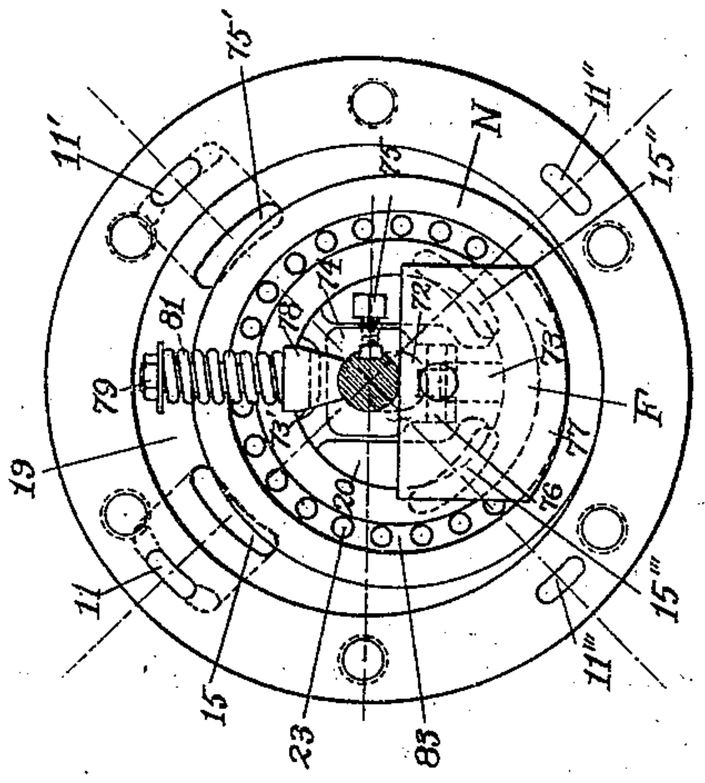

FIG 20.

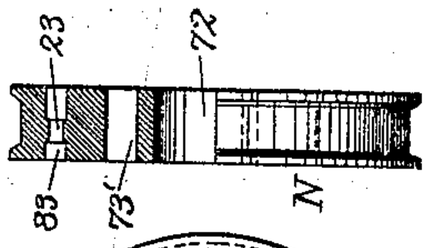

FIG 19.

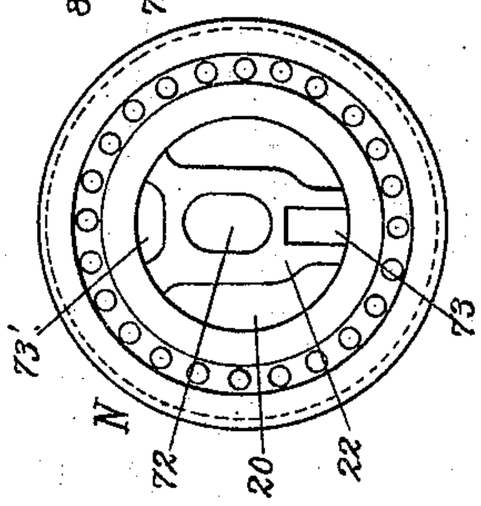

FIG 15.

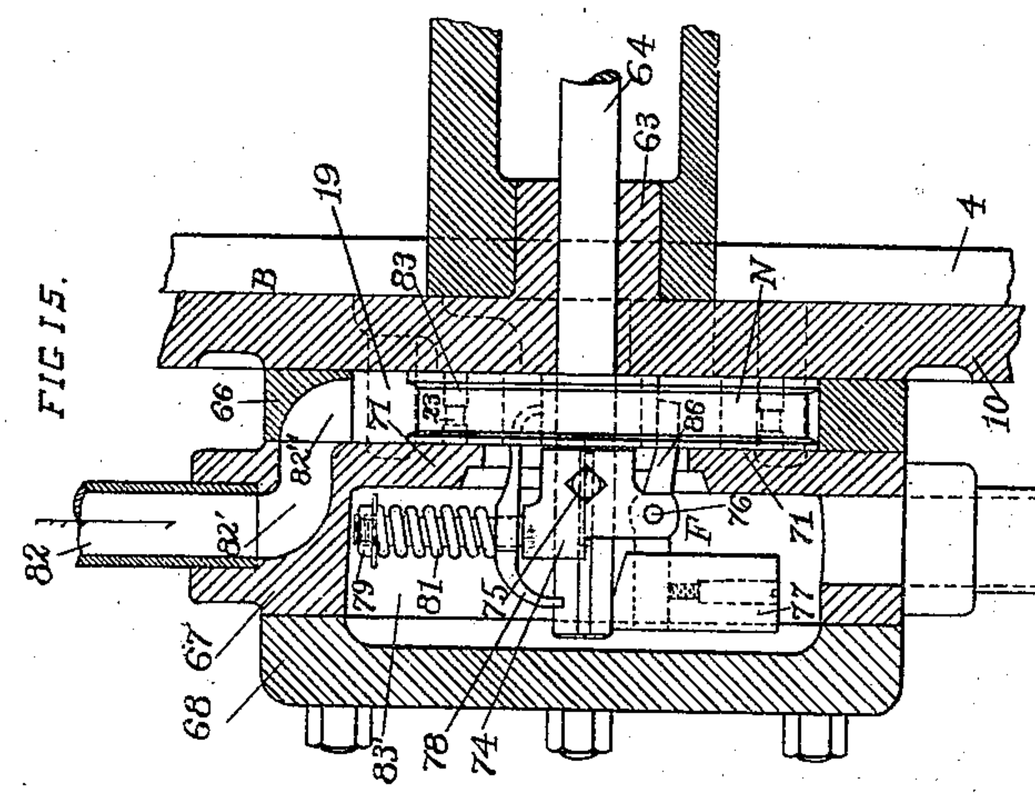

FIG 18.

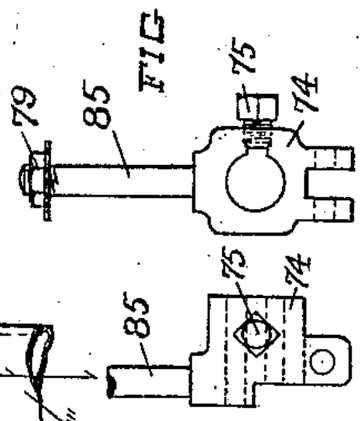

FIG 17.

82'''

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By his Attorney
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UNITED STATES PATENT OFFICE.

LEWIS C. WORRON, OF HARTFORD, CONNECTICUT, ASSIGNOR TO ABRAHAM VANDERBEEK, OF SAME PLACE.

MULTI-CYLINDER ENGINE.

SPECIFICATION forming part of Letters Patent No. 501,983, dated July 25, 1893.

Application filed December 10, 1892. Serial No. 454,708. (No model.)

To all whom it may concern:

Be it known that I, LEWIS C. WORRON, a citizen of the United States, residing at Hartford, in the county of Hartford and State of Connecticut, have invented certain new and useful Improvements in Multi-Cylinder Engines, of which the following is a specification.

This invention relates to that class of multi-cylinder engines having a series of single-acting cylinders connected with a single crank-shaft through a rocking-beam common to all of the cylinders.

The object of the invention is to furnish an engine of the class specified of improved construction and adapted for using the steam by successive expansions.

In the drawings accompanying and forming a part of this specification, Figure 1 is a plan view of a compound steam-engine embodying my present invention. Fig. 2 is a side elevation of the engine, partially in section, as seen from below in Fig. 1. Fig. 3 is an elevation of the rear end of the engine, drawn in projection with Fig. 2; the steam-chest cover being removed to show the valve-mechanism. Fig. 4 is a side view, corresponding approximately to a portion of Fig. 2, and showing the rocking-beam connected with the pistons. Fig. 5 is an end elevation of the parts shown in Fig. 4, as seen from the right-hand of said figure. Fig. 6 is an enlarged sectional elevation, in line *a b*, Fig. 3. Fig. 7 is a view similar to Fig. 3, showing the regulator-mechanism removed from the valve-shaft, and showing the valve in one of its "quarter" positions. Fig. 8 is a diagrammatic side view of the cylinder end of the engine, showing the series of pistons in positions corresponding to the position of the valve in Fig. 7. Fig 9 is an end elevation similar to Fig. 7, showing the valve advanced one-quarter of a revolution from its position in Fig. 7. Fig. 10 is a diagrammatic side view similar to Fig. 8, showing the series of pistons in positions corresponding to the position of the valve in Fig. 9. Fig. 11 is an end elevation similar to Figs. 7 and 9, showing the valve advanced one-quarter of a revolution from its position in Fig. 9. Fig. 12 is a side elevation similar to Figs. 8 and 10, showing the series of pistons in positions corresponding to the position of the valve in Fig. 11. Fig. 13 is another end elevation, showing the valve advanced one-quarter of a revolution from its position in Fig. 11. Fig. 14 is another diagrammatic side elevation, showing the series of pistons in positions corresponding to the position of the valve in Fig. 13. Fig. 15 is an enlarged, vertical, longitudinal section through the valve-mechanism. Fig. 16 is an end elevation (the valve-chest cover being removed) of the parts shown in Fig. 15, as seen from the left-hand in said figure. Fig. 17 is a side view, and Fig. 18 an end view, of the regulator-carrier. Fig. 19 is a side view of the annular valve. Fig. 20 is an edge view of the valve, partially in section, and drawn in projection with Fig. 19.

Similar characters designate like parts in all the figures.

The framework of my improved compound engine may be of any construction adapted for carrying and supporting the several fixed and operative details.

In the drawings I have shown a preferred form of framework, which is designated in a general way by B, and consists of a base-plate, 3, the rearward end-wall 4, the forward end-wall 5, and a connecting guide-bar, 6, set between said end-walls at the upper sides thereof and held in place by means of suitable screws, as 7 and 8, 7′ and 8′. For carrying the main-shaft 9, this is shown fitted within a tubular bearing, 33, fixed to the forward end-wall 5 by means of suitable bolts, as 8. The outer end of the main-shaft 34 carries a suitable driving-pulley, as A, which is shown held in place on the shaft by means of the nut 35, and having the tubular hub 36 fitting over the projecting tubular bearing 33, (see Figs. 1 and 2,) for furnishing an additional support and bearing-surface for said driving-pulley.

The inner end of the main-shaft 37 carries the crank-disk C rigidly fixed thereto; this disk has on one side thereof a bearing for a tubular journal-socket, 38, which is shown held in place in said bearing by means of the bearing-block 39, the cap 40, and the screws 41.

For communicating power from the pistons of the engine to the crank-disk C, I provide

a rocking-beam, designated in a general way by E, and adapted to have a "universal rocking movement." Said beam E is carried upon the driving-spindle, or lever-shaft, 42, whose projecting stem 43 engages and revolves in the aforesaid journal-socket 38, as shown best in Fig. 6. The driving-spindle 42 is supported to have (together with the rocking-beam itself) a universal rocking motion, by means of a spherical journal, 38, formed on said stem and journaled in a corresponding bearing formed in the framework; said journal 44 being held in place by means of the cap 45 screwed into the framework as illustrated in Fig. 6. The spherical journal of said rocker-spindle is shown located in the plane substantially of the ends of the four beam-arms 49, 49′, 49″ and 49‴ of the main-beam E. Beyond said spherical bearing thereof, the driving-spindle has a rearward projecting stem, 50 (see Figs. 4 and 6) for driving the valve-mechanism of the engine, as hereinafter described.

For controlling the movements of the rocking-beam E and preventing rotation thereof, this beam is shown provided with a guide-arm, 51, carrying a guide-block, 52, located in a longitudinal plane bisecting or intermediate to the angle or planes of the beam-arms 49 and 49‴, as illustrated by the detail views Figs. 4 and 5. The guide-block 52 is fitted to work in the slot 52′ of the guide-bar 6, as illustrated in Figs. 1 and 2. Said guide-block being pivotally supported on the guide-arm of the rocking-beam by means of some suitable stud, as 53, permits of the sidewise movement of the rocking-beam as shown in Fig. 1. And said guide-block being located in a plane intermediate, as set forth, relatively to the crosswise beam-arms, so controls the motion of the beam that all of said arms have substantially the same swinging movements both longitudinally and laterally of the engine.

The cylinders of the engine may, if preferred, be constructed separately from the framework and from each other, but I have herein shown all of the steam-cylinders formed integrally with the framework. The two high-pressure cylinders, 26 and 26′, are shown at the upper side of the engine, while the two low-pressure cylinders, 27 and 27′, are shown located near the lower side of the engine; all of the cylinders are preferably grouped or arranged with their axes substantially parallel with, and at equal distances from, the axis (continued) of the main-shaft. The said cylinders are provided with pistons designated in a general way by 54, 54′, 54″, and 54‴, respectively. As the construction of all of the pistons may be the same, a detailed description of one of them will be understood to apply to all of them, with the exception of the indices of the reference-characters. The piston 54, in the preferred form thereof herein shown, consists of the piston-head 54, fitted with one or more piston-rings, as 55, and constructed for connection with the rocking-beam. For this purpose the piston-head 54 is centrally bored to receive the spherical end 56 of the connecting-rod 58; this rod is held in place in the piston by means of the cap 57 shown firmly screwed into the piston-head for receiving the thrust of the piston. The cap 57 being screwed into the inner end of the piston-head, as shown best in Fig. 6, is accessible through the cylinder when the cylinder-head 10 (hereinafter described) is removed. At its opposite end, the connecting-rod 58 is similarly connected with the rocking-beam by means of the spherical end 59 of said rod journaled in the end of the rocking-beam arm 49 under the cap 60, this being held in place by means of the screws 61 and 62, in a well-known manner. The spherical end 59 of said rod is shown constructed separate from the rod, and removably fixed thereto by means of a screw-thread on the rod; this is for the purpose of putting the rod through the cap 60 of the beam-arm before assembling the engine. The rod being put through the cap, the spherical end 59 is then firmly screwed onto the arm, after which this is set in place in the beam-arm-bearing and the cap 60 secured in place by the screws shown therefor. The details of each of the piston-connections are shown of the same construction and arrangement as hereinbefore described, each detail of the series being designated by the same reference-character with the addition of an index-mark corresponding to that of the reference-character of the particular piston to which the connecting-rod is applied. The series of cylinders being grouped, substantially as shown, around the axis (continued) of the main-shaft, the rearward ends of the cylinders are closed by a single plate, 10, serving as a cylinder-head and carrying the steam-chest, the valve, and the valve-actuating mechanism. In practice, said plate may be located on the frame B by means of the projecting bearing 63, fitting a corresponding bore shown in the framework. In the present instance, said projecting bearing is centrally bored for receiving the driving-shaft 64 of the valve-mechanism; which shaft is also designated as the "valve-shaft." Said shaft 64 is driven from the rocking-beam through the aforesaid stem of the beam-spindle 50, which stem fits in a corresponding inclined bore in the head 65 of the valve-shaft, this head being usually (as shown in Fig. 6) a separate piece rigidly fixed to the aforesaid end of the valve-shaft 64. The stem 50 should be fitted into the valve-shaft head in a manner so as not to cramp the parts, but to secure the free running thereof.

Upon the outer side of the cylinder-head or plate 10 is placed the steam-chest 66; upon this, again, is placed the steam-chest cover 67; which cover is formed hollow for receiving the regulating apparatus of the valve-mechanism, and is itself covered on the outer side thereof by the plate 68. The valve-chest and its cover, and also the outer cover 68, are

(or may be) held in place by a series of ordinary studs, 69, passing through all of said parts and screwed into the cylinder-head plate 10, these studs being provided at their outer ends with the usual nuts, 70.

The steam-distribution valve, which is shown of an annular form, is designated in a general way by N, and is constructed to fit closely between the rearward surface of the cylinder-head 10 and the forward surface of the valve-chest cover 71, as will be understood by comparison of Figs. 6 and 15. The valve N is connected with the valve-shaft 64 to have a uniform rotary movement with said shaft, and in the present instance is also adapted to have a sliding movement transversely of the valve-shaft for the purpose of varying the ratio of expansion of the steam by changing the time of port-closure. For this purpose the valve-ring N has therein the driving-bar 22, in which is formed the slot 72 for the passage through the valve of the valve-shaft 64. Said bar has also formed therein suitable notches or recesses, as 73 and 73′, for receiving the ends of the valve-driving arms. The valve-shaft 64 is furnished with a suitable hub 74, (removably fixed thereto by means of the set-screw 75 or other like devices,) for carrying, pivotally supported therein at 76, the counter-weight lever 86, whose forward end engages in the recess 73 of the driving-bar 22 of the valve N, and whose rearward end carries the counter-weight or regulator-weight 77. On the rapid rotation of the valve-mechanism, said weight acts by its centrifugal momentum. As a means for sliding the valve N toward the regulator-lever 86, the regulator apparatus is provided with the lever 78, whose inner end engages in the recess 73′ of the valve-driving bar 22 whose outer end bears upon the valve-shaft; and upon the middle portion of which lever the regulator-spring 81 takes its bearing; said spring reacts against the nut 79 of the stem 85 formed on said hub for carrying said spring pressure bar 78, as illustrated in Figs. 15 to 18, inclusive.

When the valve-shaft and the mechanism carried thereby is rapidly revolved, the centrifugal force of the regulator-weight 77 acting through the lever 86 carries the valve transversely of the valve-shaft toward the pressure-bar 78, until the force of said weight is counterbalanced by the resistance of the regulator-spring 81, and the valve thereby brought to rest (as to its said transverse movement) at a position corresponding to the rotary speed thereof and to the force of the weight and spring. This action, it will be observed, follows in a general way the operation of other shiftable-eccentric valve-regulating apparatus now used on high-speed steam-engines; but contrary to the practice heretofore adopted, the weight-and-spring regulating apparatus herein described is here applied directly to the rotating valve, and this is done in a simple and effective manner; and the connection between the weight and spring is such (as hereinbefore pointed out,) that while running, all of the parts are held in close engagement with each other, so that there is no free play between them, and consequently no rattling or jarring detrimental to the mechanism.

Steam is applied to the valve-chest 66 through the supply-pipe 82 and a passage-way, 82′—82″, Fig. 15; said pipe in Figs. 1 and 2 is shown furnished with an ordinary stop-valve, 82‴, for the usual purpose. Within the steam-chest the live steam passes around the outside of the valve-end until it comes to some open port through which it can pass into the high-pressure cylinder or cylinders of the engine. On the discharge of the steam from the high-pressure cylinder, it is exhausted through the interior space 20 of the valve into the exhaust-chamber 83′ of the valve-chest cover, whence it passes out through the exhaust-pipe 82⁗ and is finally disposed of.

The distribution of the steam to the respective cylinders is effected by means of suitably-arranged ports co-acting with the valve and the passage-way within the valve; through which passage-way the steam is conveyed from the high-pressure to the low-pressure cylinders.

The high-pressure cylinders, 26 and 26′, are provided each with a port, 15 and 15′, respectively, which are successively uncovered by the movement of the valve to open communication between the steam-chest (outside of the valve N) and the interior of the cylinder. Similarly, each of the low-pressure cylinders is provided with a steam-port, 15″ and 15‴, respectively, for opening communication between the space within the valve and the interior of the cylinder. Said low-pressure ports are, however, shown located at a lesser distance from the valve-shaft, so that the valve always protects the same against the admission thereto of the live steam. The relative location of said several ports is also such that on the movement of the valve to cover the high-pressure ports, the interior annular passage-way 83 of the valve is brought into communication simultaneously with the port of a high-pressure cylinder and the port of a low-pressure cylinder, as shown in Fig. 13, thereby opening communication between the two cylinders and conveying the partially-expanded steam from the high-pressure cylinder, to be further expanded in the low-pressure cylinder, after the usual manner of using the steam in other types of compound engines. On the further eccentrically-rotating movement of the valve, this again opens communication between the high-pressure and low-pressure cylinders, and the steam-chest and the central valve-space, respectively, for repeating the foregoing operations.

As a means for "balancing" the valve, the steam is (according to a well-known principle) brought against both sides thereof. This is done through the medium of auxiliary

passage-ways 11, 11′, 11″ and 11‴, connecting the principal ports formed in the cylinder head-plate, and also through the medium of a series of transverse openings or passage-ways 23 communicating with the passage-ways 83 formed in the inner and outer faces of the valve, as clearly shown in Figs. 6, 16, 19 and 20.

For a more particular understanding of the cycle of operations, reference is made to Figs. 7 to 14, inclusive, representing four successive "quarter" positions of the valve and pistons. The revolution of the crank C is divided into "quarter" stages or cycles, the valves N being successively in each of the four quadrants, *e*, *f*, *g* and *h*, and moving in the direction of the circular arrow. It should be noted that the steam-chest, as shown in Figs. 7, 8, 9, 10, 11, 12, 13 and 14, is open; this is to show the successive positions of the valve N, but when considering its operation, the steam-chest may be regarded as closed, as in Fig. 6.

First position, (Figs. 7 and 8.)—The mechanism of the engine having been properly assembled, with the crank C set at an angle of ninety degrees (modified only by the usual "lead" of the valve) from the line of the transverse (or regulating) movement of the valve, the operative parts are then in the first "quarter" stage or cycle of their revolution. At this time the center line or radius of the crank may stand, for instance, in the quadrant *e*, and coincide with the line *a b;* the corresponding position of the valve N is in the quadrant *f*, and its line of transverse movement parallel with the line *c d*. In this position the valve N closes (ordinarily) to the live steam the ports of both high-pressure cylinders, and opens communication through the interior passage of the valve between the high-pressure cylinder 26 and the low-pressure cylinder 27′; during this stage the live steam already in the high-pressure cylinder 26′ is expanding, as also the low-pressure steam in the low-pressure cylinder 27.

Second position, (Figs. 9 and 10.)—In this position, the valve has advanced to open the port of the cylinder 26′ to the live steam; to open communication between the low-pressure cylinder 27 and the exhaust-chamber 83′ through the middle space of the valve 73; also, to begin to open cylinder 26 to live steam, and to open cylinder 27′ in the exhaust steam chamber through the valve-passage 73. At this time the piston 54 is being operated directly by the high-pressure steam, and the piston 54‴ is being operated by the steam exhausted from the opposite, high-pressure cylinder 26.

Third position, (Figs. 11 and 12.)—In this position the valve has advanced to the quadrant *h*, thereby opening the cylinder 26 to the live steam, exhausting the cylinder 27′, and beginning to open communication from the high-pressure cylinder 26′ to the low-pressure cylinder 27.

Fourth position, (Figs. 13 and 14.)—In this position the valve has advanced into the quadrant *e*, thereby cutting off the live steam from the cylinder 26, opening communication from the high-pressure cylinder 26′ to the low-pressure cylinder 27, and completing the exhaustion of the cylinder 27′.

In Figs. 8, 10, 12 and 14, the movements of the several pistons are represented by arrows, those of the pistons 26 and 27 being shown by solid-line arrows, and those of the pistons 26′ and 27′ by dotted-line arrows. In Figs. 7 and 8, the cylinders 26 and 27 are shown exhausting, the opposite cylinders 26′ and 27′ being at work. In Figs. 9 and 10, the pistons of cylinders 26 and 27′ are shown at opposite ends of their strokes respectively; the pistons of the intermediate cylinders 26′ and 27 being approximately at mid-stroke. In Figs. 11 and 12, the cycle of piston movement has advanced through one "quarter," bringing the pistons of the cylinders 26′ and 27 to the opposite ends of their strokes respectively, and the pistons of cylinders 26 and 27′ to mid-stroke. In Figs. 13 and 14, the pistons of cylinders 26 and 27′ are shown at the opposite ends of their strokes respectively, the pistons of the intermediate cylinders 26′ and 27 being at mid-stroke.

Having thus described my invention, I claim—

1. In a compound engine, the combination of a high-pressure and a low pressure cylinder having their ports located in the valve seat, a valve shaft, a valve mounted upon and rotating with said shaft and having transverse movements thereon, and a spring-and-weight governor in direct connection with said valve and shaft, substantially as and for the purpose described.

2. In a compound engine, the combination with two high-pressure and two low-pressure cylinders arranged in pairs about the valve axis and having their ports located in the valve-seat at different distances, respectively, from said valve axis, of the valve-shaft, the rotating valve transversely-movable upon the shaft and having an interior passage eccentric to the valve axis, whereby the exhaust of the high-pressure cylinder is conveyed to the opposite low-pressure cylinder, and a spring-and-weight governor in direct connection with the valve and shaft, substantially as and for the purpose set forth.

3. In a compound engine, the combination with the series of cylinders having their ports located in the valve-seat at different distances from the axis of the valve movement, and with the shaft, of an eccentrically-disposed rotating-valve having the annular passage-way formed in its inner and outer faces eccentric to its axis for opening communication between opposite cylinders, and having transverse openings therethrough in communication with said passage-way to admit steam to both sides thereof, and a governor to regulate the movement of the valve transversely of its

axis of rotation for varying the ratio of expansion, substantially as described.

4. In an engine, the combination with the cylinders, the pistons and main-shaft, of a rocking-beam having ball and socket connections with the pistons, and having an independent central driving-spindle provided with a tubular journal socket at one end and supported in a bearing in a crank-disk secured to the main-shaft and provided with a spherical journal at its opposite end which is supported in the frame of the engine centrally with relation to the axis of the main-shaft and in alignment transversely with the ends of the rocking-beam, a rotary-valve and an independent valve-shaft, one end of which is connected with the rocking-beam spindle, substantially as and for the purpose described.

5. In an engine, the combination with the cylinders, the pistons, the main-shaft, and a rocking-beam intermediate to the pistons and main-shaft, of the valve and valve-shaft, and the valve-shaft-actuating stem 50 carried by the rocking-beam and operatively connected with the valve-shaft for actuating the same, all organized and co-acting substantially as described.

6. In an engine, the combination with the main-shaft and rocking-beam, of the driving-spindle having a spherical journal at one end supported in a journal-bearing in the frame of the engine and axially-aligned with the main-shaft, and having the tubular journal socket at its opposite end, the crank-disk fixed to said shaft and having a journal-bearing for said tubular socket, and a bearing-block and fastening for securing the said socket in place, substantially as described.

7. In an engine, the combination with the cylinder, of the piston, the main shaft, the rocking-beam, and the independent supporting-spindle for said rocking-beam having a spherical journal at one end supported in the frame and indirectly connected with the main-shaft at the opposite end, and capable together with the rocking-beam of a universal rocking movement to actuate said shaft, the connecting-rod spherically journaled at one end thereof in the piston and having the spherical journal-socket removably-secured to its opposite end and seated in a spherical bearing in the end of the rocking-beam, and caps securing the ends of the connecting-rod in place in their respective bearings, substantially as described.

8. In a multi-cylinder compound engine, the combination of four cylinders arranged equidistant and parallel with relation to the axis of the main-shaft, the main-shaft the crank or crank-disk secured to said shaft, the rocking-beam supported upon an independent spindle journaled at one end in the engine-frame, and at its opposite end in the crank-disk upon the main-shaft and capable of universal rocking movements for actuating the main-shaft, and having four cross-wise arms connected at their ends by balls and sockets with the pistons of the several cylinders, respectively, and the guide-arm 51 secured to the rocking-beam intermediate to the planes of said beam-arms, and a guide-bar on the engine-frame engaging said guide-arm for controlling the movement of the rocking-beam, substantially as described.

9. In a compound engine, the combination with the high-pressure cylinder and its port, and the low-pressure cylinder and its port, of the steam-chest, the valve-shaft, the valve having the elongated central opening movably-mounted upon said shaft and dividing the steam-chest into two parts, one for the live-steam, and one for the exhaust-steam, and having a transverse movement upon the shaft, substantially as described, for intermittently opening communication with the live-steam space and the high-pressure cylinder, and the exhaust-steam space and the low-pressure cylinder and adapted between these times for opening communication between the two cylinders through a passage-way in the valve, substantially as set forth.

10. The combination with the valve-chest and its ports, of the valve-shaft, the rotatable valve movable transversely of the shaft, the regulator-lever pivotally supported on the shaft and bearing upon the valve, the lever 78 bearing at one end against the shaft, and at the other end against the valve in opposition to the normal action of the regulator-weight, and the regulator-spring carried by the shaft and bearing against said lever 78, whereby the valve is movable transversely of the shaft and the slack of the joints is taken up, substantially as described.

11. In a compound engine, the combination with the high-pressure and the low-pressure cylinders and their pistons, and the main-shaft, of the rocking-beam having the independent supporting-spindle journaled at one end in the engine-frame and indirectly connecting the main-shaft at its opposite end, connecting-rods having a universal-connection with the arms of the rocking-beam and pistons, the independent valve-shaft connected at one end with the rocking-beam spindle, the rotating-valve having the elongated central opening which embraces the valve-shaft, and having passage-ways therein arranged and operating as described, to first open communication for the live-steam to the high-pressure cylinder, then cut off the live-steam, and open communication from the high-pressure cylinder to the interior of the valve to the low-pressure cylinder and then exhaust the low-pressure cylinder through the middle space of the valve, while again admitting live-steam to the high-pressure cylinder, and a spring-and-weight governor in connection with the valve and valve-shaft for the purpose of regulating the transverse movements of the valve and consequently the ratio of expansion of steam by changing the time of port closure, substantially as described.

12. In a compound engine, the combination

with the frame, of the cylinders having a main and auxiliary ports, as described, the steam-chest having the inlet and exhaust ports, the annular valve having the elongated central opening, and having the eccentric passage-ways 83 formed in its inner and outer face with the transverse openings 23 communicating therewith, the valve-shaft extended through the elongated central opening in the valve, a governor directly connecting said valve and valve-shaft, the pistons, the main-shaft, and the walking-beam mounted upon an independent spindle and indirectly connected with the main-shaft, pistons and valve-shaft, substantially as and for the purpose described.

13. In an engine, the combination with the valve-chest and its ports, the valve-shaft, the revoluble valve movable transversely on the shaft, of a governor comprising a hub adjustably-secured to the shaft, a lever pivoted to said hub at one side and engaging the valve at one end, a counter-weight pivotally-supported at the opposite end of said lever, an oppositely-disposed regulator-lever engaging the valve at one end and bearing upon the shaft at its opposite end, and a spring bearing upon said lever to counter-balance the centrifugal force of the counter-weight and regulate the transverse movement of the valve, substantially as and for the purpose described.

14. In an engine, the combination with the valve-chest and its ports, and the valve-shaft, of the revoluble valve having the central elongated opening through which the valve-shaft extends, and transverse recesses 73, 73′, a governor for said valve comprising a hub adjustably-secured to the shaft, a lever pivotally-connected to said hub having a bearing at one end in the recess 73 of the valve, and having a counter-weight pivotally-secured to the opposite end, a stem secured to the hub at the opposite side, a lever movably-mounted on said stem, bearing at one end upon the valve-shaft, and having a bearing at its opposite end in the recess 73′ of the valve, a spiral spring mounted upon said stem and bearing upon the said lever, and a nut screwed upon the end of the stem and bearing against the spring to regulate the tension thereof, all co-acting to regulate the transverse movement of the valve upon its shaft, substantially as and for the purpose described.

15. In a multi-compound-engine, the combination with the engine-frame, of a series of cylinders radially-disposed around a common center, a steam-chest intermediate to, and in communication with, said cylinders, a revoluble valve having a central elongated opening, and independent valve-shaft extended through said opening having a bearing in the cylinder head-plate located between the cylinders and steam-chest, a main-shaft, a rocking-beam interposed between the main-shaft and valve-shaft, and mounted upon an independent spindle indirectly connected with the main-shaft through the medium of a crank at one end, and supported by a spherical journal in the engine-frame at the opposite end and connected to the valve-shaft by a stem projecting beyond the said spherical bearing engaging a head upon the valve-shaft, (the said rocking-beam having a series of arms,) the pistons located in said cylinders, and the piston-rods having ball-bearings at each end, and connected with the arms of the rocking-beam and the pistons, respectively, all combined and co-acting, substantially as and for the purpose described.

16. In a compound-engine, the combination of a high-pressure and a low-pressure cylinder having their ports located in the valve-seat, of the valve-shaft, the rotating valve transversely-movable upon said shaft having an annular passage eccentric to the valve axis, whereby the exhaust of the high-pressure cylinder is conveyed to the low-pressure cylinder, and a spring-and-weight governor in operative connection with the valve and shaft, substantially as described and for the purpose set forth.

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