(No Model.) 5 Sheets—Sheet 1.

C. C. WORTHINGTON.

DIRECT ACTING ENGINE.

No. 342,669. Patented May 25, 1886.

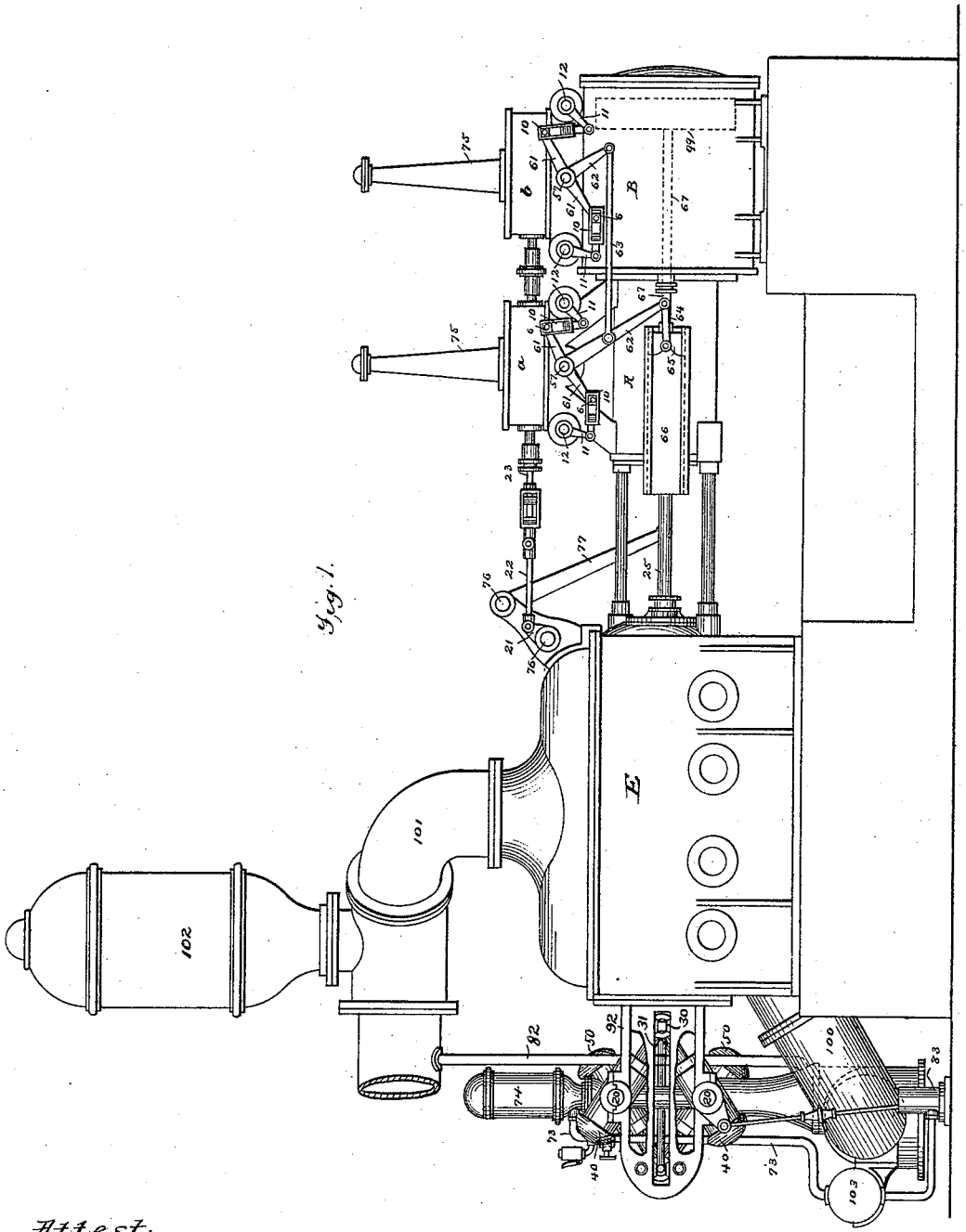

Fig. 1.

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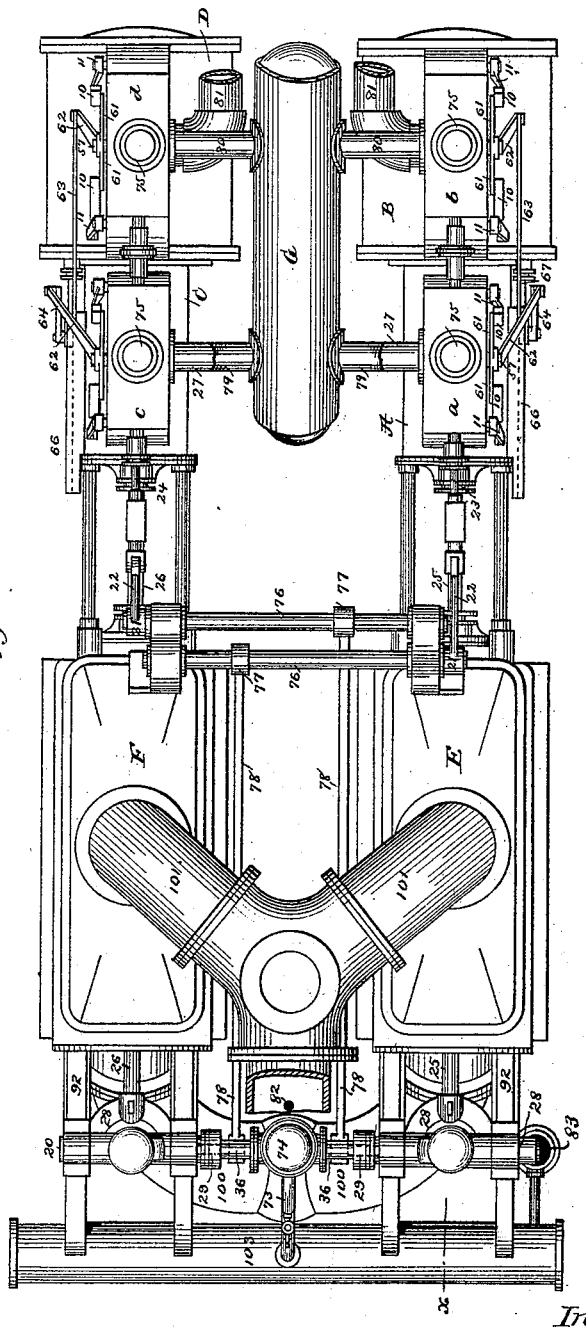

Fig. 2.

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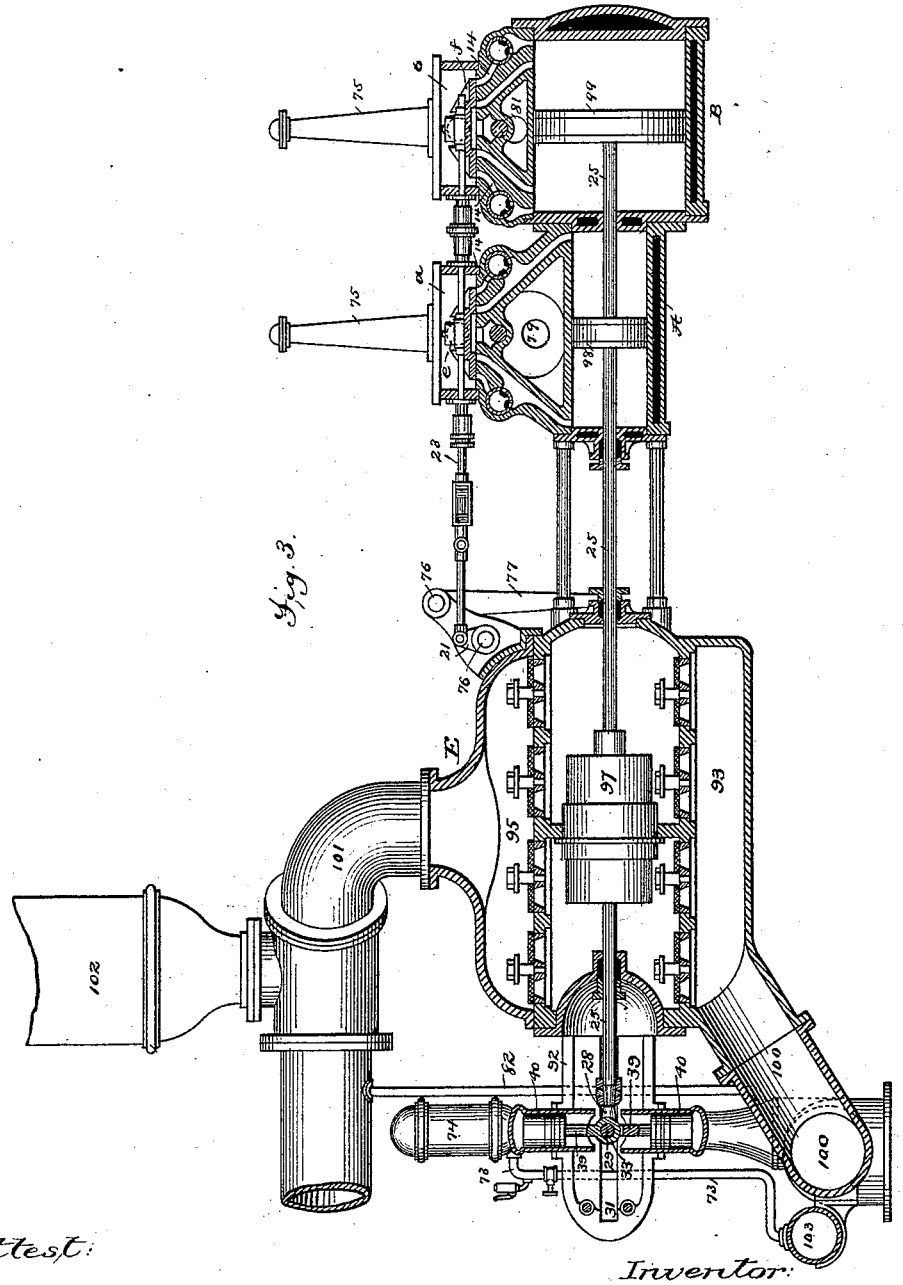

Fig. 3.

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DIRECT ACTING ENGINE.

No. 342,669. Patented May 25, 1886.

Fig. 4.

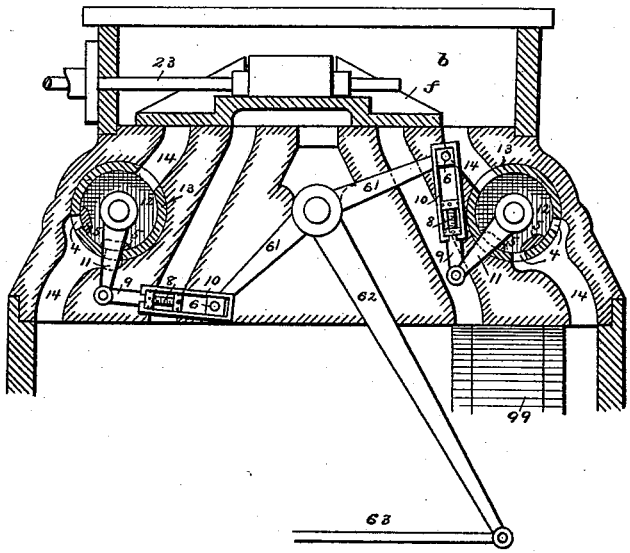
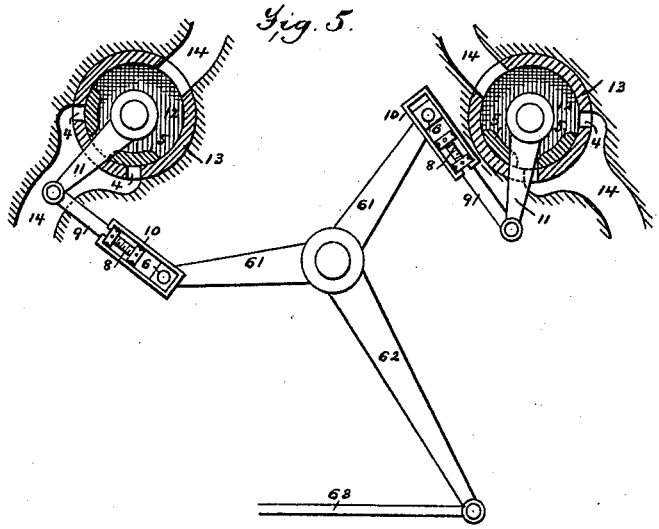


Fig. 5.



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C. C. WORTHINGTON.

DIRECT ACTING ENGINE.

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Fig. 6.

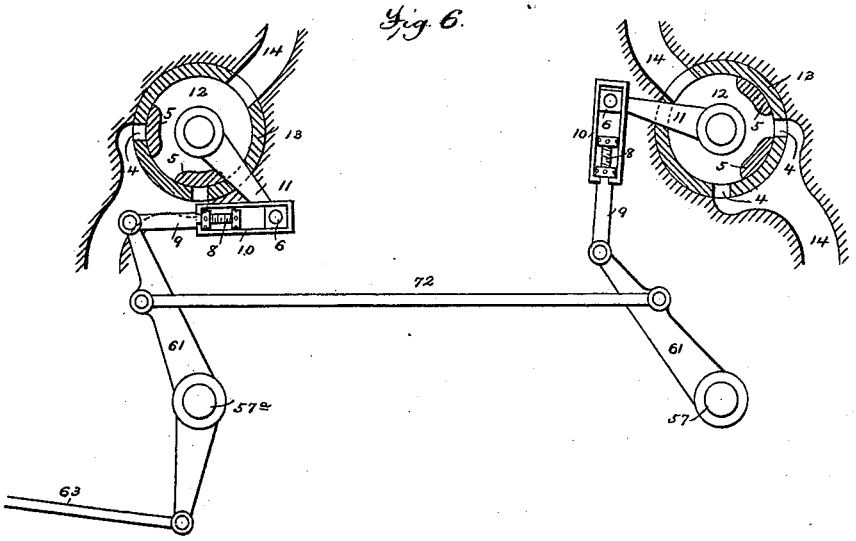
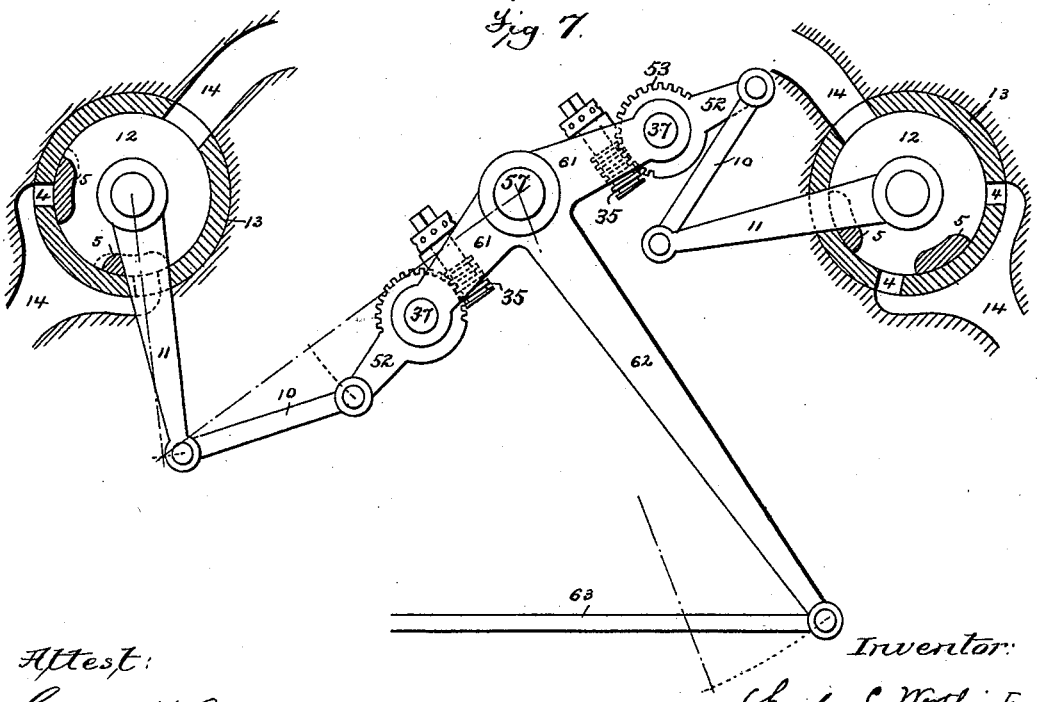


Fig. 7.



Attest:

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UNITED STATES PATENT OFFICE.

CHARLES C. WORTHINGTON, OF IRVINGTON, NEW YORK.

DIRECT-ACTING ENGINE.

SPECIFICATION forming part of Letters Patent No. 342,669, dated May 25, 1886.

Application filed November 10, 1885. Serial No. 182,330. (No model.) Patented in England December 22, 1885, No, 15.770.

To all whom it may concern:

Be it known that I, CHARLES C. WORTHINGTON, a citizen of the United States, residing at Irvington, county of Westchester, and State of New York, have invented certain new and useful Improvements in Direct-Acting Engines, fully described and represented in the following specification and the accompanying drawings, forming a part of the same.

The present invention relates, generally, to that class of engines which are known as "direct-acting," and particularly to those engines which are provided with one or more compensating or auxiliary cylinders and pistons, which are supplied with a suitable motor-fluid, and are arranged to act in opposition to the main piston or pistons during the first part of the stroke of the latter and in conjunction therewith during the latter part of the stroke, enabling the admission of steam to the main cylinder or cylinders to be cut off before the stroke is completed without reducing the power of the engine at the end of the stroke. One form of such an engine is shown and described in United States Letters Patent No. 292,525, heretofore granted to me.

The present invention consists in certain combinations with such engines of devices for operating the plugs, valves, or cocks by which the admission of steam is cut off from the steam cylinder or cylinders, whereby a more effective operation is maintained.

In the accompanying drawings the improvements are illustrated as applied to a duplex compound engine, but they are, however, equally applicable to duplex or single engines which are either simple or compound.

Figure 1 is a side elevation of a duplex compound pumping-engine embodying the present invention, the parts being shown in the positions they will occupy when the pistons of the two sides of the engine are at the ends of their strokes in opposite directions. Fig. 2 is a plan view of the engine, showing the parts in the positions they will occupy when the pistons of both sides of the engine are at the middle of their strokes. It is to be understood, however, that when in operation the two sides of the engine are never in these relative positions, they being shown in these positions simply for the purpose of more readily explaining the invention. Fig. 3 is a sectional elevation taken upon the line *x x* of Fig. 2. Fig. 4 is an enlarged diagrammatic view illustrating the construction and operation of the cut-off mechanism; and Figs. 5, 6, and 7 are similar views illustrating modified forms of the means for operating and the operation of said cut-off mechanism.

Referring to said drawings, it is to be understood that, as there illustrated, the steam end of the engine, or what may be termed the "engine proper," consists of four steam-cylinders, A B and C D, which are arranged in pairs and to operate upon the compound principle, the pair A B forming one side and the pair C D the other side of the duplex engine. The pistons 98 99 of the cylinders A B are connected to the single piston-rod 25 and the pistons of the cylinders C D are connected to the single piston-rod 26 in the same manner.

The cylinders A B and C D are provided with the usual steam-chests, *a b* and *c d*, having ordinary slide-valves, *e f*, as therein shown, of D form which are provided with balancing pistons suspended from swinging rods, which are hung in the trunks 75 in the well-known manner.

The two induction and exhaust valves *e f* for each side of the engine are operated by the same valve-rod, and these rods 23 24 are provided with the usual connections, consisting of links 22, rock-shafts 76, having arms 21 77, and links 78, connected at their outer ends to cross-rods 29, attached to the ends of the piston-rods 25 26 through yokes 28, by which the valves of each side of the engine are operated by the movement of the other, which connections are fully set forth and described in another application filed by me in the United States Patent Office September 26, 1885, Serial No. 178,248, to which reference may be had.

The steam-chests *a c* are provided with induction-pipes 27, through which the steam is supplied to the cylinders A C direct from the boiler. After acting in the cylinders A C the steam is exhausted through the pipes 79 and enters the tank G at a reduced pressure, which pressure is determined by the amount of expansion permitted in the cylinders A C. From

the tank G the steam passes through the pipes 80 to the steam-chests *b d*, and thence to the larger cylinders B D, in which it acts and is allowed to expand down to any desired point, after which it is exhausted through the pipes 81 to a condenser or to the open air. The organization and operation thus briefly described is common, and will be readily understood by those familiar with this class of engines.

The induction-ports 14 of each of the cylinders A B and C D are provided with bushings 13, having plugs or rotary valves 12, which extend through the walls of the ports 14, and are provided with arms 11, which are connected by links 10 with two pairs of levers, 61, that are fulcrumed on studs 57, as clearly shown in Figs. 1, 2, and 4. As the construction and arrangement of these levers, arms, and connections for each pair of cylinders are duplicates, a specific description of those for one pair will suffice for both. The levers 61, Figs. 1 and 4, are provided with arms 62, connected by a link, 63, so that the two levers 61 of each pair are caused to move in unison. One of the arms 62 of the pair of levers 61 is extended and connected by a link, 64, with a head, 65, that is arranged to slide in a bearing, 66, located at the side of the cylinder A, (and of the cylinder C of the other side of the engine.) The head 65 is provided with a rod, 67, which passes through a stuffing-box in the end of the cylinder B, (and of the cylinder D of the other side of the engine,) and is connected to its piston 99. The bushings 13 (see Fig. 4) are provided with ports 4, which open into the induction-ports 14, and the valves 12, which are cut away at their centers, are provided with solid portions 5, which are so located that as the valves are turned they will pass over and close the ports 4. The ends of the levers 61 are connected to the links 10 by means of heads 6, which slide in slots 7, formed in the links, as best shown in Fig. 4, thus allowing an amount of lost motion between the levers and the arms 11. The parts 9 of the links 10 are tapped and provided with screws-bolts 8, the heads of which, occupying the space formed by the slots 7, form adjustable stops, which limit the motion of the heads 6 in said slots, and which may be adjusted in and out of said parts 9 to change the amount of lost motion in the links 10, and thus vary the point at which the steam is cut off from admission to each of the steam-cylinders. The parts will be so proportioned and adjusted that when the pistons of the cylinders A B and C D commence their strokes the ports 4 of the bushings at the ends of the cylinders which are receiving steam will be open and the ports 4 at the opposite ends will be closed, as shown in Fig. 4.

The water end of the engine consists of two water-cylinders, E F, the plungers 97 of which (only one of said plungers being shown) are connected directly to the piston-rods 25 26 in the usual manner. The water-cylinders E F are provided with the usual suction and force chambers, 93 and 95, the former communicating with the suction-main 100 and the latter with the force-main 101 in the usual manner. The force-main is also provided with the usual air-compression chamber, 102, to equalize the flow of the water discharged from the pump.

The piston-rods 25 26, instead of terminating at the plungers of the water-cylinders, are extended and pass through stuffing-boxes in the ends of said cylinders, and are connected to the piston-rods 39 of two pairs of oscillating cylinders, 40 50, which are arranged at the ends of the water-cylinders, substantially as shown in my former Letters Patent, and in my said application before referred to, and are mounted upon trunnions 20, which are supported in a suitable frame-work, 92, extending from the ends of the water-cylinders.

Each of the rods 25 26 is provided at its end with a yoke, 28, (see Figs. 2 and 3,) the arms of which are provided with openings through which passes a rod, 29, the ends of which are provided with suitable heads, 30, which slide in bearings 31, formed in the frames 92. The rods 39 of two of the cylinders, 40 50, (the lower ones, as shown) are provided with yokes the arms of which lie just inside the arms of the yokes 28, and are pivoted to the rods 29. The rods 39 of the other two cylinders, 40 50, are provided with heads 33, which just fit between the arms of the yokes of the rods of the lower cylinders, and are also pivoted to the rods 29. The rods 29, where they pass through the heads 33 and the arms of the yokes last mentioned, are provided with suitable bushings (not shown) to reduce the wear upon the bearings.

The motor-fluid will be supplied to the oscillating cylinders 40 50 behind their pistons through ducts provided in the trunnions 20 and enlargements formed on the sides of the cylinders, which ducts communicate with four horizontal branch pipes, 36, (two only of which are shown,) leading from a main vertical pipe opening at its upper end into a closed chamber, 74, which chamber communicates by a pipe, 73, with an air-tank, 103, which is supplied with air by a compressor, 83. The cylinders 40 50, the pipes 36, and the vertical pipe leading from the pipes 36 to the chamber 74 are filled with a liquid which also partly fills the chamber 74. The pipe leading from the chamber 74 to the pipes 36 is provided with a governor-valve, which is controlled through a pipe, 82, by the pressure in the force-main, and operates to regulate the flow of the liquid from the chamber 74 to the cylinders 40 50, all as is fully shown in my prior application before referred to.

As thus far described the operation of the engine will be now explained, it being assumed for the purposes of this description that the compressor 83 has been operated by hand or otherwise so that the proper pressure exists in the tank 103 and by means of the pipe 73, also on the surface of the liquid in the chamber 74, as is fully described in my said appli-

cation. The operation and the functions of the oscillating cylinders 40 50, as well as of the governor-valve connections, are so fully set forth and explained in my said application that no description thereof is deemed necessary herein, the pistons 98 99 of the cylinders A B being at one end of their stroke and ready to commence their stroke toward the water-cylinders, in which position the oscillating cylinders 40 and their pistons will be ready to act in opposition to the movement of the main piston-rod 25. It will be assumed that the slide-valves *e f* of those cylinders have been moved so as to uncover the induction-ports 14 thereof and permit the steam to pass from their steam-chests *a b* through said ports to the valves 12, controlling said ports. The solid portions 5 of the valves 12 will at this time be in such position as to uncover the openings 4 in their bushings 13, and thus allow the steam to pass into the cylinders A B. As the steam thus admitted to the cylinders causes the pistons 98 99 to move onward such movement will be imparted through the rod 67, head 65, and link 64 to the arms 62 and their pair of levers 61 of the cut-off mechanisms.

As the cut-off mechanisms for all four cylinders are exact duplicates, a description here of the operation of one will suffice for all. During the first part of the stroke the heads 6 of the lever 61 will move idly in the slots 7 of the links 10, and will consequently not move the valves 12. When, however, the piston arrives at a point where it is desired to cut off the further admission of steam behind the piston, the head 6 at that end of the cylinder which is receiving steam will come into contact with the head of the bolt 8 and quickly turn the valve 12, so that its solid portions 5 will cover the ports 4, and thus shut off the further admission of steam behind the piston. After this takes place, and while the piston is still moving in the same direction, and during the remainder of its stroke, the heads 6, owing to the position to which the link 10 has been moved with relation to the fulcrum of its lever 61, will move back idly in the slot 7. As the piston nears the end of its stroke, however, the head 6 at the other end of the cylinder, which has been during the movement of the valve just referred to moving idly in the slot 7 of its link 10, first toward the arm 11 and then away from it, will in this latter movement come into contact with the end of the slot, and continuing its movement move the link 10 so as to turn the valve 12 of that end of the cylinder from the closed position shown in Fig. 4, so as to uncover the ports 4 and permit steam to enter that end of the cylinder when the main slide-valve, as *f*, is reversed, the completion of this opening movement of the valve 12 taking place simultaneously with the completion of the stroke of the piston toward that end of the cylinder. Upon said reverse movement of the slide-valve taking place, the return movement of the piston will take place, when the operations of said cut-off mechanism will be repeated, it being understood, of course, that the valve 12 last referred to will be operated to cut off the admission of steam in the same manner as the valve 12 first referred to. From this it will be seen that upon the movement of the piston during which the valve is closed there is lost motion between the lever 61 and the arm 11 of the valve both before it is and after it has been closed, (during which latter movement the other arm of the lever 61 has operated to open the other valve, 12,) while upon the movement of the piston during which the valve is opened the lost motion all occurs before it is opened. It will also be observed that the lever 61, links 10, and arms 11 are so arranged with relation to each other that as the lever is rocked in either direction the link 10 and the arm of the lever, which are connected to the valve which is to be closed to shut off steam, form a toggle, which causes the valve to be moved quickly as the toggle is straightened, and then allows the valve to dwell as the toggle is bent in the opposite direction.

By adjusting the bolts 8 the length of the slots 7 can be varied, so as to cause the valves to be operated to close the ports 4 sooner or later, and thus vary the point of cut-off, as may be desired.

It is obvious that the position of the fulcrum or stud 57, upon which the arm 62 and lever 61 are pivoted, may be changed with respect to the valves 12 to any point (preferably on the cylinder) that the manufacturer of the engine may desire; and that instead of having the two arms of the lever 61 fulcrumed on a single stud they may be arranged singly and fulcrumed separately upon studs, the two arms or levers being, however, connected together, so as to move in unison.

Such modified constructions are illustrated by Figs. 5 and 6, which will now be described.

In Fig. 5 it will be seen that the fulcrum of the lever 61 and the arm 62 is arranged at a point considerably below each of the valves, as distinguished from the position illustrated in figures of the drawings before described, wherein it is shown as about or substantially in line with and between said two valves, the form of the lever and its arm in this illustration being changed from a T shape to a shape corresponding to a Y; and it is apparent that if it should be found desirable to locate this fulcrum above instead of below the valves such a changed location would simply necessitate a change in the shape of said lever and arm as a whole, and in their proportions as well as their connecting links and arms, and that whatever such location may be the functions and operation of the valves they operate will remain or be substantially unchanged.

In the structure shown in Fig. 6 the lever 61 is divided and separately fulcrumed upon studs 57 57^a, projecting from the wall of the cylinder. The said levers 61 are, as in the structures heretofore described, connected to

the arms 11 by links 10; but in this case the heads 6 are on the arms 11 instead of on the levers. The two levers 61 are connected by a rod, 72, pivoted to each of them, so that they will be caused to move in unison. One of the levers 61, preferably that nearest the water-cylinders, will be provided with an arm, to which a connecting-rod, 63, is pivoted, which, if the engines are of the compound type, will be connected with a similar arm operating valves of the other cylinder, as does the like rod in the structure shown in Fig. 1. The functions and operations of the valves operated by the levers thus separately fulcrumed will be substantially the same as those heretofore described, and hence need no further detailed description.

In each of the forms of levers for operating the cut-off mechanism thus far described lost motion has been provided between the arms 11 of the valves and the levers operating them, so that at certain periods of the stroke of the steam-piston the valves controlling the induction-ports are at rest both before they have been operated to open said ports and after they have been operated to close the same.

In the construction shown in Fig. 7 the arrangement of the parts is similar to that first described, except that the links 10, instead of having a sliding pivotal connection with the arms of the lever 61, have a fixed pivotal connection with said lever. There is, therefore, in this case no lost motion between the arms 11 and lever 61; but the necessary time between the commencement of the stroke and the closing of the cut-off valve is secured by the lap of the valve—that is to say, the valves and bushings are so constructed and proportioned that although the valves commence to move at the beginning of the stroke the parts 5 will not commence to close the ports 4 until the stroke is partly completed, and that the small amount of movement given to the valves after the ports are closed by the straightening of the toggles formed by the links 10 and the arms of the lever 61 will not serve to uncover the ports.

As a means of regulating the time at which the valves shall be closed to cut off the admission of steam to the cylinder with respect to the position of the steam-piston therein, the levers 61 are each provided with an adjustable portion, 52, to which one end of the links 10 are pivoted, which portions are pivoted to the arm of the lever upon studs 37. Around such pivotal studs these portions are provided with segmental worm-wheels 53, the teeth of which are engaged by worms 35, journaled in suitable bearings on the side of the lever 61. These worms are provided with heads, by which they may be turned so as to adjust said portions around upon their studs, as is clearly seen in Fig. 7. The cut-off may be also changed to vary the point of the stroke at which the steam is to be shut off by changing the lengths of the arms 11 of the valves and of the links 10; but the means of adjustment shown and previously described is preferable, as it admits of a great range of adjustment.

In conclusion, therefore, it will be seen that by the provision of the improved cut-off mechanism the admission of steam to the cylinders A B and C D may be shut off after their pistons have advanced a certain distance—say one-half, or somewhat more or less than half-stroke—the remainder of the stroke being accomplished by the expansive force of the steam already in the cylinders, aided by the power exerted by the pistons of the compensating cylinders, the gradual falling off of power due to the expansion of the steam in the main cylinders being compensated for by the gradual increase of available power exerted by the pistons of the compensating cylinders.

It is to be observed that while the arms 62 of the cut-off mechanism are shown as operated by connections with the pistons 99 of the cylinders B and D said arms may be connected directly or indirectly to the levers 77 of the valve-actuating mechanism, and, further, when the distance between the water-cylinders and the steam-cylinders admits of the employment of a cross-head for the main piston-rods 25 26 said arms 62 may be connected to and be operated by such cross-heads, and, in fact, in any other manner the manufacturer may deem desirable; and, furthermore, that when duplex or single engines having only one cylinder are provided with this improved cut-off mechanism the single pair of valves may be connected and operated in either of the ways described, in which instance, of course, it would be simply dispensing with the second pair of valves and their operating connections and the connecting-rod 63. So, also, it may be remarked that, instead of providing two compensating cylinders for each of the main piston-rods, only one such cylinder may be provided, and the compensating cylinder or cylinders, instead of being located at the outer end of the water-cylinder and arranged to oscillate, may be located between the water and steam cylinders or at the outer ends of the steam-cylinders, and they may be arranged to operate upon the main piston-rods in any of the ways described and shown in my former Letters Patent No. 292,525, or in any other way.

What is claimed is—

1. The combination, with the main cylinder or cylinders and piston or pistons of a direct-acting engine, and a compensating cylinder or cylinders and piston or pistons arranged to act in opposition to the main piston or pistons during the first part of the stroke and in conjunction therewith during the last part of the stroke, of a slide valve or valves for controlling the admission and exhaust of the steam to and from the main cylinder or cylinders, the cut-off valves 12, arranged in the induction-ports and having the arms 11, and the lever or levers 61, connected to the arms 11 by

the links 10 and operated from some moving part of the engine, said lever or levers, arms, and links being arranged to operate substantially as described.

2. The combination, with the main cylinders and pistons forming the two sides of a direct-acting duplex engine, and a compensating cylinder or cylinders and piston or pistons for each side of the engine, which are arranged to act in opposition to the main pistons during the first part of the stroke and in conjunction therewith during the last part of the stroke, of slide-valves for controlling the admission and exhaust of the steam to and from the main cylinders, connections by which the slide valve or valves of each side of the engine is or are operated by the other side of the engine, the cut-off valves 12, located in the induction-ports and having the arms 11, and the levers 61, connected to the arms 11 by the links 10, and operated by the same side of the engine, said levers, arms, and links being arranged to operate substantially as described.

3. In a direct-acting engine provided with a compensating cylinder or cylinders, the combination, with cut-off valves arranged at opposite ends of the steam-cylinder, of an arrangement of levers and arms connected with said valves and with the rod 67, secured to the steam-piston and passing through the end of the steam-cylinder, whereby said valves are positively operated both in opening and in closing, substantially as described.

4. The combination, with the cylinders A B and their cut-off valves, as 12, of the rod 67, secured to the piston of the cylinder B, and the levers 61, having arms 62, connected to said rod and to the cut-off valves, substantially as described.

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

CHAS. C. WORTHINGTON.

Witnesses:
B. W. PIERSON,
W. A. P. BICKNELL.