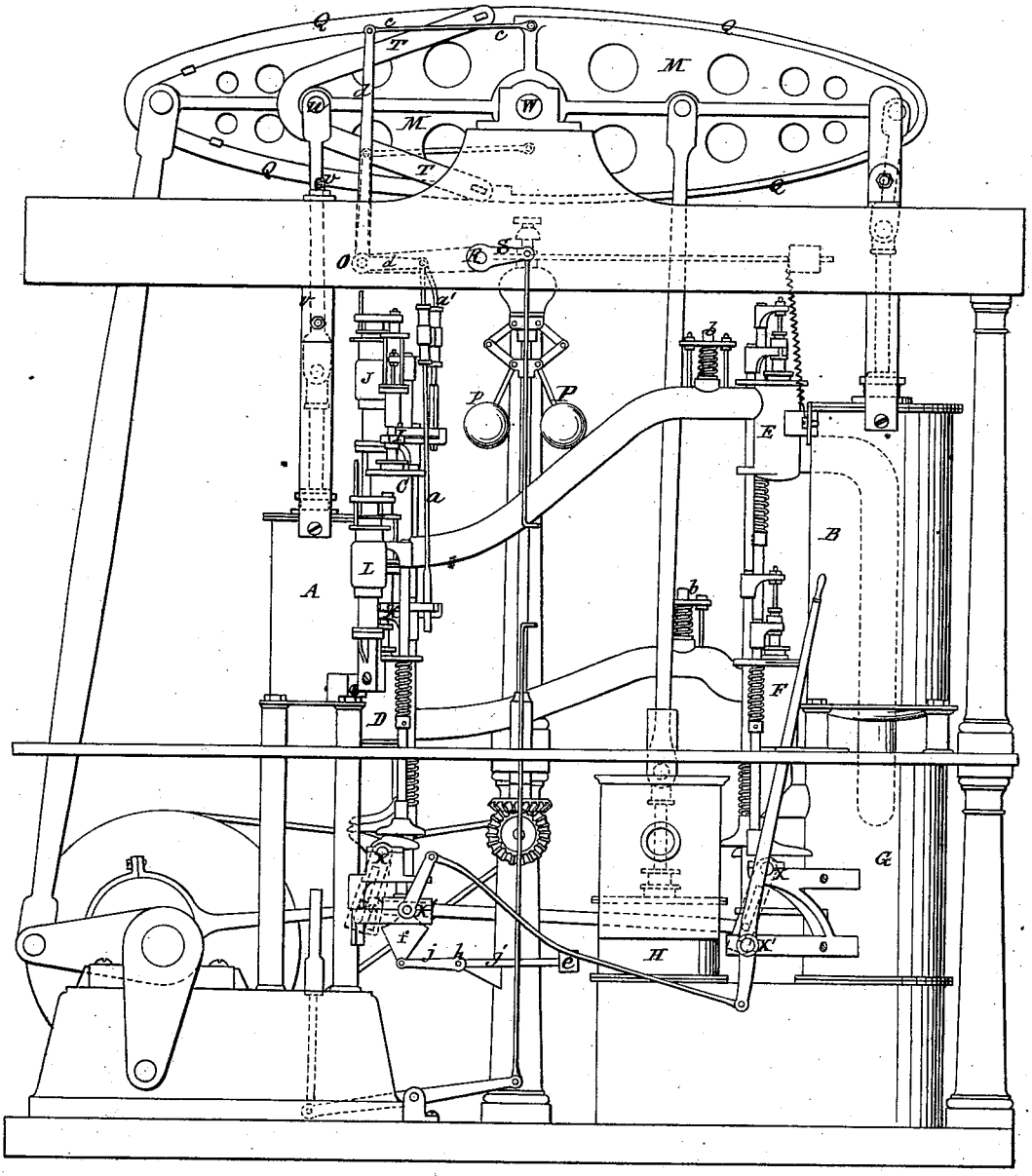
4 Sheets--Sheet 1.

F. E. SICKELS.

Compound Steam-Engine.

No. 161,711. Patented April 6, 1875.

Fig. 1.



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4 Sheets--Sheet 2.

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Fig. 2

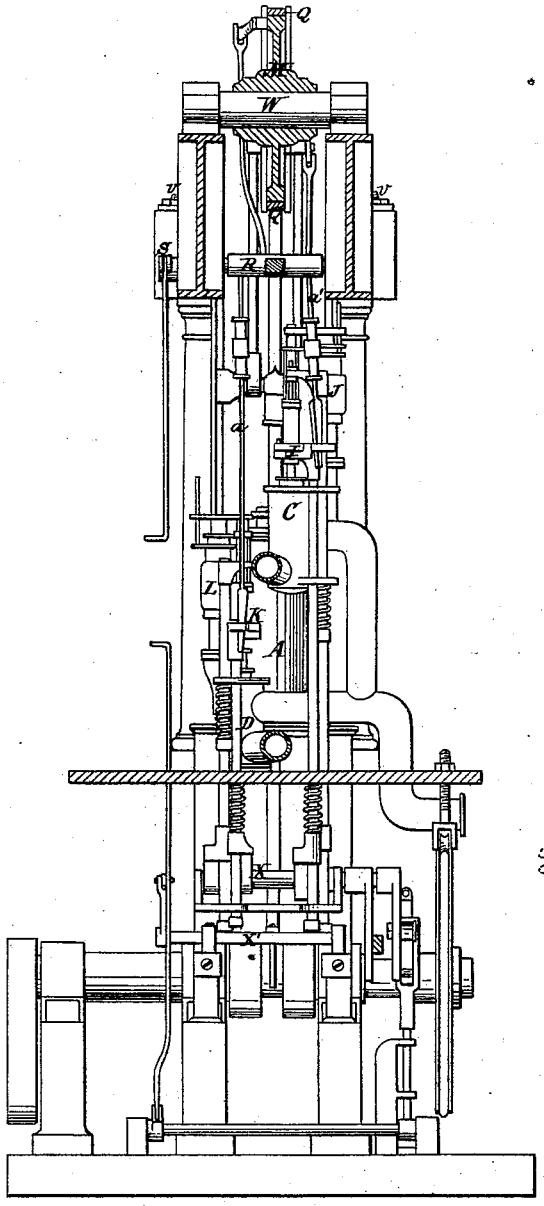

Fig. 3.

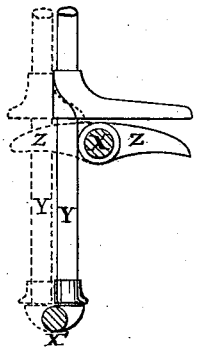

Fig. 4.

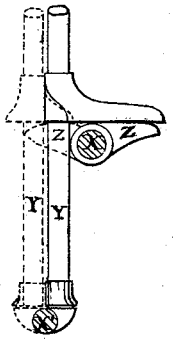

Fig. 5.

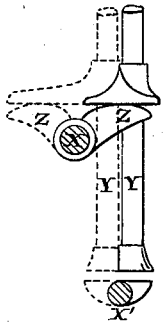

Fig. 6.

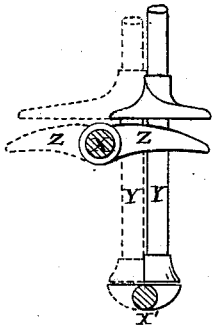

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Fig. 7.

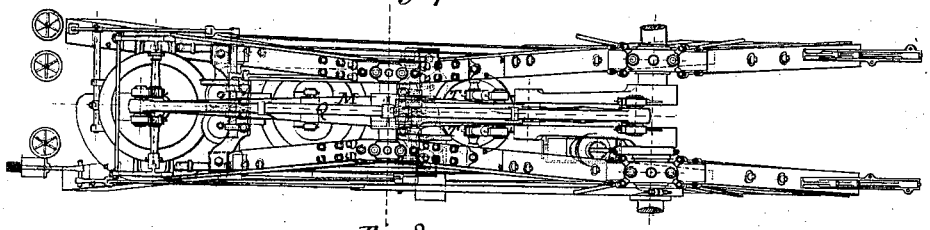

Fig 8.

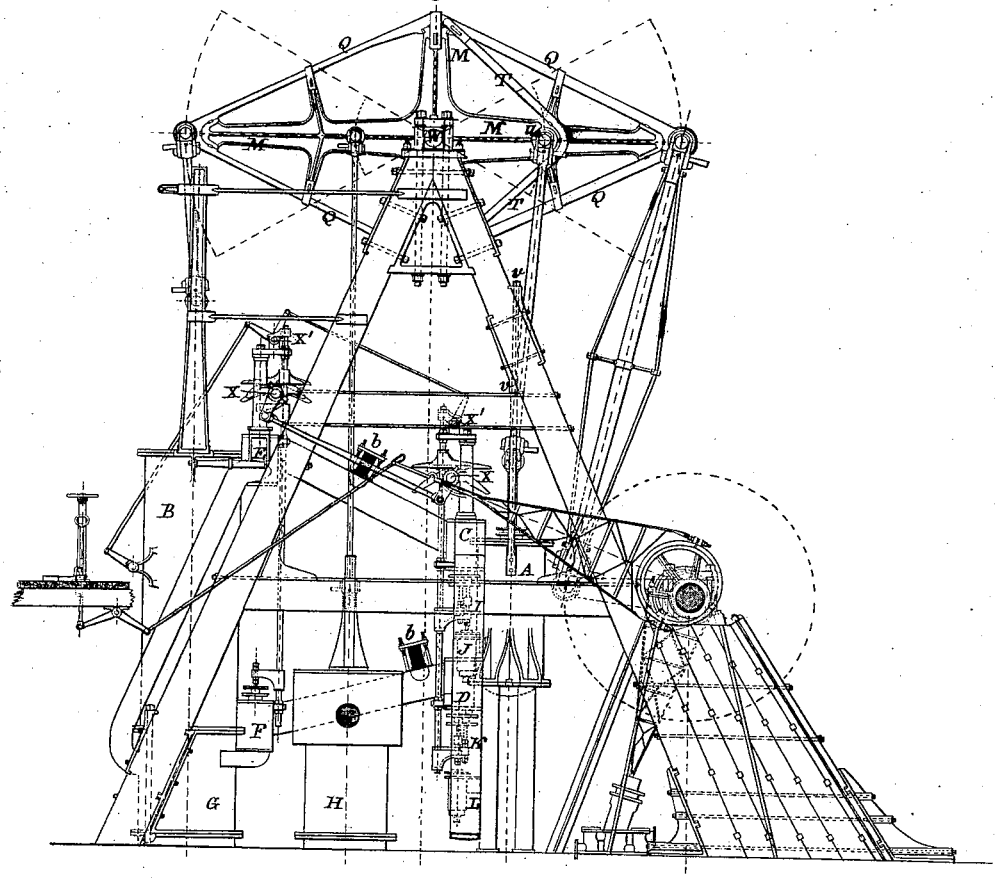

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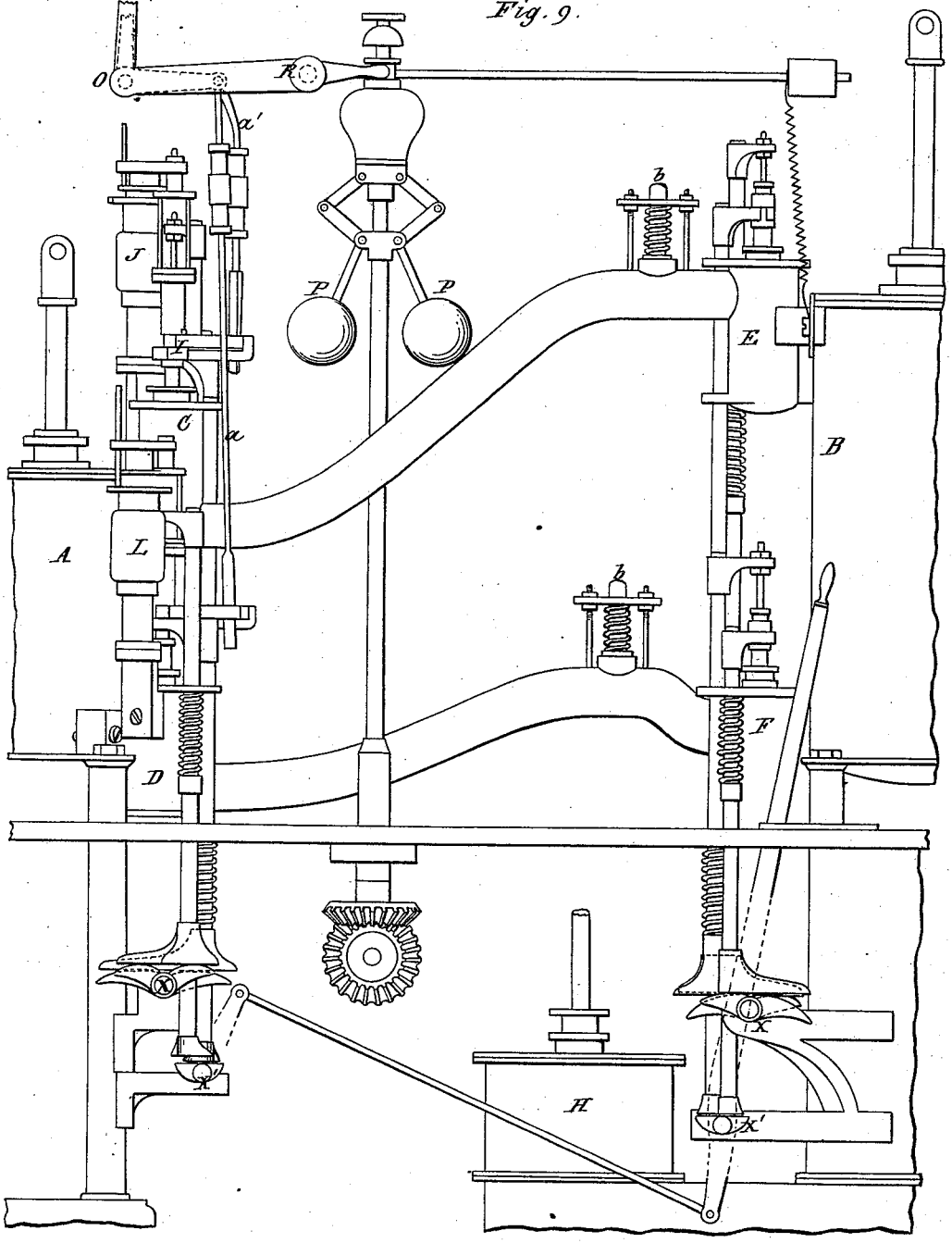
Fig. 9.



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UNITED STATES PATENT OFFICE.

FREDERICK ELSWORTH SICKELS, OF SWARTHMORE, PENNSYLVANIA.

IMPROVEMENT IN COMPOUND STEAM-ENGINES.

Specification forming part of Letters Patent No. **161,711**, dated April 6, 1875; application filed February 27, 1875.

To all whom it may concern:

Be it known that I, FREDERICK ELSWORTH SICKELS, of Swarthmore, in the county of Delaware and State of Pennsylvania, have invented certain new and useful Improvements in Steam-Engines; and that the following is a full, clear, and exact description of the same, reference being had to the accompanying drawings making a part of this specification, which drawings represent my improvements as applied to both land condensing and marine condensing engines, and in which drawings—

Figure 1 represents a side view of the engine, with some of the frame removed to better show the working parts. Fig. 2 represents a vertical cross-section of the same. Fig. 3 represents a side view of the toes on the rock-shaft and the feet on the lifting-rods of both the main and hand rock-shafts, to work the steam-valves of the large cylinder, and shown detached from the engine. Fig. 4 represents a side view of the toes on the rock-shaft and the feet on the lifting-rods of both the main and the hand rock-shafts, to work the exhaust-valves of the large cylinder, and shown detached from the engine. Fig. 5 represents a side view of the toes on the rock-shaft and the feet on the lifting-rods of both main and hand rock-shafts, to work the exhaust-valves of the small cylinder, and shown detached from the engine. Fig. 6 represents a side view of the toes on the rock-shaft and the feet on the lifting-rods of both the main and the hand rock-shafts, to work the steam-valves of the small cylinder, and shown detached from the engine. Figs. 7 and 8 represent my invention as applied to a marine condensing-engine, and show, respectively, a top and a side view, with the trip-motion and governor omitted, for the sake of clearness in the drawing. Fig. 9 represents, on an enlarged scale, the principal operating parts of the engine, omitting the frame and much of the detail that otherwise would obscure these more active co-operating parts.

My invention relates, first, to the combination of the trip cut-off and its fluid-check with a compound engine, for the purpose of more economically using the steam, and reducing the strain from the unequal action of such cut-off.

Second, my invention relates to the combination of the trip cut-off with its fluid-check, the governor, and the compound engine, for the purpose of securing, with increased economy, an efficient manner of regulation, by preventing the unequal action of the cut-off from injuriously acting on the governor.

Third, my invention relates to the combination of the skeleton beam with the double truss, to carry the extra load of the small cylinder on an intermediate point between the ends of the beam.

Fourth, my invention relates to the means of holding open both of the exhaust-valves of the small cylinder when the engine is unhooked, in combination with the blow-valves on the exhaust-pipes of that cylinder, to prevent undue compression of the steam in stopping the engine.

Fifth, my invention relates to the combination of a rock-shaft working the valves of the small cylinder and a rock-shaft working the valves of the large cylinder, so as to open and close the steam direct from the boiler to the large cylinder, and thus facilitate the working of the engine by hand.

To enable those skilled in the art to make and use my invention, I will proceed to describe the same with reference to the drawings, first premising that the description will be confined mainly to the special features claimed, the general characteristics of a compound engine being well understood by those skilled in steam-engineering, and needing no detailed description here.

The small cylinder is represented at A, and the large cylinder at B. C represents the upper valve-chest of the small cylinder, and D the lower valve-chest of the same. E represents the upper valve-chest, and F the lower valve-chest, of the large cylinder. The condenser is shown at G, and the air-pump at H. I, Figs. 1, 2, and 8, represents the cut-off for the upper end of the small cylinder, it being a trip cut-off, with a fluid-check, J, as seen in dotted lines in Fig. 8; and K, in the same figures, represents the cut-off for the lower end of the small cylinder, with its fluid-check L, also in dotted lines.

In Fig. 1, *a* represents the trip-rod for the lower trip cut-off. This rod receives motion by means of a connecting-rod, *c*, that operates

a bent lever, *d*. The bent lever *d* vibrates on a long pin, *o*. (Shown in dotted lines in Fig. 1.) *a'* represents the upper trip-rod, receiving motion from the opposite side of the beam by means of a similarly-bent lever, like that at *d*, vibrating on the same pin *o*. The pin *o* is held by arms on the shaft R, as seen in Fig. 1, which shaft extends through the engine-frame, and said arms extend from the shaft R close to the inside of the frames on each side, and support the ends of the pin *o*. The shaft R has a central arm, leading to and connecting with the governor P, Fig. 1. When this arm is fastened to the shaft R, so as to operate it, then the governor controls the point of cut-off. When the arm is detached, then a similar arm, S, connected to the shaft R on the outside of the engine-frame, can be operated to set or shift the cut-off by hand. As the bent levers are lowered in turning the shaft R around, the cut-off is shortened; and by raising the pin *o*, in turning the shaft R around in the opposite direction, the cut-off is lengthened.

When the governor controls the trip cut-off with its fluid-check in a compound engine, the irregular action of the cut-off (due to its not being a positive motion, and to the irregular action of the fluid-check) is modified; and this irregular action is measurably relieved by the action of the steam as it exerts its power during one-half of the stroke, and then exerts another portion of its power during the other half of the stroke, thus balancing any irregular action of the cut-offs placed at each end of the cylinder; whereas, by using the trip cut-off with its fluid-check on a single engine, if the fluid-check or other portions of the cut-off so act as to cause one end of the cylinder to take more steam than it properly should take, then the impulse given to the engine acts on the governor and causes it to shift the cut-off, and thus cut off the steam too short on the other end of the cylinder, and this irregular action continues.

The inherent defect arising from the operation of the trip cut-off with its fluid-check on a single engine is remedied by combining it with a compound engine, and economy is secured, with great regularity of motion in each half of the stroke as compared with the other half, notwithstanding any irregular motion of the cut-off arising from its not being a positive motion.

In working the trip cut-off with its fluid-check in connection with a compound engine at a fixed point, the irregular action of the cut-off, caused by its being detached from the engine and controlled by a fluid-check at each half of the revolution, is partially remedied, as the amount of steam thus liable to vary at each stroke is distributed throughout the whole revolution, reducing the inequality of the strains on the engine, and economizing in the construction and wear of the machinery.

In Figs. 1, 2, 7, and 8, M represents a cast-iron skeleton beam, with an outside wrought-iron strap, Q, extending around it. T represents truss-straps extending around the pin *u*, Figs. 1, 8, to take the strain brought upon the beam from the small cylinder, and to convey it to the outside truss-strap Q, thus putting the interior cast-iron skeleton in further compression, and the outside truss-trap in further tension, in carrying the load of the small cylinder.

As the strain from the small cylinder is applied intermediate between the center and the end of the beam, the intermediate or double truss-strap may be varied in shape to take the tension and put compression on the cast-iron skeleton in conveying the strain to the connecting-rod. As herein shown, the vertical strains at the center points of the main strap from the large and small cylinders tend to neutralize each other.

In Figs. 1 and 8, *v* represents bolts, holding the strain of the steam on the top and bottom of the small cylinder to the frame which supports the center-pin W of the beam. In the land-engine this frame is shown as horizontal, with one of the upright columns omitted. In the marine-engine the legs of the frame are shown as diagonal. By connecting the small cylinder directly to the frame the reaction of the steam upon the cylinder top and bottom tends to balance the direct action of the steam in working the engine. To save material these bolts *v* are shown as extending directly from the guide-rods up to the frame. They may be separate bolts or braces, extending from the cylinder upward to the frame, so as to hold both in tension and compression.

The main rock-shafts are represented at X X, and the hand rock-shafts at X' X'. The main and hand rock-shafts of the land-engine are shown detached in Figs. 3, 4, 5, 6, in the position they would assume if the engine were unhooked. The lifting-rods are shown at Y Y, and Z Z are the toes on the rock-shafts. The lifting-rods Y Y, Fig. 5, that work the exhaust-valves of the small cylinder, are held up by the toes Z Z on the rock-shaft X, thus holding open both exhaust-valves of that cylinder when the engine is unhooked. The steam-valves of the small cylinder are closed as the lifting-rods Y Y, Fig. 6, are down. Both the steam and exhaust valves of the large cylinder are closed as the rods Y Y, Fig. 3, and Y Y, Fig. 4, are down. In working by hand it is, therefore, only necessary to open the top steam-valves of both cylinders to apply the steam direct from the boiler to the top of the large cylinder; and to apply steam direct to the bottom of the large cylinder it is only necessary to open the bottom steam-valves of both cylinders, thus blowing through the valves of the small cylinders, the hand rock-shaft of the large cylinder operating its valves in the usual manner. The toes on the hand rock-shaft are so placed and connected together as to open the steam-valves at the same end of the cylinder for each stroke of the steam-pistons, whereas in working "hooked on," as it is termed, the main rock-shaft opens

the steam-valves at opposite ends of the cylinder for each stroke of the piston, and blowing through is avoided, practically, by turn-down the steam-toes Z Z, Fig. 6, as much as the exhaust-toes Z Z, Fig. 5, are turned up on the main rock-shaft of the small cylinder. The main rock-shaft X, Fig. 3, of the large cylinder has the steam-toes Z Z, Fig. 3, turned down, as compared with the exhaust-toes Z Z of Fig. 4, to give lead to the exhaust-valves of the large cylinder, and to close the steam-valve of this cylinder before the end of the stroke, and thus compress the steam in the exhaust-pipe of the small cylinder that is flowing into this pipe from that cylinder toward the end of the stroke, as the exhaust-valves of the small cylinder are held open longer by the exhaust-toes Z Z, Fig. 5, than the steam-valves of the large cylinder are held open by the steam-toes Z Z, Fig. 3, of the large cylinder.

When the engine is unhooked and the main rock-shafts, as before explained, take the positions shown in Figs. 3, 4, 5, and 6, any steam that may be in the small cylinder cannot be injuriously compressed by the motion of the engine, as, both exhaust-valves being open, the steam can escape out of the blow-valves *b*, Figs. 1 and 8, while, at the same time, all of the valves are placed in a favorable position to work the engine by hand in applying steam direct to the large cylinder.

The rock-shafts in Fig. 1 are shown as being below the cylinders, and in Fig. 8 as being above the cylinders. They are sometimes placed midway of the cylinder. The rock-shafts in Fig. 1 are shown as working single poppet-valves, while those in Fig. 8 are represented as working double poppet-valves.

In working compound engines by hand the engineer is obliged to open and close additional admission-valves, and to aid in this operation the counter-weight *e*, Fig. 1, is placed to act on the cam *f*, so that, at each vibration of the hand rock-shaft from the center of motion, the end of the arm *j*, holding a roller that travels up the sides of the cam *f* as the weight *e* descends, the arm *j* vibrating on the pin at *h*, thus assisting the engineer to open the valves of both cylinders.

What I claim as new, and desire to secure by Letters Patent, is—

1. The combination of the trip cut-off and its fluid-check with the compound engine, substantially as described.

2. The combination of the trip cut-off and its fluid-check with the governor and the compound engine, substantially as described.

3. The combination of the double truss with the skeleton beam, to carry the load of the small cylinder, substantially as described.

4. The toes on the rock-shaft of the small cylinder, to hold open the exhaust-valves of that cylinder, in combination with the blow-valves on the exhaust-pipes, to avoid compressing the steam, substantially as described.

5. The combination of the rock-shaft to work the valves of the small cylinder for blowing through, with the rock-shaft that applies the steam direct from the boiler to the large cylinder, substantially as described.

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