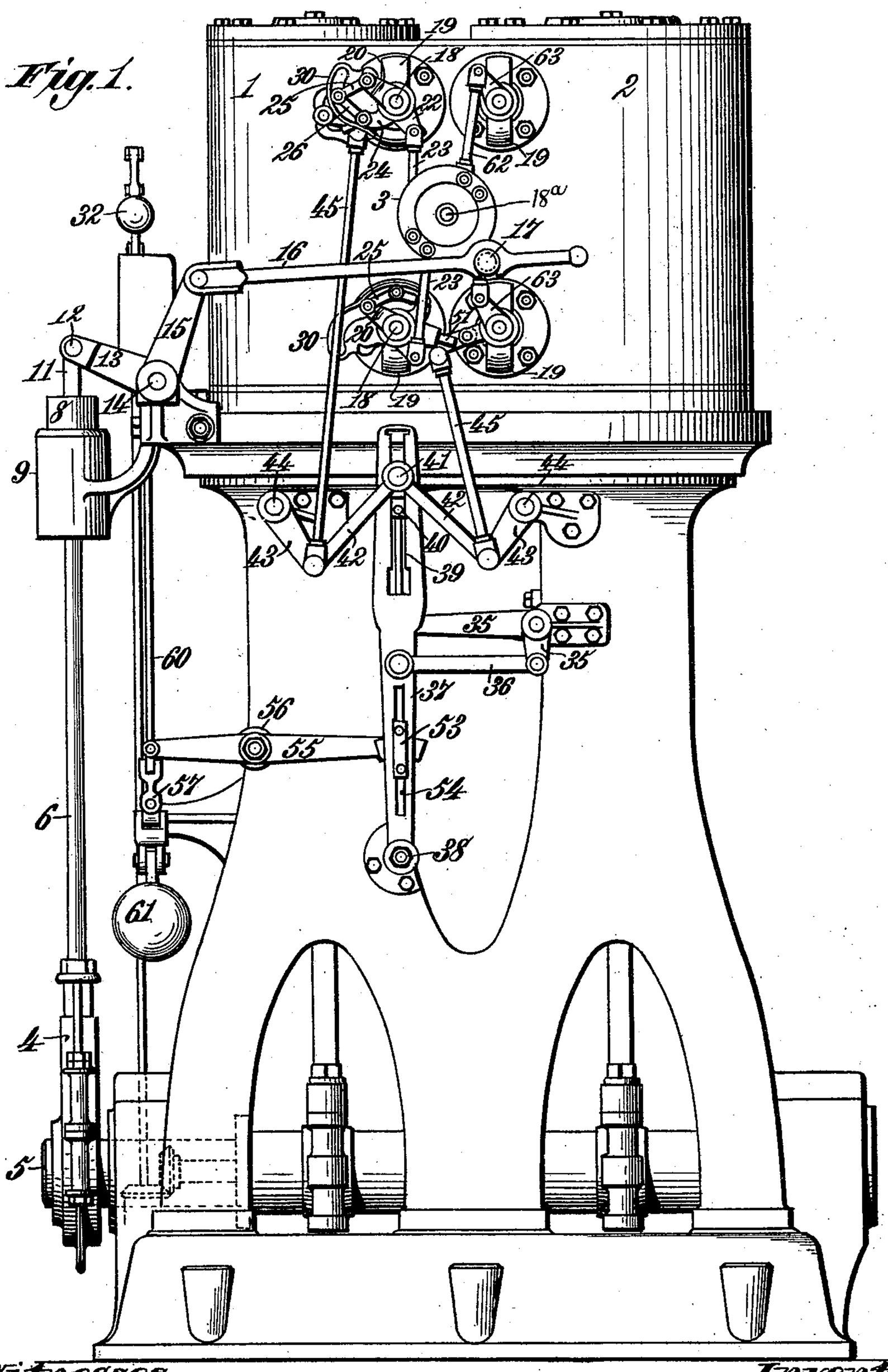
(No Model.) 4 Sheets—Sheet 1.

J. DOW.

STEAM ENGINE.

No. 594,336. Patented Nov. 23, 1897.

Fig. 1.



Witnesses.
Robt Gruett.
J. B. Keiper.

Inventor.
Josiah Dow.
By James L. Norris.
Atty.

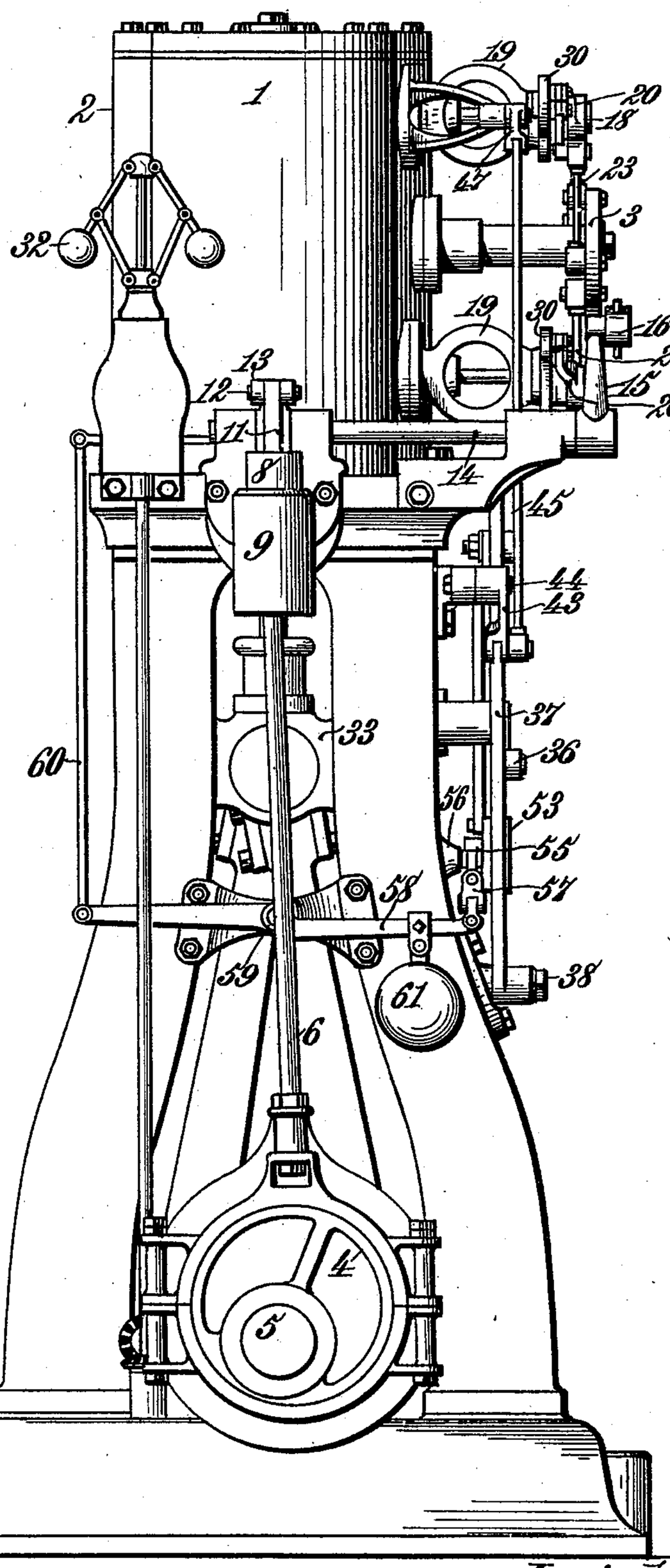
(No Model.) 4 Sheets—Sheet 2.

J. DOW.

STEAM ENGINE.

No. 594,336. Patented Nov. 23, 1897.

Fig. 2.



Witnesses.
Robt. Everett.
F. B. Keeler.

Inventor.
Josiah Dow.
By James L. Norris.
Atty.

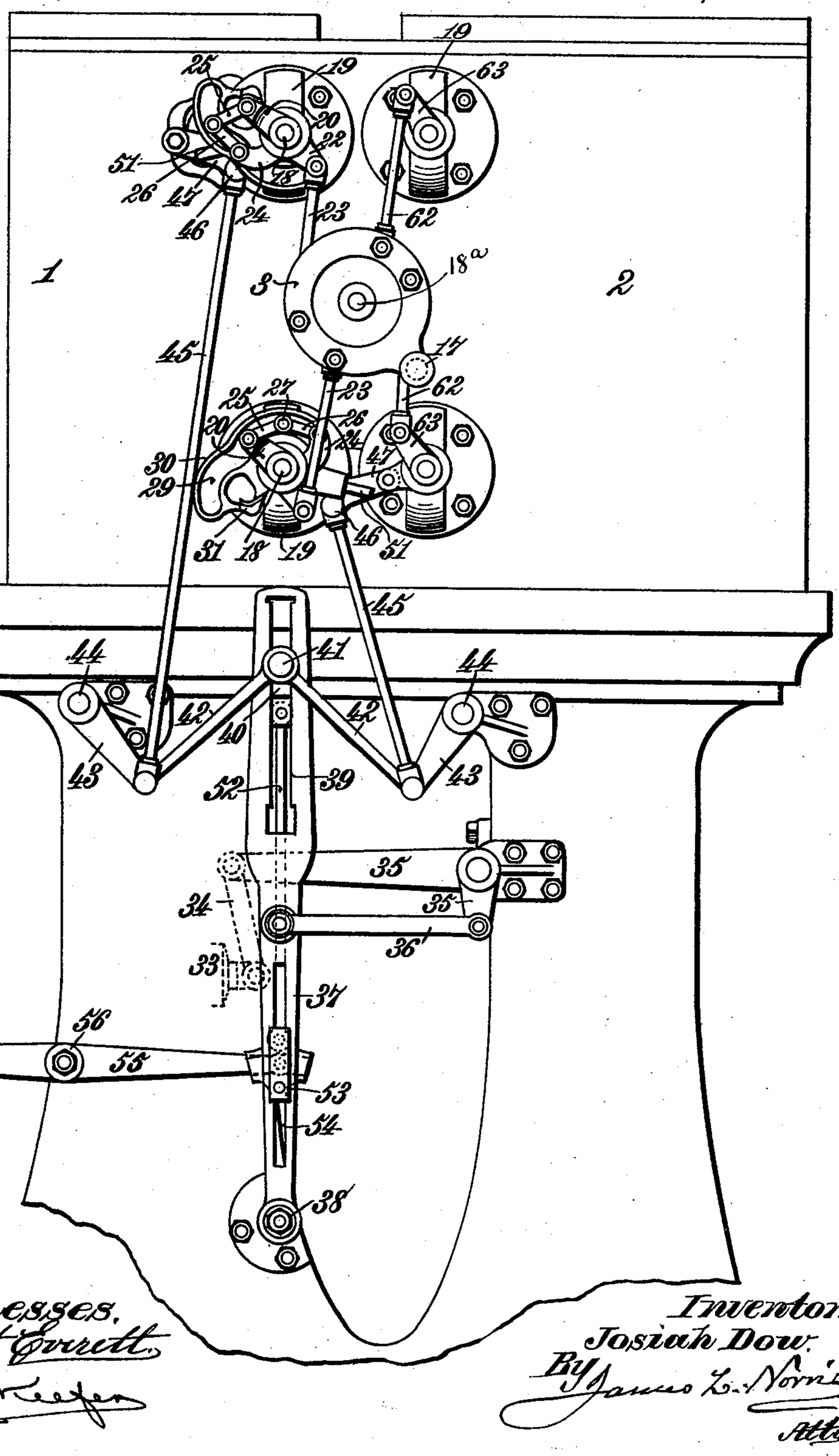
(No Model.) 4 Sheets—Sheet 3.

J. DOW.

STEAM ENGINE.

No. 594,336. Patented Nov. 23, 1897.

Fig. 3.



Witnesses.
Robert Everett.
W. B. Keeler

Inventor:
Josiah Dow.
By James L. Norris.
Atty.

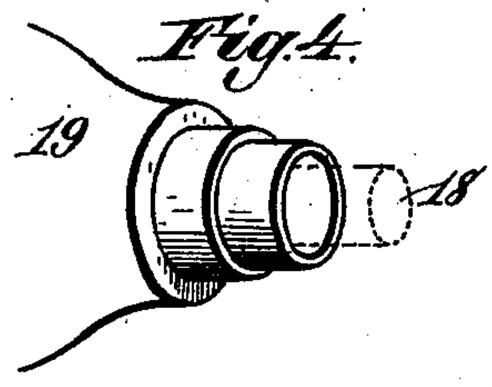
(No Model.) 4 Sheets—Sheet 4.

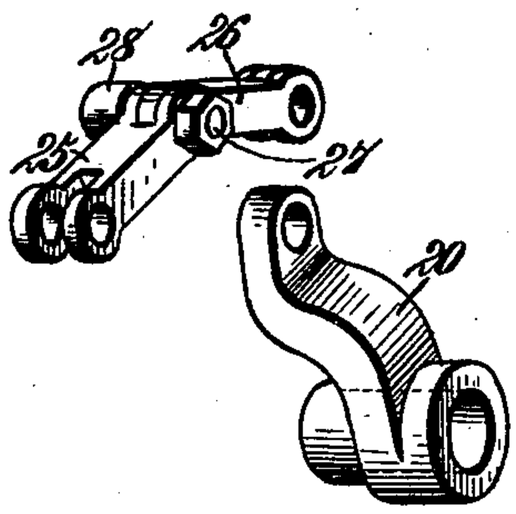
J. DOW.

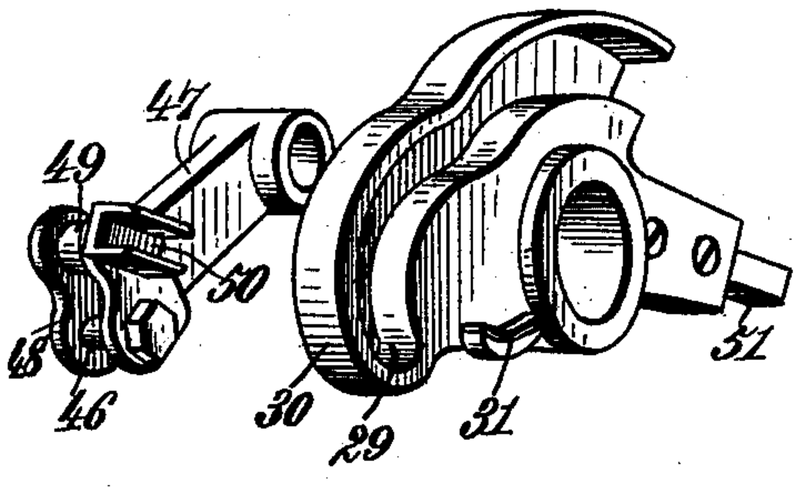
STEAM ENGINE.

No. 594,336. Patented Nov. 23, 1897.

Fig. 4.







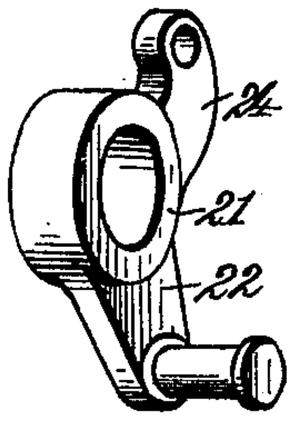


Fig. 5.

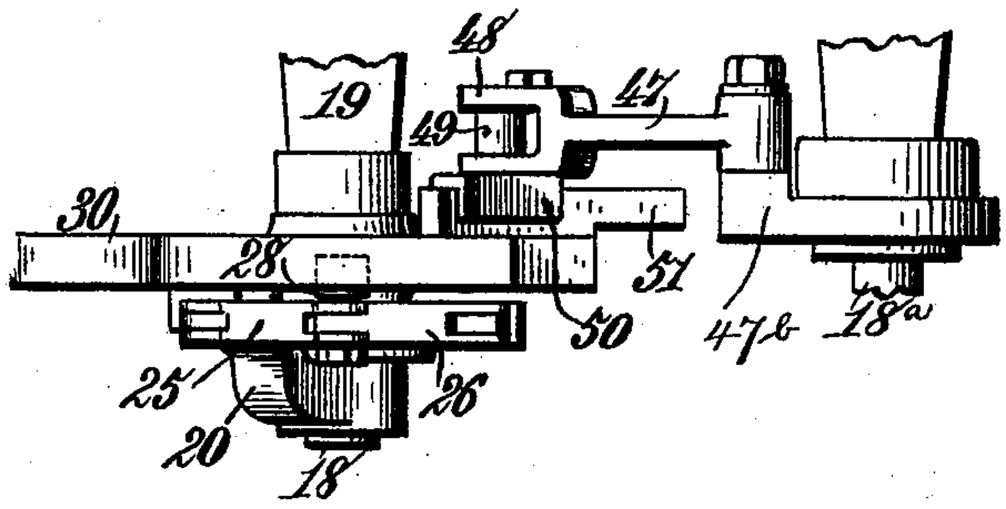


Fig. 6.

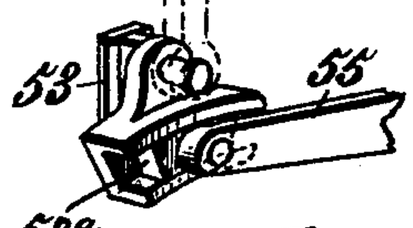
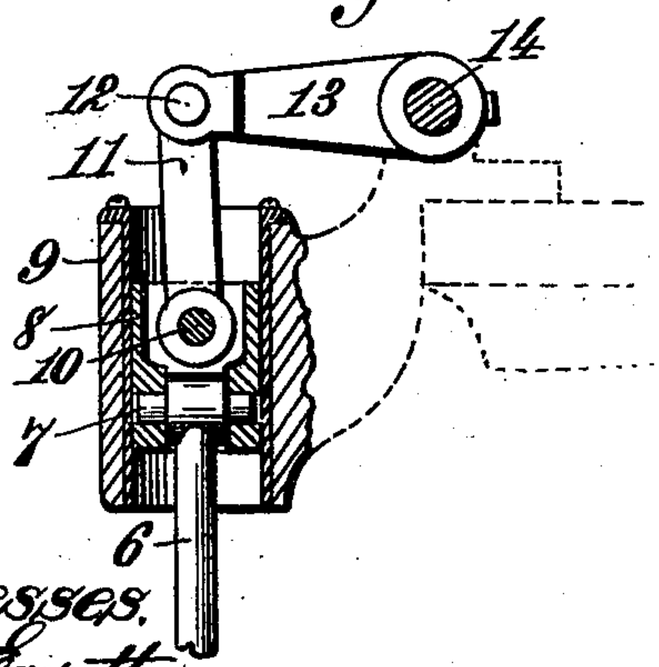


Fig. 7.



Witnesses.
Robert Gruett.
F. B. Keefer

Inventor:
Josiah Dow.,
By James L. Norris.
Atty.

UNITED STATES PATENT OFFICE.

JOSIAH DOW, OF PHILADELPHIA, PENNSYLVANIA.

STEAM-ENGINE.

SPECIFICATION forming part of Letters Patent No. 594,336, dated November 23, 1897.

Application filed January 11, 1897. Serial No. 618,829. (No model.)

To all whom it may concern:

Be it known that I, JOSIAH DOW, a citizen of the United States, residing at Philadelphia, (Germantown,) in the county of Philadelphia and State of Pennsylvania, have invented new and useful Improvements in Steam-Engines, of which the following is a specification.

This invention relates to steam-engines, and has for its principal object an improved valve-gear and cut-off connections adapted to provide means for a more positive, close, and accurate cut-off in that which is known as the "Corliss" method of steam-distribution and thus to attain a much higher velocity than has been possible through the use of a "drop" cut-off or similar mechanism.

It is another purpose of my invention to provide in such an improved manner for the actuation of an oscillatory valve covering both induction and eduction that all the events or positions of the said valve which controls the flow of steam into the cylinder, excepting the cut-off, shall be positively maintained through the action of a wrist-plate that receives motion primarily from an eccentric on the main engine-shaft, while the movement for the cut-off mechanism is taken through a cut-off lever almost directly from the cross-head of the engine, so that the cut-off may be accomplished at the same position of the piston relative to the stroke for both directions of its movement, the time of effecting the cut-off being regulated by a governor. The resistance to the action of the governor may be increased or decreased through the adjustment of a movable weight connected with the cut-off mechanism, so that while the throttle is quite open and the valve-gear running in its normal condition the engine may be set to run at any required speed.

Other objects and advantages of the invention will hereinafter appear with reference to the novel construction and arrangement of parts as described and claimed.

In the annexed drawings, illustrating my invention, Figure 1 is an elevation of a vertical compound engine, showing in front view the valve-gear and cut-off connections. Fig. 2 is an elevation of the same at a right angle to the view shown in the preceding figure. Fig. 3 is an enlarged view of the valve-gear and cut-off mechanism. Figs. 4, 5, 6, and 7 are enlarged detail views of parts hereinafter referred to.

As shown in Fig. 1, the reference-numeral 1 designates the high-pressure cylinder, and 2 the low-pressure cylinder, of a compound engine, in which the said cylinders are placed in such close and compact relation that simple and direct steam-passages will serve to connect the valves of the two cylinders. Each valve at the high-pressure cylinder is preferably to control both the induction and eduction for that cylinder, and the exhaust from the high-pressure cylinder determines the lead of steam for the low-pressure cylinders, although the gearing is as well adaptable to the ordinary relation of the valves to the cylinders as in the original Corliss engine. The valves for both the high-pressure and low-pressure cylinders are of a well-known oscillatory type, and their special construction need not be shown or described. Although the drawings show a vertical compound engine, it will be apparent that without essential change in construction or action the valve-gear and cut-off mechanism may be applied to either a single-cylinder or a two-cylinder engine arranged either vertically or horizontally, as preferred.

For controlling or maintaining all the positions or events of the oscillatory valve or valves, excepting the cut-off, there is provided a wrist-plate 3, that receives motion primarily from an eccentric 4, fixed upon the main shaft 5 of the engine. The eccentric-rod 6 has its outer attachment upon a pin 7, carried by a cylindrical sliding block 8, that is adapted to move within a cylindrical guide-sleeve 9, fastened firmly upon the frame or housing of the engine. This sliding block 8 carries also a pin or bearing 10, that is located at right angles to the pin 7, which connects with the eccentric-rod. The pin 10 affords a bearing or attachment for one end of a link 11, the other end of which connects through a pin or bearing 12 with the outer end of an arm 13, that is attached to and gives motion to a rock-shaft 14, mounted on the engine-frame at right angles to the main shaft. The rock-shaft 14 carries another arm 15, with the outer end of which is connected the usual hooked rod 16, that is adapted to connect with

a stud 17 on the wrist-plate 3 and through which the said wrist-plate receives motion from the eccentric on the main engine-shaft.

That portion of the valve-gear which is immediately about each valve-stem 18 is set upon a bonnet 19, attached to the cylinder at each valve. There is keyed to the projecting end of the valve-stem 18 the collar portion of a crank-arm 20, immediately behind which is another collar 21, that is mounted to oscillate upon a bearing at the end of the bonnet. This collar 21, through a crank 22 thereon, receives movement from the wrist-plate 3 by means of a rod 23, that connects these parts. The collar 21 has also fastened or cast upon it an arm or spur 24, set in line with the outer end of the valve-stem crank-arm 20, to which it is connected by means of toggle-jointed links 25 and 26, the center joint of which carries a strong pin 27, having thereon an anti-friction-roller 28, that preferably engages and follows a curved groove or slot 29 in a cut-off plate 30, set immediately behind the said links. This cut-off plate 30 has its bearing upon the bonnet at the back of the collar 21, and its movements are parallel with the movements of the collar crank-arm 22, valve-arm 20, and their connecting-links. The outer end of the valve-arm or crank 20 is curved backward to bring it into direct line of movement with the arm or spur 24 and in the direct line of force through the links 25 and 26 without requiring offset-joints and also to provide that the pin 27, with its roller 28, may run in the groove or slot 29 of the cut-off plate 30 with the least possible offset. The axis of movement of the cut-off plate 30, the arms 22 and 24 of collar 21, and the crank or valve arm 20 are identical with that of the oscillatory valve and its stem. The arc-shaped groove 29 in the cut-off plate 30, through which the roller 28 runs, is concentric with the axis of the valve through the greater part of the length of said groove or slot, and it will be seen that as long as the roller 28 is held in this concentric portion of the groove the crank 22, which receives movement direct from the wrist-plate 3 and the crank 22 on the stem of the valve, must move exactly together, by which means the valve is rocked or oscillated to the opening of the exhaust, back again to its closing, and onward to the opening of the steam-port directly from the wrist-plate movements. Furthermore, the groove or slot 29 is so arranged that when the steam-port is fully open the roller 28 has passed by easy change into another portion of the groove 29, constituting an arc that is concentric not with the axis of the valve-stem 18, but with the center of the pin, making the joint with the link 26 upon the outer end of the crank or valve arm 20, this arc in the groove 29 having a radius of construction just equal to the length of the link 26 from center to center of its joint-pins. On reaching this changed arc the roller 28 is carried through it, pressure from the spur 24 helping a ready expansion, and as the end of the valve-arm 20 is now exactly in the center of the arc through which the roller 28 moves, while the connecting-link 26 has the exact length of its radius, the valve can no longer move, notwithstanding an onward movement of the spur or arm 24 to its finish in that direction. The end of the crank or valve arm 20 necessarily keeps its position in relation to the center of the arc in which the roller 28 is moving. Consequently if the cut-off plate 30 is oscillated it will carry the valve-arm 20 with it, only changing the relative position of the roller 28, within the arc of which the end of said valve-arm is the center.

Obviously the principle for control of the valve lies in keeping the middle joint of the toggle-links (*i. e.*, the pin 27 therein) moving first in an arc, or nearly an arc, concentric with the center of the valve-stem until the valve is open, or as nearly so as may be desired, after which it must pass through another arc eccentric with this but concentric with the center of the pin upon the end of the valve-stem crank-arm 20, the means for accomplishing this to be so controlled by the governor, through the cut-off mechanism, regardless of its particular form, whether that of a plate with a groove in which a roller runs or connecting links and cranks—in the present construction a plate and groove being preferred—that the cut-off and other movements of the valve may be controlled as described.

There is positioned upon the cut-off plate 30 a buffer 31, guarded by leather or other substance calculated to prevent shock, and so located as to meet the valve-arm 20 just before the position at which said valve-arm comes to rest through its decreasing motion controlled by the roller 28 as it passes through a reverse arc in the groove or slot 29, where the concentric and eccentric portions of said groove are joined. This buffer 31 obviates all risk of strain in the parts at the moment of cut-off, which is brought about by a backward movement or oscillation of the cut-off plate 30, actuated through connections that will be presently described. The cut-off plate is always in position to allow the roller 28 to pass into the eccentric portion of the slot or groove 29, and thus receive the valve-crank 20 in its place of rest time enough before the beginning of a stroke of the engine to insure the valve its free opening by means of the wrist-plate movement, except when under urgency the cut-off has acted so early to prevent any opening of the steam-port for that stroke. Upon the end of the valve-crank 20 reaching its position in the center of the eccentre arc, although the said crank or valve arm is now at rest in relation to the cut-off plate, the roller 28 moves onward through the slot or groove 29, while the actuating spur or arm 24 is permitted to approach the valve-arm through toggle action of the links 25 and 26, and with a long cut-off may even start to return in its regular movement before the cut-off through movement of the plate 30, which

has more rapid action, can take place. Under an extreme necessity the wrist-plate movement alone, acting through the links 25 and 26, may actuate the valve to a closing of the steam-port through the cut-off being held very late in the stroke. Therefore as the time of effecting the cut-off through movement of the plate 30 is regulated by a governor 32 it may take place at any part of the stroke so determined from its beginning to as near its end as the wrist-plate movement can properly effect—that is to say, there is no interval between the latest action of the cut-off mechanism proper and the closing of the valve as effected by the wrist-plate movement alone at the end of the stroke.

The movement for the cut-off mechanism is taken as directly as possible from the cross-head 33 of the engine, that it may be not only simple and direct in application, but also, which is of much importance, that the cut-off may be accomplished at identical positions of the piston for both directions of its movement with its own "angular advance." This is impossible through use of an eccentric for this purpose, as it has its own degree and time of angular advance. From the cross-head 33 motion may be transmitted through a system of levers 34 35 36 or an equivalent lever or levers and as directly as may be practical to a cut-off lever 37, having its bearing or fulcrum 38 at or near one end. In the outer portion of this oscillatory cut-off lever 37 is a longitudinal slot 39, in which is carried a sliding block 40, controlled in position by the governor, as presently explained. The block 40 carries a pin or center 41, upon which are pivoted links 42, leading off at each side to rocker-arms 43, that are fulcrumed, as at 44, to the engine-frame or cylinder-housing. To the joint connections of the links 42 and rocker-arms 43 are attached connecting-rods 45, leading to pins 46 upon rocker-arms 47, which actuate the cut-off plates 30, one for each valve of the high-pressure cylinder in a compound engine, as shown, or as in a single-cylinder engine one for the valve at each end of such cylinder. These valves each comprise both induction and eduction events for its end of the cylinder. Cut-off is always completed at an identical position of the rocker-arm 43 and rocker-arm 47 no matter at what part of the stroke it may take place, and these rocker-arms are so arranged that if the sliding block 40 is down in the slot 39 cut-off will come much sooner in the stroke of the engine than if the block be up, the range of movement following such part of the whole stroke as may be desired, from no admission of steam at all to a coincidence with the closing of the valve effected by the main gearing actuated from the wrist-plate. It will be seen that the connecting mechanism from the attachment at 41 on the sliding block 40 in the cut-off lever 37 through to the gearing upon the valve-stem is so arranged that only just such part of the whole movement of the cut-off lever which is coincident with that of the piston of the engine shall reach the valve as is necessary to effect the cut-off or closing of the steam-port, the remainder being lost motion as regards the movement of the cut-off plate 30, this lost motion being taken from one limit or the other of the movement of the rocker-arm 43 and rocker-arm 47, according to the position of the block 40 in its slot 39, the links 42 and connecting-rods 45 having certain parts of the movement of their ends through arcs in which they swing, while conveying little or no movement to the cut-off plate. This concentration of the movement of the cut-off plate 30 to just the limit necessary to accomplish the cut-off is greatly helped by reason of the connection between the rocker-arm 47 and the plate 30 taking place through reversed and intersecting arcs and with a sliding movement through parts hereinafter described, which also secures, aided by the connecting-rod action, an easy and gradually-increasing motion for the cut-off plate from its position of rest to a rapid completion of the cut-off and then a gradual diminution of motion to its second point of rest. The effect of this action is to make the cut-off very quick at its finish, avoiding "wire-drawing," and of exact degree at whatever part of the stroke it may occur, the whole cut-off mechanism being at the same time easy running and operating with great smoothness, freedom from wear, and without shock either in starting the movement of the plate 30 or in bringing it to rest.

The rocker-arm 47 has upon its outer end, beneath the plate 30, a bearing 48, Figs. 4 and 5, which holds a loose pin 49, having formed upon its end outside the said bearing and nearest the plate a groove or guideway 50, that fits smoothly and slidingly upon a bar or rod 51, that is firmly attached to the back of the cut-off plate 30, the object being to provide a smooth and free sliding connection between the cut-off plate 30 and the rocker-arm 47 that will permit the end of said rocker-arm to act in its reversed arc upon proper movement of the cut-off plate. The proper degree of movement of the cut-off plate 30 is concentrated from the longer arc of movement of the cut-off lever 37 through the rocker-arm 43 at its lower limit of movement in consequence of the movement of rod 45 as it approaches (or even passes) the rocker-arm fulcrum 44 and at the upper limit of movement in said rocker-arm 43 in consequence of the arrangement of parts by which its relation to the cut-off lever 37 is changed through upward or outward movement of the sliding block 40, also through the rocker-arm 47, by which the cut-off plate 30 is immediately actuated in consequence of the arc of movement in said rocker-arm being opposed to that of the bar 51, secured to the said cut-off plate, which, through the sliding motion of guide 50 upon the bar 51, provides a gradual diminu-

tion or acceleration of the movement of the cut-off plate that may at extremes even bring it to rest while the rocker-arm 47 still moves. The attachment of the rocker-arm 47 to the connecting-rod 45 is shown at 46 as separate from the pin 49 and its bearing 48; but it is obvious that, if desired, these parts may be arranged coincident.

In a vertical compound engine, as shown, the rocker-arm 47 at the upper steam-valve is supported from a bracket-arm 47^a, Fig. 2, adjacent to the stem 18 of that valve. At the lower steam-valve the rocker-arm 47 is more conveniently fulcrumed to a projection of a collar 47^b on the end of the bonnet, through which projects the stem 18^a of the adjacent lower exhaust-valve, as clearly shown in Fig. 5.

The sliding block 40 in the slot 39 of cut-off lever 37 is connected by means of a link or rod 52 to another sliding block 53, engaged in a slot 54 near the fulcrumed end of the cut-off lever. This block 53 has a similar longitudinal movement with the connected block 40, the two thus being made coincident in action. In the sliding block 53 is a groove 53^a, preferably made in the form of an arc for ease of connection with one end of a two-armed lever 55, that is fulcrumed at 56 on the engine-frame. The other end of this two-armed lever 55 connects, through a link 57, with one end of a two-armed lever 58, fulcrumed at 59 and arranged substantially at a right angle to the first-named lever 55, that immediately connects with the slide-block 53 of the cut-off lever. One end of the lever 58 connects, through the rod 60, with the governor mechanism 32, as shown. Through this or a similar connection with a governor mechanism the sliding blocks 40 and 53 are drawn downward for an earlier cut-off and pushed upward for a later cut-off, while the arc-groove 53^a in the sliding block 53 permits free movement of the cut-off lever 37 without disturbance to this regulation of position for the said sliding blocks. The position of the sliding block 40 in the slot 39 determines the point in the stroke of the engine at which the cut-off shall take place for both ends of the cylinder, the two links 42 acting equally. The connections to the governor may be varied to be more or less direct, according to circumstances, even to a direct connection with sliding block 40; but in any case they should be balanced, so that the work upon the governor shall be as light as possible and equal in degree, whether the block 40 be moved upward or downward. As the movement of the connections on one side of the lever is effecting a cut-off for their end of the steam-cylinder those of the other side are by reverse movement restoring the cut-off plate 30 to its original position for the beginning of another stroke. One of these actions presses upward or outward upon the block 40, while the other draws downward or inward upon it. Thus with such correction for balance as may be necessary they neutralize each the action of the other as regards movement of the block 40 and leave it free to easy regulation by the governor.

To provide for increasing or decreasing the speed of the engine through an increase or decrease in the resistance to the action of the governor as exerted through the cut-off mechanism, there may be placed intermediate the governor and the cut-off a movable weight 61, suspended, for instance, from the lever 58 in such a manner as to be capable of adjustment toward and from the lever-fulcrum. By adjustment of this weight 61 upon its supporting-lever the speed at which the engine is to run will be increased through increasing the resistance against action of the governor by a movement outward of the weight upon the lever, and conversely the speed will be decreased by decreasing that resistance through an adjustment of the weight inward. The same effect and action may be obtained through use of a spring or other similar means of increasing and decreasing the tension upon the lever. In this manner, though the throttle is full open and the valve-gear running in its normal condition, the engine may be set to run very slowly while warming up and waiting for its work, and be then started into full action and speed simply by moving the weight 61 to its proper position upon the lever.

In a compound engine the wrist-plate 3 will be connected by rods 62 to rigidly-attached arms 63 on the stems of the low-pressure valves.

Throughout the engine, whether constructed with one or more cylinders, either vertical or horizontal, there is a perfect balancing, as by part against part where practicable or by counterbalance, if necessary.

What I claim is—

1. In an engine, the combination with an oscillatory valve controlling both induction and eduction, and a valve-gear comprising a wrist-plate and connections actuated from an eccentric on the main engine-shaft, of governor-controlled cut-off mechanism actuated from the movement of the cross-head and piston-rod of the engine, whereby a variable cut-off is effected at the same position of the piston relative to the stroke for both directions of its movement and at any point of the stroke, substantially as described.

2. In an engine, the combination with a valve, and a valve-gear comprising a wrist-plate and valve connections actuated from an eccentric on the main engine-shaft, of a cut-off lever having direct connection with and actuated from the movement of the piston-rod and engine cross-head, a governor-controlled slide-block carried by said cut-off lever, a cut-off plate in toggle-link connection with the valve-gear and its wrist-plate, and connecting mechanism from the governor-controlled slide-block to the said cut-off plate, substantially as described.

3. In an engine, the combination with a valve, and a valve-gear comprising a wrist-

plate actuated from an eccentric on the main engine-shaft, of a cut-off lever actuated from the movement of the cross-head and piston-rod of the engine, a governor-controlled slide-block carried by said lever, a slotted cut-off plate, a collar having two arms to one of which is attached a connecting-rod from the wrist-plate, toggle-links connecting the other arm of said collar to a rigid arm on the valve-stem, a roller at the connecting-joint of said toggle-links and engaged in the slot of the cut-off plate, and lever connections from the governor-controlled slide-block to the cut-off plate, substantially as described.

4. In an engine, the combination with a valve, the valve-gear, and wrist-plate connections, of a cut-off lever actuated from the movement of the piston-rod and engine cross-head, a governer-controlled slide-block carried by said cut-off lever, a cut-off plate having a slotted portion in toggle-link connection with the valve-gear and wrist-plate, a rocker-arm having a pivotal link connection with the governor-controlled slide-block, a rocker-arm slidingly connected with the cut-off plate, and connecting-rods between the said rocker-arms, substantially as described.

5. In an engine, the combination with a valve, the valve-gear, and its wrist-plate, of a cut-off lever actuated from the movement of the piston-rod and engine cross-head, coincidently-acting slide-blocks carried by said cut-off lever, a cut-off plate actuated from one of said slide-blocks and in variable connection with the valve-gear and wrist-plate, a governor having lever connections to the other one of said slide-blocks, and a movable weight supported by said lever connections and adjustable thereon to vary the resistance to the action of the governor through the cut-off mechanism and thereby control the engine speed, substantially as described.

6. In an engine, the combination with a valve, the valve-gear, and its wrist-plate, of a rock-shaft provided with two arms one of which has an actuating connection to the said wrist-plate, a guide-sleeve rigid on the engine-frame, a slide-block arranged in said sleeve and provided with two pins or pivot-bearings at right angles to each other, a link connecting one of said pins to an arm of the said rock-shaft, and an eccentric-rod connecting the other of said pins to an eccentric on the engine-shaft, substantially as described.

7. In an engine, the combination with an oscillatory valve having its stem provided with a rigid crank-arm, of an oscillatory collar mounted concentric with the axis of said valve and provided with two arms one of which is in line with the outer end of the valve-arm, toggle-links connecting said collar-arm and valve-arm, a connecting-rod between the other collar-arm and a wrist-plate that is actuated from the engine-shaft, a cut-off plate having a slot that is concentric for the greater part of its length with the axis of the valve and for the remainder of its length concentric with the pin that makes connection between the outer end of the valve-arm and one of said toggle-links, a roller engaged in said slot and mounted on the joint that connects the two toggle-links, and governor-controlled mechanism connected with the said slotted cut-off plate and actuated from the engine cross-head, substantially as described.

8. In an engine, the combination with an oscillatory valve having its stem provided with a rigidly-attached crank-arm, of an oscillatory collar mounted concentric with the axis of said valve and provided with two arms, toggle-links connecting one of said collar-arms with the valve-arm, a connecting-rod between the other collar-arm and a wrist-plate, a cut-off plate having an arc-slot that is partly concentric with the valve-axis and partly eccentric thereto, a roller engaged in said slot and mounted on a pin at the joint connection of the two toggle-links, a cut-off lever actuated from the movement of the piston-rod and engine cross-head, a governor-controlled slide-block carried by said lever, and connections from said slide-block to the cut-off plate, substantially as described.

9. In an engine, the combination of a wrist-plate actuated from an eccentric on the engine-shaft, an oscillatory valve, a valve-gear through which the valve is oscillated to the opening of the exhaust then back again to its closing and onward to the opening of the steam-port directly from action of the wrist-plate, a cut-off plate having slot and toggle-link connection with the valve-gear and wrist-plate, and governor-controlled mechanism connected with said cut-off plate and actuated from the movement of the engine cross-head, substantially as described.

10. In an engine, the combination of an oscillatory valve, a wrist-plate, valve-gear through which the valve is oscillated to the opening and closing of the exhaust and onward to opening of the steam-port directly by action of the wrist-plate, a cut-off plate having slot and toggle-link connection with the valve-gear and wrist-plate, and governor-controlled mechanism for effecting cut-off through said plate at any point in the stroke and without interval between the latest action of the cut-off plate and the closing of the valve by wrist-plate movement, substantially as described.

11. In an engine, the combination of an oscillatory valve, a wrist-plate, valve-gear actuated from said wrist-plate for controlling induction and eduction through said valve, a cut-off plate having variable slot and toggle-link connection with the valve-gear and wrist-plate, a cut-off lever actuated from the movement of the piston-rod and engine cross-head, a governor-controlled slide-block carried by said lever, and rocker mechanism having a pivotally-linked connection with said slide-block and a sliding connection with the cut-off plate, substantially as described.

12. In an engine, the combination with a

valve, a wrist-plate, a valve-gear, and cut-off plate, of a slotted cut-off lever, coincidently-acting slide-blocks carried in the slots of said lever, rocker mechanism connecting one of said slide-blocks with the cut-off plate, the other one of said slide-blocks being provided with an arc-groove, and a lever having one end slidingly engaged in said arc-groove and its other end connected with a governor mechanism, substantially as described.

13. In an engine, the combination with a valve, a valve-gear, and a variable cut-off, of an oscillatory cut-off lever, coincidently-acting slide-blocks carried by said lever and connected with each other by a link or rod, connections from one of said slide-blocks to the cut-off proper for concentration of motion upon only the necessary movement of the cut-off, and governor mechanism connected with the other slide-block, substantially as described.

14. In an engine, the combination with a valve and valve-gear, of governor-controlled cut-off mechanism actuated from the movement of the cross-head and piston-rod of the engine, the said cut-off mechanism comprising means for effecting concentration of motion upon only the necessary movement of the cut-off, substantially as described.

15. In an engine, the combination with a valve, and valve-gear actuated from the engine-shaft, of a governor-controlled cut-off mechanism actuated direct from the movement of the cross-head and piston-rod of the engine, with provision for concentration of motion upon only the necessary movement of the cut-off, substantially as described.

16. In an engine, the combination with a valve, and valve-gear, of an oscillatory cut-off lever, a governor-controlled slide-block carried by said lever, and a variable cut-off controlled from said slide-block with provision for concentration of motion upon only the necessary movement of the cut-off, substantially as described.

17. In an engine, the combination with a valve, and valve-gear through which the valve is actuated to the opening and closing of the exhaust and onward to opening of the steam-port, of a variable cut-off, a governor for controlling the cut-off, and means for varying the resistance to the action of the governor through the cut-off mechanism to thereby control the engine speed, substantially as described.

18. In an engine, the combination with a valve, and valve-gear, of a variable cut-off operating partly in an arc concentric with the valve-stem and partly in an arc eccentric thereto, an oscillatory cut-off lever, a slide-block carried by said lever and having link and rocker-arm connection with the cut-off proper, the said connection being arranged for concentration of motion upon only the necessary movement of the cut-off, a governor for controlling the slide-block movement, and means for varying the resistance to the governor action through the cut-off mechanism, substantially as described.

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

JOSIAH DOW.

Witnesses:
CHAS. J. SCHAEFER,
ANNIE E. CONNELL.