(No Model.)

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M. N. & E. P. LYNN.

DIRECT ACTING STEAM ENGINE.

No. 366,228. Patented July 12, 1887.

Fig. 7.

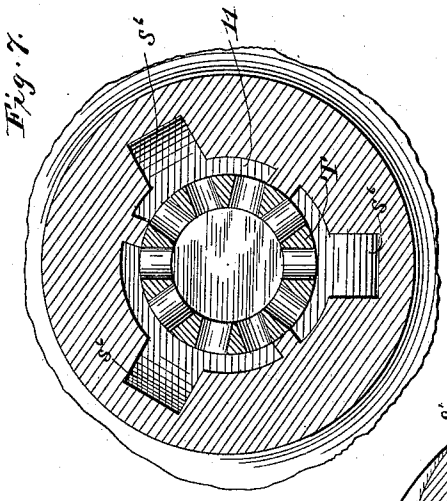

Fig. 1.

Witnesses.
Chas. R. Burr.
A. J. Stewart.

Inventors.
Murabeau N. Lynn
Elyvore P. Lynn
By Church & Church.
their Attorneys.

(No Model.)

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M. N. & E. P. LYNN.

DIRECT ACTING STEAM ENGINE.

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Fig. 3.

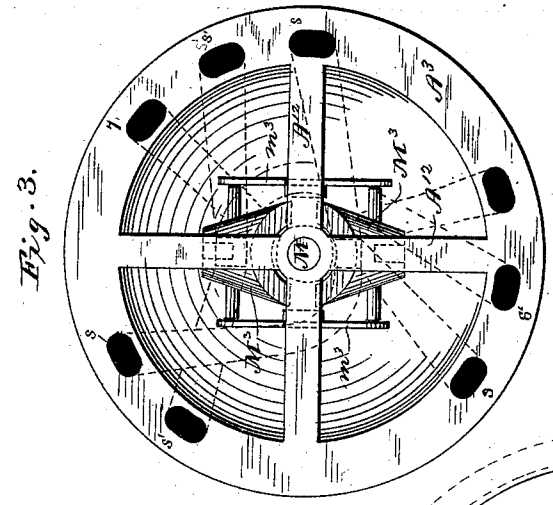

Fig. 2.

Witnesses.
Chas. R. Burr.
A. J. Stewart

Inventors.
Mirabeau N. Lynn
Elmore P. Lynn
by Church & Church
their Attorneys.

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M. N. & E. P. LYNN.

DIRECT ACTING STEAM ENGINE.

No. 366,228. Patented July 12, 1887.

Fig. 4.

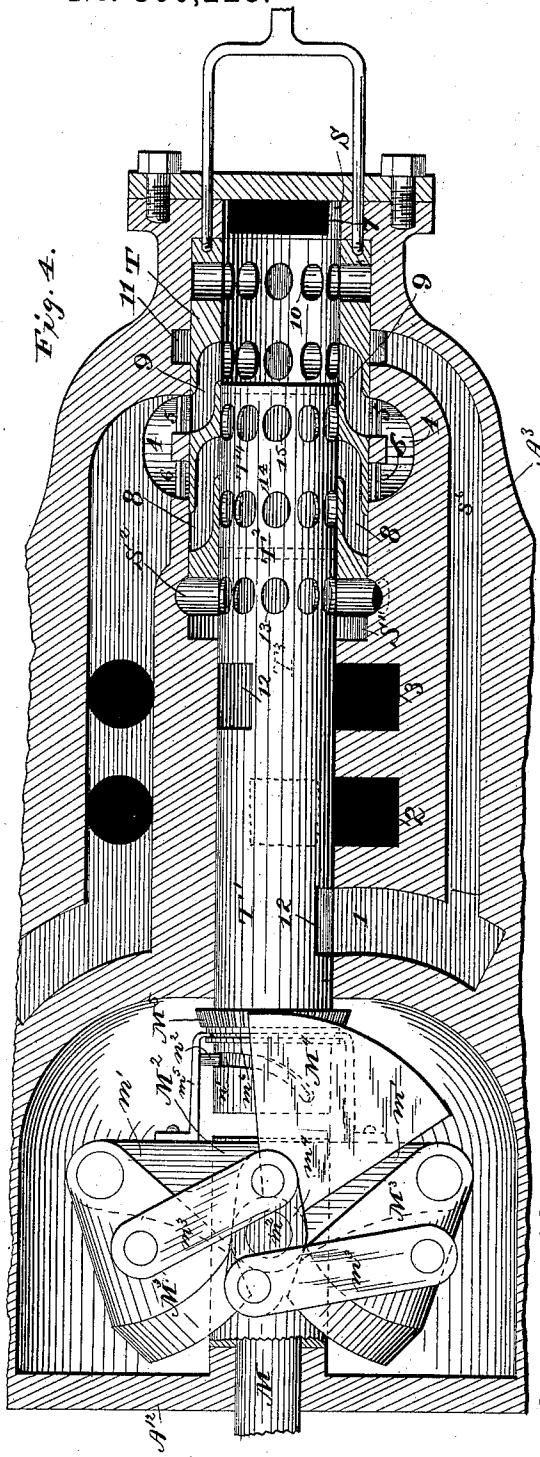
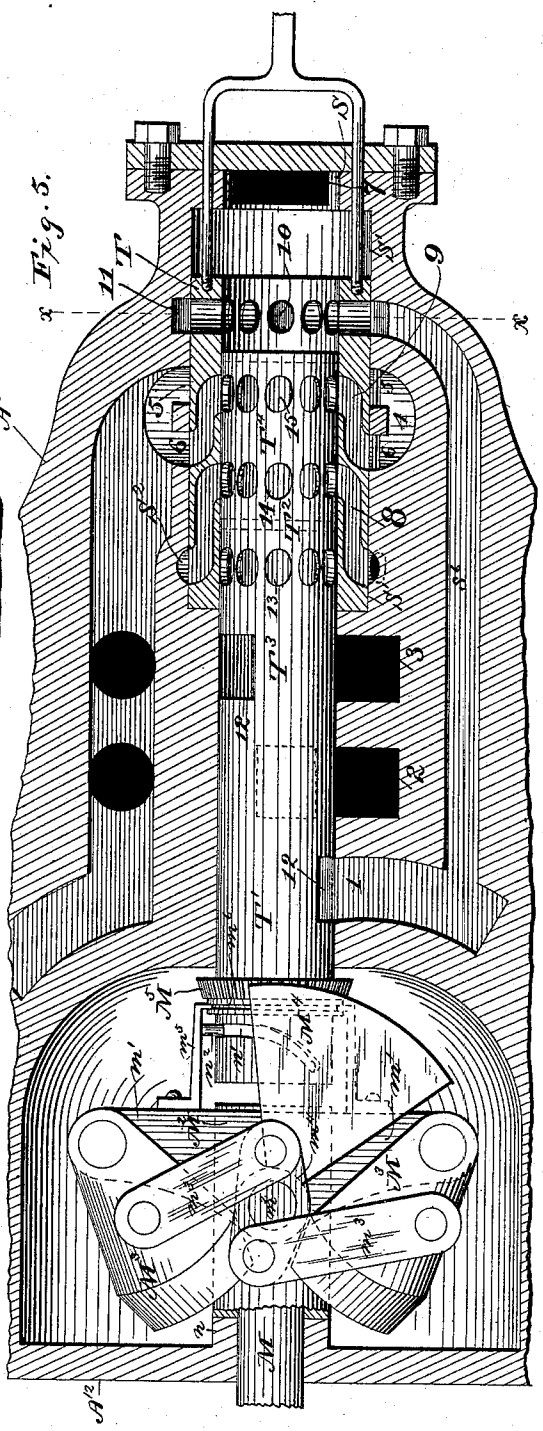


Fig. 5.



Witnesses.
Chas. R. Burr
A. J. Stewart

Inventors.
Mirabeau N. Lynn
Elmore P. Lynn.
by Church & Church
their Attorneys.

(No Model.) 5 Sheets—Sheet 4.

M. N. & E. P. LYNN.

DIRECT ACTING STEAM ENGINE.

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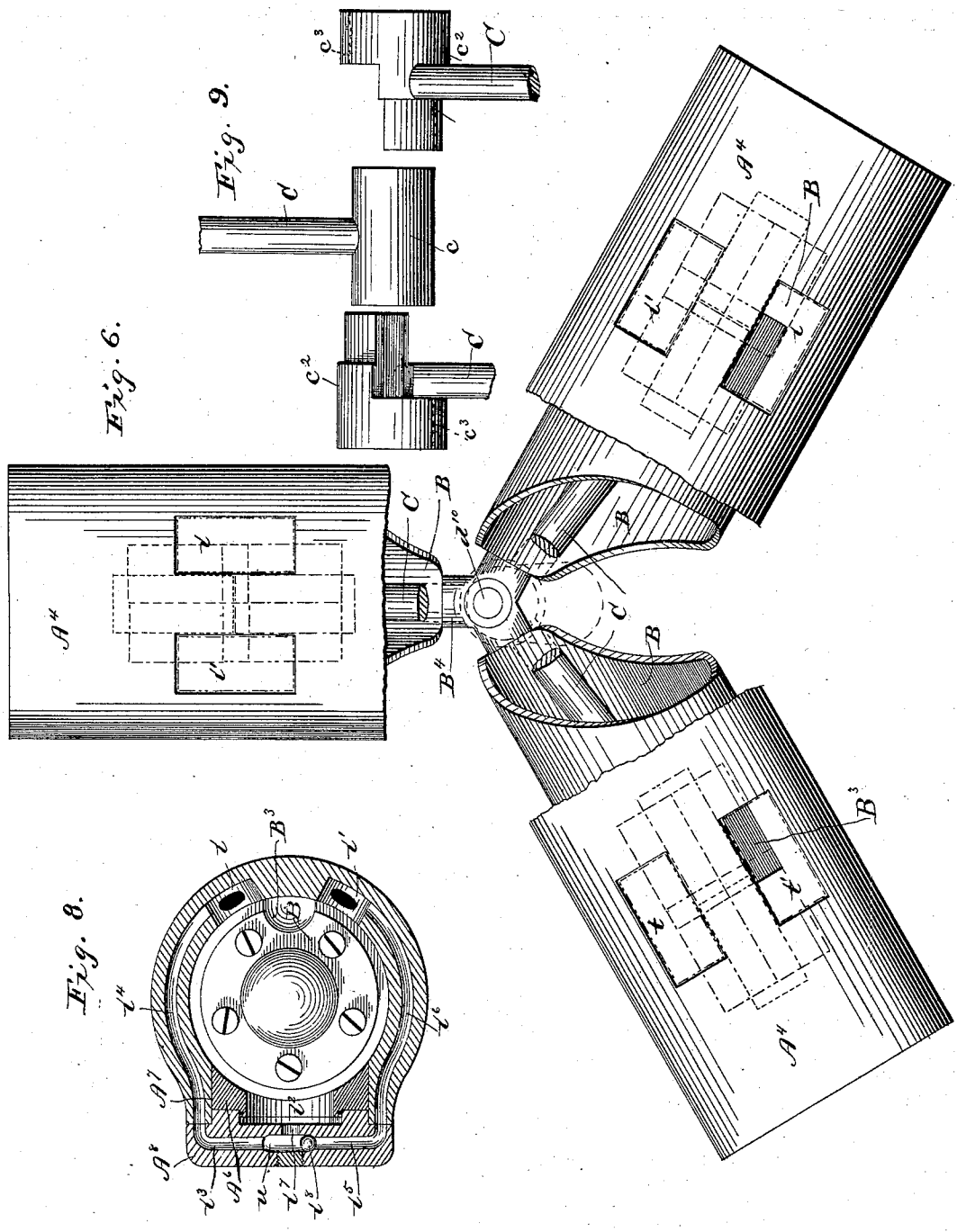


Witnesses.
Chas. R. Burr.
A. J. Stewart.

Inventors,
Mirabeau N. Lynn
Elmore P. Lynn
by Church & Church
their Attorneys.

(No Model.)

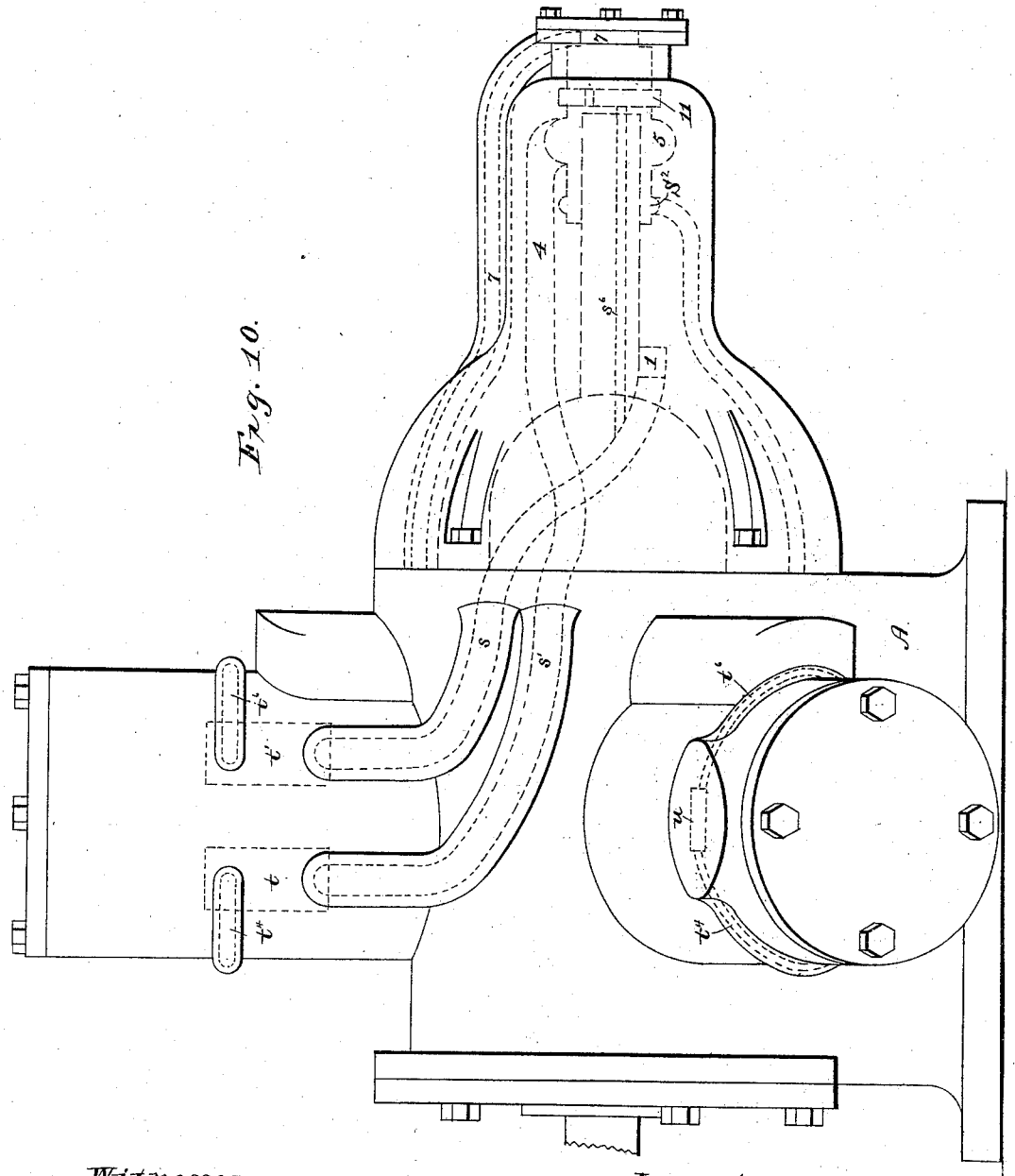
5 Sheets—Sheet 5.

M. N. & E. P. LYNN.

DIRECT ACTING STEAM ENGINE.

No. 366,228. Patented July 12, 1887.

Fig. 10.



Witnesses.
Chas. R. Burr.
Fred F. Church.

Inventors.
Minabeau N. Lynn & Elmer P. Lynn
by Church & Church
their Attorneys.

UNITED STATES PATENT OFFICE.

MIRABEAU N. LYNN AND ELMORE P. LYNN, OF RISING SUN, INDIANA, ASSIGNORS, BY MESNE ASSIGNMENTS, TO THE LYNN ENGINE COMPANY, OF DAYTON, OHIO.

DIRECT-ACTING STEAM-ENGINE.

SPECIFICATION forming part of Letters Patent No. 366,228, dated July 12, 1887.

Application filed February 10, 1886. Serial No. 191,470. (No model.)

To all whom it may concern:

Be it known that we, MIRABEAU N. LYNN and ELMORE P. LYNN, both of Rising Sun, in the county of Ohio and State of Indiana, have invented certain new and useful Improvements in Direct-Acting Steam-Engines; and we do hereby declare the following to be a full, clear, and exact description of the same, reference being had to the accompanying drawings, forming a part of this specification, and to the figures and letters of reference marked thereon.

This invention relates to improvements in that class of direct-acting steam-engines wherein three cylinders are radially disposed about a crank-shaft and the pistons are caused to act independently upon the crank-pin; and it consists in certain novel and improved constructions, arrangements, and combinations of parts, as hereinafter more fully described, and pointed out in the claims.

In the accompanying drawings, Figure 1 is a longitudinal vertical section through our improved engine. Fig. 2 is an end view with head and valve mechanism removed. Fig. 3 is an end view of the removable head carrying governor and valve mechanism. Fig. 4 is an enlarged view of the valve mechanism and governor for controlling the speed of the engine. Fig. 5 is a similar view with the valves set for reversing the movement of the engine. Fig. 6 is a diagrammatic view of the pistons, their pitmen, the crank, and the tripod for oscillating the pistons, illustrating the movement of the parts for controlling the admission and escape of steam in the cylinders. Fig. 7 is a section on the line $x\ x$ of Fig. 5. Fig. 8 is a transverse section through one of the cylinders. Fig. 9 is a detail of the pitman. Fig. 10 is a side elevation in outline, showing the steam and exhaust passages in dotted lines.

Similar letters of reference in the several figures indicate the same parts.

The main frame A of the engine is composed of a central casing, A′, removable heads A^2 A^3, and three radiating cylinders, A^4. Within each cylinder works a piston, B, whose pitman C is connected to the crank d on the main driving-shaft D within the casing A′. The driving-shaft D, to whose inner end the crank-pin d and counter-balance d' are attached, is supported in an elongated bearing, a, on the head A^2. The counter-balance d' is recessed to fit and extended over the inner end of the bearing a, and at the outer end said bearing is provided with a chamber, a', and cap-plate a^2, fitting the shaft, forming a chamber to accommodate packing-rings d^3, applied to the shaft D. These packing-rings, of rubber or other flexible material, are split at one side, the proximate edges converging and meeting at the surface of the shaft, and they are formed with circumferential grooves to receive and retain elastic compression-springs d^4, preferably composed of spiral springs, as shown, said compression-springs serving to hold the packing-rings against the periphery of the shaft and compensate for wear at that point by the compression of the meeting edges, and the packing-rings themselves serving to form a tight joint at the outer end of the bearing, so as to prevent the escape of steam or the lubricant from the interior of the casing. A passage, d^5, connects the chamber a' with the interior of the casing, and the lubricant is supplied to the bearing through passages a^5 a^6, the latter provided with a pipe, a^7, standing vertically in a cup shaped recess, a^8, having an overflow-pipe, a^9, whose end dips below the top of pipe a^7, by which means the condensed water will be drawn off as it collects in the cup, and the oil will be floated and discharged through pipe a^7 to the bearing. By means of the passage d^5 the pressure of the exhaust-steam within the casing is applied to the outer end of the bearing, so as to produce a balance of pressure in the latter and permit the lubricant to circulate freely, at the same time serving to return the oil, water, &c., which may have passed through the bearing and into the chamber a'.

The pitmen C are applied to the crank-pin in the following manner, in order to secure a firm bearing on each other, as well as upon the crank-pin: One of the pitmen C is provided with a T-head, c, through which is formed a

socket fitting the crank-pin. Each of the other pitmen is provided with a projection or tongue on one side and a collar, c^2, on the other side of the head, with a circular bearing fitting the periphery of the head c of the first named pitman. The collar c^2 is formed with a concave bearing, c^3, to receive the tongue of the other pitman, and spaces are formed between the sections to permit each pitman to vibrate independently of the others as the pistons reciprocate and the crank revolves.

The pistons B are preferably formed in two sections, b b', each consisting of a cylindrical portion, b^2, closed at one end by a head or diaphragm, b^3, and bolted or otherwise securely fastened together with the heads in contact, as shown. In each head is formed a hemispherical recess or bearing, b^4, to receive a ball, B', into which the pitman is screwed, the latter passing through a suitable opening in the head of the inner section, b'. The ball-and-socket connection or joint thus formed between the piston and pitman is designed to permit of the necessary vibratory movement of the pitman and an oscillatory movement of the piston within the cylinder, as hereinafter described, and any other connection which will accomplish the same or a like result may be substituted, if desired.

Each cylinder is chambered or made double to form a steam-jacket, and is, moreover, provided with two steam-passages, s s', terminating within the cylinder in ports t t' t^2, the two former, t and t', constituting the inlet and exhaust ports, respectively, and the third, t^2, the balancing-port. The inlet and exhaust ports t t' are of equal dimensions and located at the same level, being elongated in the direction of the length of the cylinder, and are set at a distance apart equal to their width, while the balancing-port t^2 is located at a point equally distant from the ports t t' and opposite the blank space between the latter, for a purpose to be described.

Each piston is provided with packing-rings at or near the extremity of the outer section, and with a port, B^3, preferably located at about the level of the ball-and-socket joint, and opening into the cylinder above the piston-head. This port B^3 has an elongated opening corresponding in size and shape with the inlet and exhaust ports. The balancing-port t^2, through which steam is applied to the piston to balance the pressure at the inlet-port, is provided with a ring-valve, A^6, held by the pressure of steam on its outer edge against the piston to prevent leakage, as described in another application filed herewith, Serial No. 188,722, said ring being inserted through an opening, A^7, in the cylinder, over which a head or cap plate, A^8, is secured.

If the engine is designed to be run in but one direction—that is, without reversing the direction of rotation of the shaft—the arrangement of the ports and steam-passages would be made similar to those described in our before-mentioned application—that is to say, the balancing-port and inlet-port would be located at diametrically-opposite sides of the cylinder and connected together and to the steam-supply, and the inlet and exhaust ports would be located at different levels and the piston be given a motion with respect thereto to cause its port to produce a lap and lead; but in order to provide for reversing the engine the ports are arranged as described, and the connections between the steam-passages are modified in the following manner: In the cap to balancing-port is formed a transverse chamber, u, communicating at one end, through a passage, t^3, with the passage t^4, leading to the inlet-port t, and at the other end connecting through a passage, t^5, with the passage t^6, leading to the exhaust-port t'.

The chamber u communicates with the balancing-port t^2 through an opening or port, t^7. The passages t^3 and t^5 terminate within this chamber u, and on opposite sides of the port t^7, and a ball or other form of movable valve, t^8, adapted to close either passage t^3 or t^5, is arranged within said chamber, so that when the steam-pressure is upon the inlet-port the valve t^8 will be forced over and close the passage t^5, communicating with the exhaust, and when the engine is to be reversed and the steam admitted to the cylinder through what was before the exhaust-port the valve t^8 will be forced to the opposite side of the chamber, thereby admitting steam to the balancing-port t^2 through passage t^6, and closing the passage t^3, which is then in communication with the exhaust. It is for the purpose of thus balancing or nearly balancing the pressure upon the piston at either the inlet or exhaust ports that the balancing-port is located opposite the blank space between the ports, rather than opposite the general inlet-port.

The alternate opening and closing of the inlet and exhaust ports is effected by the pistons as they reciprocate within the cylinders by giving to the pistons an oscillating movement about their longitudinal axes as they run back and forth, and this movement may be effected in the following manner: Each piston is provided with a radially-projecting arm or block, B^4, preferably formed with an extension, b^6, lying parallel with the piston and working in an arc-shaped slot or chamber formed in the walls of the cylinder or in the casing. Both the block B^4 and its extension b^6 are grooved or slotted on a line radial to the axis of the pistons, forming a way, b^7, in which a guide block or sleeve, b^8, is fitted to slide toward and from the piston.

Upon an extension, d^{10}, of the crank-pin d is fitted a hub, B^5, provided with three radially-projecting arms, b^9, located at equal distances apart and standing at right angles to the crank d^{10}. These arms b^9 are cylindrical and fitted to reciprocate and rotate within the guide blocks or sleeves b^8.

As shown in the drawings, the arms b^9, in-

stead of being of uniform diameter throughout their length, are each formed or provided with an enlarged portion or shoulder at the point of attachment to the hub B^5, and the lower extremity of the sleeve b^8, as well as the guide-way formed in the piston, is correspondingly enlarged to accommodate said enlarged portion or shoulder, the object being to strengthen the connection and give increased bearing-surfaces.

The hub B^5 and its arms b^9, constituting what is herein termed the "tripod," is the medium employed for converting the rotary motion of the crank-pin into an oscillatory reciprocating movement of the piston in the following manner: The tripod as a whole rotates in unison with the crank-pin about the center of the driving-shaft; but, unlike the pitmen, each of its arms while traversing a circular path is maintained at all times in a plane parallel to the axis of one of the cylinders, for as the driving-shaft revolves the thrust of the crank upon the tripod is distributed equally upon opposite sides of the center and is transmitted through the arms b^9, two of which at least are acting at all times to the pistons, causing the latter as they reciprocate within the cylinders to oscillate back and forth about their longitudinal centers, thereby alternately opening and closing the inlet and exhaust ports. Thus each arm of the tripod, while retaining its parallelism with the axis of the piston, is caused to traverse a circular path about a center at right angles to the line of movement of the piston, and as the latter oscillates about its longitudinal center the arm of the tripod, moving in a plane tangential to such movement, causes the box or sleeve in which it has its bearing to slide in and out in the ways attached to the piston. The extension d^{10} of the crank upon which the tripod is mounted is preferably set to one side of the center of the crank-pin, in order to increase the throw of the arms b^9 as compared with the pistons, and thus, in a measure, compensate for the decreased movement of the piston at the extremity of its oscillation when the arm b^9 is at the end of its outward movement in the ways on the piston. In the example given the parts are so arranged that when the pistons are at the outer extremity of their movement within the cylinders, with the crank in line with the latter, the arm b^9 of the tripod will stand parallel and in line with the pitman, and the piston will be held at the center of its oscillatory movement, with the port in the piston above and midway between the inlet and exhaust ports.

As the driving-shaft is rotated and the piston moves inward, the arm b^9 of the tripod turns the piston around, (the lateral movement thus produced being the greatest as the pitman and crank cross the center line,) rapidly uncovering the inlet-port and admitting steam above the piston. This lateral movement of the piston continues, but with gradually-diminishing velocity as compared with the longitudinal movement of the piston, until the crank has made nearly a quarter-revolution and the piston a half-stroke. The piston has now arrived at the limit of its lateral movement or oscillation in one direction, and as the crank passes beyond the quarter it starts in the opposite direction, carrying the port downward and toward the exhaust-port until the piston has arrived at the end of its inward reciprocation, and the port is brought to a position between and below the inlet and exhaust ports, corresponding exactly with that occupied above said ports when at the opposite extremity of its movement. As the crank passes the center line and the outward movement of the piston begins, the latter is carried rapidly to one side, so as to open the exhaust-port, the movements of the piston on this side and with respect to the exhaust-port being exactly the same as when taking steam.

As the resultant of the combined reciprocating and oscillating movements of the piston as thus produced, the port in the latter is caused to traverse an ellipse as developed upon the inner wall of the cylinder with the inlet and exhaust ports standing parallel with the major axis and at the extremes of the minor axis. The major axis of the ellipse as well as of the ports being parallel with the cylinder, it follows that the movement of the port in the piston will be the same on both sides of the center, and that the lateral movement as compared with the longitudinal movement will be greatest when the piston is at the extremes, and least at the half-stroke. The inlet and exhaust ports are thus located and arranged with respect to the movement of the piston and its port, in order that their relations may be changed and the engine driven in the reverse direction by admitting steam through what was before the exhaust-port and allowing it to escape through what was previously the inlet-port, without any change or alteration in the driving mechanism.

It will be observed that the inlet and exhaust ports are both opened and closed on the same side, that the full opening occurs at about half stroke of the piston, and that both ports are closed at the full stroke.

The valve and governing mechanism designed for use in connection with our improved engine is mounted upon the removable head A^3 of the casing and driven from the end of the extension d^{10} of the crank-pin, so that it can all be removed or applied to the engine together. This mechanism comprehends an automatic cut-off valve and governor for controlling its movements, a throttling-valve, also actuated by the governor, and a reversing-valve co-operating with the throttling-valve.

The steam-passages s, communicating with the inlet-ports t and balancing-ports t^2 of the three cylinders, are continued through the walls of the head A^3 or in the form of separate pipes to the cylindrical chamber S in the said head A^3,

terminating therein in ports 1, 2, and 3, while the passages s', communicating with the exhaust-ports t', and also with the balancing-ports, as described, connect either through separate passages or a channel common to all with a chamber, 4, formed in the walls of the enlarged portion S′ of chamber S, and provided with two sets of ports, 5 and 6, opening into said chamber. The steam, after circulating through the jackets of the cylinders, is admitted through a passage, S^2, into the inner end of the enlarged portion S′ of chamber S.

In the outer or enlarged portion, S′, of the chamber S is fitted a sleeve or valve, T, whose inner diameter is preferably the same as that of the chamber S, said sleeve being shorter than the enlarged portion S′ and free to be reciprocated therein. In the outer end of the chamber S, and beyond the end of the sleeve T, is formed an exhaust-opening, 7, communicating with the interior of the casing, and in the sleeve T are formed three sets of openings or ports, 8, 9, and 10.

The three steam-passages leading to the inlet-ports are each connected by a passage, s^6, with an annular chamber, 11, in the enlarged portion S′ of the chamber S, said annular chamber being separated by partitions into three compartments, in each of which one of said passages s^6 terminates, as shown in Fig. 7.

Fitted to both rotate and reciprocate within the chamber S and the sleeve T is a hollow cylindrical valve, T′, closed at both ends and provided, near its outer end, with a diaphragm, T^2, which serves to separate the interior of said valve into two chambers, T^3 T^4. In the inner end of the valve, and opposite each of the steam-ports 1, 2, and 3, is formed a port, 12, opening into the chamber T^3, said ports being disposed at equal distances about the circumference of the valve, and corresponding in size with ports 1, 2, and 3. Near the outer end of the chamber T^3, and opposite the chamber in which the steam-passage S^2 terminates, are formed a series of openings, 13. The outer chamber, T^4, of the valve is furnished with two series of openings, 14 and 15.

The operation of the devices, as thus far described, is as follows: The sleeve T and valve T′ being arranged as shown in Fig. 4—that is to say, with the collar held at the outer extremity of its movement in the chamber S—the engine is ready to be started forward. When in this position, the chamber 11 is closed by the sleeve T, the passages 8 in the sleeve by the walls of the chamber S, and the valve and the openings 14 and 15 in the valve by the sleeve. The ports 5, communicating with the exhaust-passages of the cylinders, open through the passages 9 in the sleeve into the interior of the outer end of the enlarged portion S′ of the chamber S. The openings 13 in the valve are in line with the chamber communicating with the steam-passage S^2, and the ports 12 in said valve are in line with steam-ports 1, 2, and 3, leading to the inlet-ports of the cylinders. Steam having been admitted to the engine first passes through the steam-jackets around the cylinders, (to raise the temperature of the latter and prevent condensation therein, and by expanding the cylinders prevent the binding of the pistons,) and is delivered through passages S^2 and 13 into the interior of chamber T^3 of the valve, whence it is delivered to the ports 1, 2, and 3 and the cylinders connected thereto in succession through ports 12 in the valve. The alternate opening and closing of the ports 1, 2, and 3 by the ports 12 corresponds with the opening and closing of the inlet-ports in the cylinders by the pistons working therein. The exhaust from the cylinders is delivered into the chamber 4, and thence through passages 9 in the sleeve T to the interior of chamber S at the outer end thereof, and escapes into the casing through port 7.

In Fig. 10 we have shown diagrammatically the course of the steam-passages leading from the jackets of the cylinders to the valve-casing, and from the exhaust-port back to the casing of the engine; also one set of passages leading to the inlet and exhaust ports of one cylinder. The passages leading to and from the outer cylinder bear substantially the same relation to each other and to the valves as those shown in this figure, and they have been omitted to avoid confusion.

The valve T′ is driven from and rotates in unison with the main driving-shaft to preserve the proper relation of the ports 12 with the opening of the inlet-ports in the cylinder, and, as thus far described, the sleeve T performs no special office, but together with the chamber 11, passages s^6, and chamber T^4 of the valve might be dispensed with altogether, as these parts have relation only to the reversing movement, as will presently be explained. The valve T′, although rotating in unison with the driving-shaft, is designed to be so connected and arranged with respect to its driving mechanism that it may be adjusted with respect thereto either automatically or otherwise, and thereby operate as a cut-off for governing the time and duration of the admission of steam under pressure to the inlet-valve of the cylinders. To this end we propose to connect a governor intermediate or depending for its action upon the driving mechanism for rotating the valve, which governor shall operate to advance the valve in proportion to the increase in speed of the driving-shaft, thereby setting the ports 12 farther ahead, so that as the valve is rotated they will pass the ports 1, 2, and 3 at different points in stroke of the piston and operate as a cut-off. We also propose, when desired, to combine with the governor a mechanism operating upon the valve to move it longitudinally in the chamber, so that if the engine should run at a speed beyond the control of the cut-off the valve would operate as a throttle to diminish the opening through which steam is admitted to the cylinders by

causing the ports 12 and 13 in the valve to lap more or less over the adjacent wall of the chamber. Devices suitable for performing these offices are shown in the drawings, but may be varied in form and construction, as desired, so long as the automatic cut-off and throttling action are performed as hereinafter described.

Mounted in a bearing, *n*, formed in the bridge-piece or support A^{12} on the inner end of the removable head A^3, is a short shaft, M, in line with the driving-shaft, and carrying a crank-arm, M′, whose outer end fits the extension d^{10} of the crank-pin and is driven thereby.

Upon the outer end of the shaft M is secured a head or boss, M^2, provided with arms m' on opposite sides, in which the governor-weights M^3 are hung, and a transverse bearing to receive a shaft, m^2. The weights M^3 are each connected by links m^3 to arms m^4 on the transverse shaft m^2, said arms being attached to a gear-segment, M^4, so that as the shaft M is rotated the governor-weights and gear-segments partake of its movement, and as the governor-weights fly out they will, through their connections, oscillate the gear-segment.

The valve T′ is driven entirely by the gear-segments M^4 through the medium of a gear-collar, M^5, fitting upon the inner end of the valve, and connected thereto by a groove and spline, said collar being held in operative position relative to the gear-segments by a yoke or arms, m^5, attached to the head M^2, and engaging the walls of a groove, m^6, in the collar.

In practice, when the engine is at rest and the governor-weights retracted, (it being our intention to apply adjustable springs to the weights to vary their action, as desired,) the ports 12 will be in position to in turn open and close the ports 1, 2, and 3 in succession, simultaneously with the opening and closing of the inlet-ports in the several cylinders, as described. When, now, the engine is started, the valve T′ will, through the medium of the gear-segments and gear-collar, be caused to rotate in unison with the shaft M, which is driving from the crank-pin; but as the speed of the driving-shaft increases and the governor-weights are expanded or forced outward the gear-segments will be oscillated, thereby turning the valve forward, or in advance of the crank-pin, so that its ports 12 will close the ports 1, 2, and 3 in advance of the closing of the inlet-ports in the cylinders, and thus operate as a cut-off to regulate the admission of steam above the pistons.

The mechanism for actuating the sleeve or valve T, to cause it to operate as a throttle-valve when the speed of the engine exceeds the normal, can conveniently be applied to the governor in the following manner: Upon the valve T′ is formed a groove, *n′*, the forward end of which is inclined backward or inward toward the governor, while the major portion of said groove lies in the plane of rotation of the valve. A pin, n^2, secured to one of the arms m^5 of the head M^2, projects into the groove *n′*; but so long as the speed of the engine is at or below the maximum at which the governor is set to cut off it rides in the concentric portion of the groove without operating the valve, but as soon as the speed rises above the normal the pin n^2 engages the walls of the inclined portion of the groove, forcing the valve outward in the chamber S, partially closing the ports 12 and 13, and thereby diminishing the openings through which the steam has to pass before reaching the inlet-ports in the cylinders.

It will be observed that the action of the valve in throttling is in a measure distinct from its action as a cut-off, and the two functions may be performed by separate valves operating in like manner; but by the arrangement shown and described a single valve is made to serve both purposes and to simultaneously perform both operations.

As heretofore mentioned, the sleeve or valve T is not essential when the engine is designed to run constantly in one direction, its function being to reverse the engine by putting the exhaust-passages in communication with the steam-supply passage and the steam-passages leading to the cylinders into communication with the exhaust-passage 7, thereby reversing the order in which steam is admitted above the pistons, and this, too, without interfering with the throttling arrangements or the balancing of pressure upon the pistons.

To reverse the engine, the valve or sleeve T is shoved inward upon the valve T′ and within the enlarged portion S′ of the chamber S, as shown in Fig. 5. By this movement of the sleeve T steam from passage S^2 is cut off from the chamber T^3 of the valve and conducted, through passages 8 in the sleeve and 14 in the valve, into the chamber T^4. Passages 9 in the sleeve, which before conducted the exhaust from chamber 4, through port 5, into the outer end of the chamber S, are now brought opposite ports 6, leading into chamber 4, and ports 5 are closed, while ports 10 are brought opposite chamber 11, into which passages s^6, leading to the steam-passages and communicating with the inlet-ports of the cylinders, open as described. If, now, steam is admitted to the engine, it is conducted through the jackets of the cylinders into the passage S^2, from whence it is conducted, through passages 8 in the sleeve, chamber T^4, passages 9, ports 6, and chamber 4, to what was before the exhaust-ports of the cylinders. Steam being thus admitted through the exhaust-ports escapes from the cylinders through what were before the inlet-ports, the exhaust-steam from each cylinder passing, through passages s^6, chamber 11, and port 10, into the outer end of the chamber S, and through the exhaust-port 7 into the interior of the casing, as before.

Although the direction of rotation of the governor has been reversed, its weights respond in the same manner to an increase in

speed, so that while the valve is inoperative as a cut-off it serves, when reciprocated by the action of the pin in the groove, to close the steam-passages 8 and 9, through which steam is conducted from passage S^2 to chamber 4, thereby operating as a throttle. Thus, by the employment of but three co operating parts in addition to a governor, we produce an automatic throttle, cut-off, and reversing valve movement deriving motion from a single crank-pin.

We claim as our invention—

1. The combination, with the radiating cylinders and the separate pistons arranged to simultaneously reciprocate and oscillate therein to open and close the inlet and exhaust ports, of a tripod mounted upon the crank with which the pitmen co operate, the arms of said tripod engaging the pistons to oscillate the latter, substantially as described.

2. The combination, with the pistons working in separate cylinders connected to a common crank-pin and provided with an extension forming a guide or way, of the tripod mounted upon a crank moving in unison with the before-mentioned crank-pin, each arm of the said tripod engaging the guide or way in one of the pistons to oscillate the latter as it is reciprocated within its cylinder, substantially as and for the purpose specified.

3. In a three-cylinder direct-acting steam-engine such as described, wherein the inlet and exhaust ports are alternately opened and closed by the longitudinal and lateral movements of the pistons within the cylinders, and in combination with said pistons and cylinders, a revolving tripod, each of whose legs engages one of the pistons, substantially as and for the purpose specified.

4. The combination, with the cylinder provided with inlet and exhaust ports located at one side and in the same plane, and the oscillating and reciprocating pistons having a port communicating with the interior of the cylinder and co-operating with the said inlet and exhaust ports to control the admission and escape of steam, of the balancing-port formed in the wall of the cylinder upon the opposite side and equally distant from the inlet and exhaust ports, substantially as described.

5. In a direct-acting steam-engine wherein steam is admitted and exhausted in either of two ports in the cylinder to reverse the motion of the engine, the combination, with an oscillating and reciprocating piston provided with a port, as described, co-operating with said two ports in the cylinder, of the balancing-port located at equal distances from the two steam-ports, and communicating with both the steam and exhaust passages, and a valve operated by the pressure of the steam for automatically closing the opening into the exhaust-passage, substantially as described.

6. In a steam-engine such as described, wherein the piston operates as a valve to control the admission and escape of the steam, the combination, with the cylinder wherein said piston reciprocates, of a balancing-port wherein the steam is admitted and acts upon the piston in opposition to the pressure at the inlet-port, said balancing-port communicating with both the steam and exhaust passages, and a valve operated by the pressure of the steam for preventing the escape of the latter into the exhaust-passage, substantially as described, whereby when steam is admitted through the exhaust-passage and allowed to escape through the steam-passage to reverse the engine the valve will be automatically shifted to retain the pressure in the balancing-port.

7. In a direct-acting steam-engine such as described, the combination, with a cylinder having two ports on one side for the admission and escape of steam and a balancing-port on the opposite side communicating with each of the steam-passages leading to said first-named ports, and a reciprocating piston containing a port opening above its head or diaphragm, said piston being oscillated equally upon opposite sides of a central line as it reciprocates within the cylinder to alternately uncover the inlet and exhaust ports, of a valve for controlling the admission and escape of steam in each of said first-mentioned ports to reverse the motion of the engine, and a valve for closing either passage into the balancing-port, substantially as described.

8. In a multiple-cylinder direct-acting steam-engine such as described, wherein the inlet and exhaust ports are located in the cylinders and are alternately opened and closed by a port in the pistons for controlling the admission and escape of steam in the cylinders, the combination, with said cylinders and pistons, of mechanism acting upon the latter as they reciprocate within the cylinders to cause them to oscillate equally on opposite sides of a central line between the inlet and exhaust ports, whereby as the pistons reciprocate within the cylinders their ports will be caused to traverse an elliptical path intersecting the inlet and exhaust ports at diametrically-opposite points therein, and thus permit steam to be admitted and exhausted through either of said ports in the cylinder to reverse the engine, substantially as described.

9. In a three-cylinder direct-acting steam-engine, the combination, with the cylinders and pistons having inlet and exhaust ports, as described, of the pitmen interposed between the pistons and crank-pin, the tripod revolving with the crank-pin, and the boxes fitting the legs of the tripod and working in ways formed in the pistons to oscillate the latter, substantially as described.

10. In combination with the reciprocating pistons and pitman-connections permitting of an oscillating movement of the former, the tripod loosely hung upon the crank-pin and rotating therewith, each leg of said tripod engaging one of the pistons, substantially as described.

11. The combination, with the pistons reciprocating in radial lines and connected to the crank-pin, so as to be capable of an oscillatory movement about their longitudinal axes, of the tripod mounted upon and revolving with the crank-pin, and provided with radial legs standing parallel with and engaging the pistons to oscillate the latter, substantially as described.

12. The combination, with the cylinders and the pistons working therein, provided with ports and steam-passages, substantially as described, of a rotary valve common to the several cylinders for controlling the admission of steam to the inlet-ports and a governor operating upon the said valve to both rotate and reciprocate the latter, as and for the purpose set forth.

13. In combination with the rotary valve and its casing containing passages communicating with the steam-supply and inlet ports of the several cylinders, a governor rotating in unison with the driving-shaft and connected to the said valve by devices, substantially as described, whereby the rotary movement of the valve is determined by the speed of the governor-weights to operate as a cut-off and the valve is reciprocated within its casing or chamber to throttle the steam-supply passage when the speed of the engine is abnormally augmented, as set forth.

14. In a multiple-cylinder direct-acting steam-engine wherein the admission and escape of steam within the cylinders is controlled by the movement of the pistons therein, a rotary cut-off valve having separate ports corresponding in relative position to the ports communicating with the passages leading to the inlet-ports of the cylinders, and a governor through which motion is communicated from the main driving-shaft to the valve for rotating and setting the latter.

15. The combination, in a multiple-cylinder direct-acting steam-engine, of a rotary cut-off located between the steam-supply passage and the inlet-ports of the cylinders, a governor operating upon said valve to rotate and advance the position of the same proportional to the speed of the driving-shaft, and a reversing valve or sleeve, such as described, cooperating with the said cut-off valve to place the steam-passage in communication with the exhaust-ports and the exhaust-passage with the inlet-ports and thereby reverse the engine, substantially as described.

16. In combination with the tubular valve S, provided with ports 12 and 13 and chamber T^3, and a governor for rotating and reciprocating said valve, the steam-passage S^2, ports 1, 2, and 3, leading to the inlet-ports in the cylinders, and the port 5, communicating with the exhaust-passages, substantially as and for the purpose described.

17. The combination, with a valve containing chambers T^3 T^4 and ports 12, 13, 14, and 15, and the valve casing or chamber having steam-ports S^2 1 2 3 and chambers 4 and 11, the latter communicating with passages leading to the ports 1, 2, and 3, through passages s^6, of the movable sleeve provided with ports or passages 8, 9, and 10, substantially as and for the purpose described.

18. The combination, with a rotary cut-off and throttling valve for controlling the admission of steam to the inlet-ports, of a governor driven from the main shaft and connected to the valve by gear-segments, to which the weights are attached, and a toothed collar fitting the end of the valve, substantially as described.

19. In combination with a rotary cut-off and throttling valve, and as a means for driving and automatically adjusting said valve, the governor carrying gear-segments, to which the weights are connected, a gear-collar engaging said segments and fitted to the valve, so as to permit a longitudinal movement of the latter, and a pin rotating in unison with the governor and engaging a cam-groove in the valve to reciprocate the latter, and thereby close the steam-ports, substantially as described.

20. In a direct-acting multiple-cylinder steam-engine, the combination, with the rotary valve, adjustable sleeve, and valve-casing, a chamber containing the co-operating ports, as described, the whole operating as an automatic cut-off, throttle, and reversing mechanism, of a governor connected to said valve and provided with means for automatically adjusting the throw of the valve and for reciprocating the latter, substantially as and for the purpose specified.

21. In a multiple-cylinder direct-acting steam-engine, the combination, with the cylinders containing inlet and exhaust ports, the pistons provided with ports communicating with the ports in the cylinders, and devices for oscillating the pistons equally on opposite sides of a central line between the inlet and exhaust ports during the reciprocation of said pistons, substantially as described, of the cut-off valve and reversing-sleeve applied thereto, located in the valve-chamber and provided with ports, as described, and the governor connected to the valve and operating to both rotate and reciprocate the latter, whereby said valve is caused to operate as a cut-off and throttle when the engine is running forward, and as a throttle when reversed, as set forth.

22. In combination with the cut-off valve rotating in a chamber, as described, the governor mounted upon a separate shaft and connected to rotate in unison with the main drive-shaft, the gear-segments connected to and operated upon by the weights, the gear-sleeve rotating with the valve and held in position thereon by the arms attached to the governor, and the pin on one side of said arms engaging the walls of a cam-groove in the valve, substantially as described.

23. In combination with the valve containing ports 13, for admitting steam to the inlet-

ports and chamber T^4, with its ports 14 and 15, the valve-chamber containing steam-passage S^2, chambers 4 and 11, ports 5 and 6, and passages s^2 between chamber 11 and the passages leading to the inlet-ports of the cylinders, and the adjustable sleeve embracing said valve and provided with ports 8, 9, and 10, the whole arranged for operating substantially as described, and for the purpose set forth.

24. In a direct-acting multiple-cylinder steam-engine such as described, and in combination with the crank and radially-arranged pistons, the pitmen connected to the pistons, one of said pitmen having a sleeve embracing the crank-pin and the others collars on one side and interlocking projections on the other, said last-named pitman being fitted upon the sleeve of the first-named pitman, with the interlocking projection of the one embraced by the collar of the other, substantially as described.

MIRABEAU N. LYNN.
ELMORE P. LYNN.

Witnesses:
A. H. ROMSPERT,
J. H. BOGENRIFE.