(No Model.) 2 Sheets—Sheet 2.

E. J. WOOLF.

SINGLE CYLINDER COMPOUND ENGINE.

No. 475,427. Patented May 24, 1892.

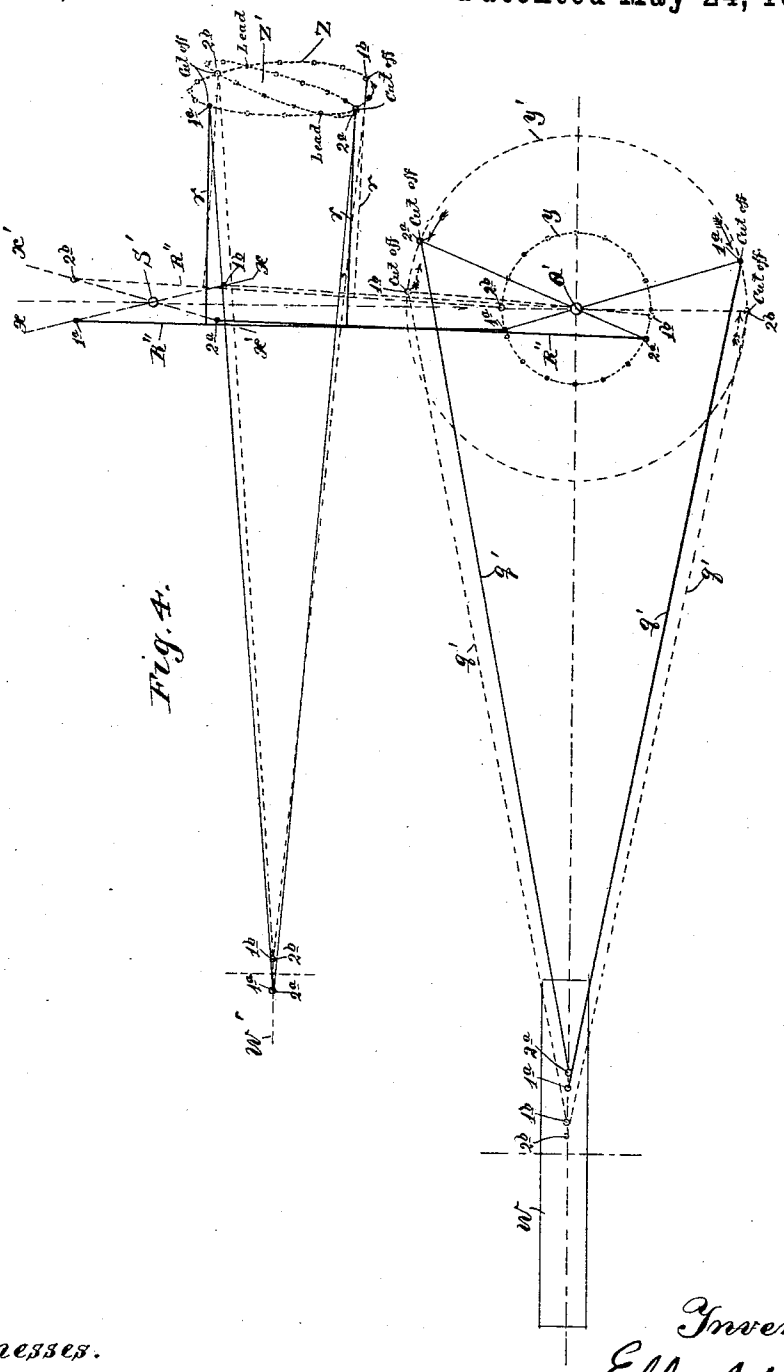

Fig. 4.

Witnesses.
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F. A. Johnson.

Inventor.
Ellis J. Woolf
By his Attorney.
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(No Model.) 2 Sheets—Sheet 1.

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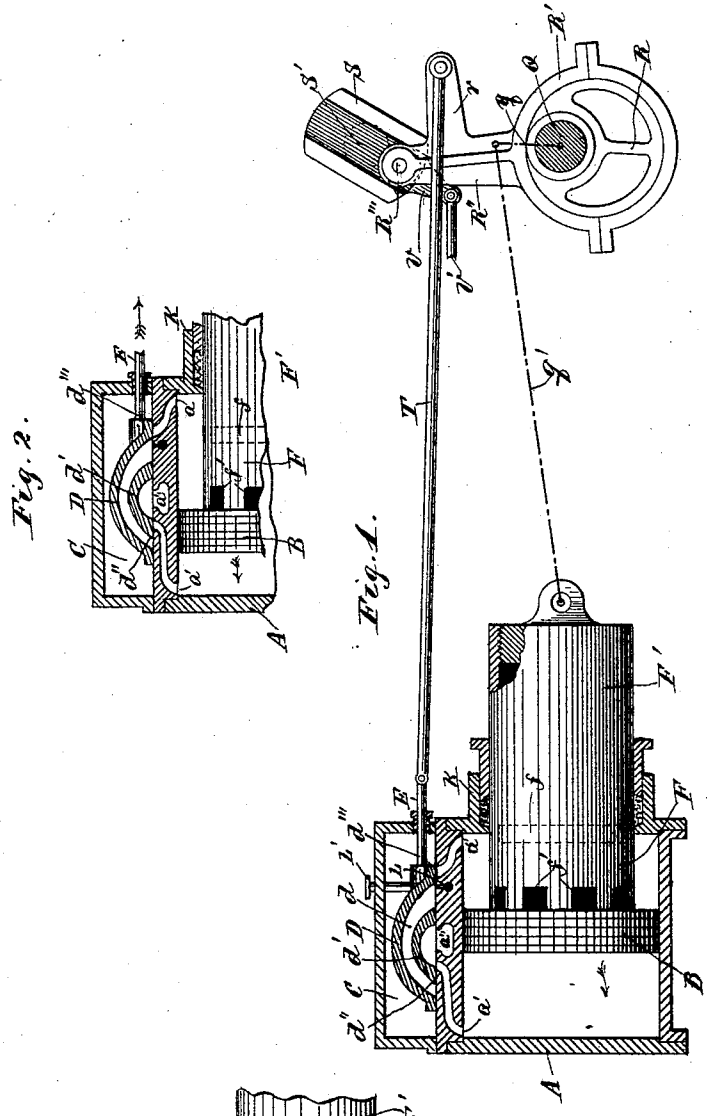

Fig. 2.

Fig. 1.

Fig. 3.

Witnesses.
A. U. Spoehl
L. A. Johnson.

Inventor.
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UNITED STATES PATENT OFFICE.

ELLIS J. WOOLF, OF MINNEAPOLIS, MINNESOTA.

SINGLE-CYLINDER COMPOUND ENGINE.

SPECIFICATION forming part of Letters Patent No. 475,427, dated May 24, 1892.

Application filed July 14, 1891. Serial No. 399,491. (No model.)

To all whom it may concern:

Be it known that I, ELLIS J. WOOLF, a citizen of the United States, residing at Minneapolis, in the county of Hennepin and State of Minnesota, have invented certain new and useful Improvements in Single-Cylinder Compound Engines; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

My invention relates to compound engines, and has for its object to provide a single-cylinder compound engine of increased efficiency.

To this end, as one feature of my invention, I so arrange the steam-passage and the valve that the opening of the port to the low-pressure end will be delayed for an interval after the exhaust begins on the high-pressure end at any desired cut-off in either motion without changing the dimensions of the valve, thus giving a longer period of expansion and allowing the stroke from the high-pressure end to be approximately completed before admission of steam to the low-pressure end, and accomplish this result without materially increasing the volume or decreasing the pressure in high-pressure end by non-effective increased area. Undue preadmission at the low-pressure end is thus avoided and compression in the same is correspondingly reduced. In my preferred construction for this purpose I locate the steam-passage in the valve itself, and construct the valve so that it has on the inner wall of the valve-cavity an outside lap equal to the outside lap on the valve proper when the valve is in its central position; or, in other words, I give the valve on the inner wall of the valve-cavity a lap, which will cover the low-pressure port for a considerable time after the exhaust begins from the high-pressure end into the valve-cavity. I thereby obtain a delay or interval between the time of the beginning of the exhaust at the high-pressure end and the beginning of the opening of the port at the low-pressure end equal to the valve and piston travel required for the ordinary lap, and the pressure is reduced at the high-pressure end only by the small amount corresponding to the proportional additional area of the steam passage or cavity in the valve.

As another feature I provide at the high-pressure end an excess of clearance or steam space, thereby obtaining an increased volume and pressure from the same when exhausted into the low-pressure end without increasing the piston area in the high-pressure end. This construction enables me to obtain equal effective pressures on both sides of the piston.

In my preferred construction this extra clearance or steam-space at the high-pressure end is obtained by providing a suitable chamber in the piston-rod, and to fill the same without interference with the action from the valve-controlled port I provide a supplementary port from the steam-chest and provide openings to the clearance-chamber in the piston-rod, so arranged that they will be central with the supplementary port when the crank is on the center. This means of filling the clearance-chamber is very desirable, as the lead-opening at the valve-port would be insufficient to give boiler-pressure in the cylinder at the beginning of the stroke if the clearance be sufficient to give equal effective pressure on the opposite sides of piston. The supplementary port extends around the piston-rod, the end wall of the cylinder being recessed for this purpose, and the lengths of the openings through the hollow piston-rod into the clearance-chamber is equal to the bridge-wall between the supplementary port and the cylinder proper. Hence when the piston is in motion the bridge-wall will cover the said openings and cut off admission through the said supplementary port.

Another feature is the combination, with the single-cylinder compound engine, of a valve-gear particularly designed to meet the requirements of such an engine. In such an engine it is very desirable to admit the steam to the low-pressure end for a longer time or greater length of stroke than to the high-pressure end, inasmuch as compression must begin in the high-pressure end coincidently with the cut-off at the low-pressure end. Hence the longer this cut-off at the low-pressure end can be delayed the better the results. The peculiar valve-gear combined with this engine accomplishes this result in both motions, (forward and backward of the engine,) and the shorter the cut-off from the high-pressure end the greater is the propor-

tionate delay in the cut-off at the low-pressure end, which is the variation desired.

The accompanying drawings illustrate the invention, wherein like letters and figures refer to like parts throughout.

Figure 1 is a sectional elevation of an engine embodying all the improvements hereinbefore specified except the supplementary ports, the valve being shown at the point of cut-off on the high-pressure end. Fig. 2 is a sectional elevation of the piston, cylinder, and valve identical with Fig. 1, except that the valve is shown at the point of exhaust at the high-pressure end. Fig. 3 is a sectional elevation of the engine proper having the supplementary port, the valve being shown at the lead-opening on the high-pressure end. Fig. 4 is a diagram illustrating the actions in both motions.

A is the cylinder; B, the piston; C, the steam-chest; D, the valve; E, the valve-stem; F F′, the piston-rod of the engine. *a* is the valve-controlled port at the high-pressure end; *a′*, the corresponding port at the low-pressure end; *a″*, the outside exhaust of the usual construction. The valve E is provided with the steam-passage *d*, which is larger at the high-pressure than at the low-pressure end. The inner wall *d′* of the valve-cavity or steam-passage *d* is provided with outside lap, as shown at *d″*, which when the valve is central is, as shown, equal to the outside lap *d‴* on the valve proper. The piston-rod is hollow, as before stated, and is closed at its outer end. It is also provided with a partition *f*, dividing the same into the two parts F F′. The part F is provided with openings *f′* for the admission of steam to its interior, and constitutes the extra clearance or steam-space chamber, before noted.

In the construction shown in Fig. 1 reliance is made on the high-pressure steam-port *a* to fill this clearance-chamber; but in the construction shown in Fig. 3 a supplementary port G from the steam-chest is provided, passing down through the bridge-wall and extended around the piston passage-way in the end wall of the cylinder, and the openings *f′* into the clearance-chamber are located far enough back on the rod, so as to be central with the port G when the crank is on the center, as before stated. When the supplementary port is employed, a packing-ring H is located in a suitable seat of the bridge-wall between the said port and the cylinder proper. The piston-rod may be packed by a stuffing K of the ordinary construction.

Provision is made by a duct L and steam-pipe L′ for the admission of live steam to the interior of the valve at will in case the same should be necessary to start the engine.

Q is the power-shaft driven from the crank and connecting-rod in the usual way, the positions of which are shown by the lines *q* and *q′*.

R is the valve-driving eccentric on the power-shaft Q.

R′ is the eccentric-strap, which is provided with an extended arm R″, the outer end of which is constrained to move in a definite path variable at will by a guide S, fixed to the end of a rock-shaft S′. The engagement of the outer end of the arm R″ with the said guide is preferably made by a roller R‴.

T is the eccentric-rod, which extends directly from the arm R″ to the valve-stem; but, instead of being connected to the said arm in the center line of the said arm's motion, is connected to an offset-arm *r*, projecting from the rear of the same or in a direction away from the cylinder. The position of the guide S with reference to a vertical line determines the direction of the power-shaft's movement, and the intermediate positions or angle at which it stands with reference to the vertical in either motion determines the point of cut-off and the other actions. The guide is rocked to reverse the power-shaft or vary the actions in any suitable way, as by the lever-arm V and lever-rod V′. This gear is in its general features identical with the gear patented to myself and John Peebles, of date July 30, 1889, under patent numbered 407,806, modified forms of which are also shown in the patent issued to E. J. Woolf, of date January 13, 1891, numbered 444,563, and in the patent issued to E. J. Woolf and John Peebles, of date July 14, 1891, No. 455,872, but differs therefrom in the location of the offset arm or point with reference to the direction of the eccentric-rod. In the said prior patents and in all uses hitherto made of the said gear it was applied to simple engines, and in such usage direct connection from an offset-arm projecting away from the cylinder was not desirable. With the single-cylinder compound engine, however, this construction gives the exact results desired, as before stated.

The diagram Fig. 4 shows the actions of this gear for one revolution of the crank in both the forward and backward or under and over motion of the crank. This diagram is drawn from exact scale, and all the parts are symmetrical throughout. The eccentric is located opposite the crank.

W represents the path of the piston-rod pin, which of course corresponds to that of the piston in the cylinder.

W′ represents the path of the valve-stem pin, which corresponds to that of the valve.

X X represent the center line of the guide S in the over motion of the crank, looking from the cylinder, and X′ X′ the position of the same in the reverse or under motion of the crank.

Q′ represents the center of the power-shaft.

Y represents the path of the eccentric, and Y′ the path of the crank-pin.

Z represents the path of the offset point of attachment or pivot-pin connecting the eccentric-rod to the offset arm *r* when the guide S is set for the over motion or in the line X X. The curve Z′ represents the path of the same

point when the guide S is set for the under motion or in its reverse position in the line X′ X′. The positions of the different points are represented by 1^a 1^b in the under motion of the crank and by 2^a and 2^b in the over motion of the crank.

1^a represents the point of cut-off at the high-pressure end and 1^b at the low-pressure end, and 2^a and 2^b the like points in the other motion. With this explanation the various positions can be readily traced on the diagram. An inspection of the path of the cross-head pin will show that the cut-offs 1^b and 2^b from the low-pressure end, corresponding to the cut-offs 1^a and 2^a from the high-pressure end, are relatively late, the proportional distance being in the case shown about two to one.

It should be noted that the piston-rod is enlarged to reduce the effective area in the high-pressure end of the cylinder.

What I claim, and desire to secure by Letters Patent of the United States, is as follows:

1. In a single-cylinder compound engine, a valve provided with a cavity for the passage of the steam from the high to the low pressure end of the cylinder and having on the inner wall of the valve-cavity a lap covering the low-pressure port for delaying admission to the low-pressure end after the exhaust begins from the high-pressure end into the valve-cavity, substantially as described.

2. In a single-cylinder compound engine, a piston-rod recessed to constitute an extra clearance or steam-space chamber at the high-pressure end and provided with openings to the said chamber for the inlet and outlet of the steam, substantially as and for the purpose set forth.

3. In a single-cylinder compound engine, the combination, with the cylinder having an excess of clearance in the high-pressure end without increase of the piston area in the same, substantially as and for the purpose set forth, of a supplementary port from the steam-chest for filling the said extra clearance or steam-space chamber.

4. In a single-cylinder compound engine, the combination, with a piston-rod recessed to constitute an extra clearance or steam-space chamber at the high-pressure end and having openings to the said chamber, of a supplementary port from the steam-chest for filling the said chamber, substantially as described.

5. In a single-cylinder compound engine, the combination, with the piston-rod recessed to provide an extra clearance or steam-space chamber, of a supplementary port from the steam-chest and openings from said chamber through the wall of the piston-rod located at a point on the same back of the piston-head and so as to be central with the said port when the crank is on the center, and a packing-ring seated in the bridge-wall between the said port and the cylinder proper, substantially as and for the purpose set forth.

In testimony whereof I affix my signature in presence of two witnesses.

ELLIS J. WOOLF.

Witnesses:

JAS. F. WILLIAMSON,

E. F. ELMORE.