(No Model.) 2 Sheets—Sheet 1.

E. W. HARDEN.

TRIPLE EXPANSION ENGINE.

No. 516,434. Patented Mar. 13, 1894.

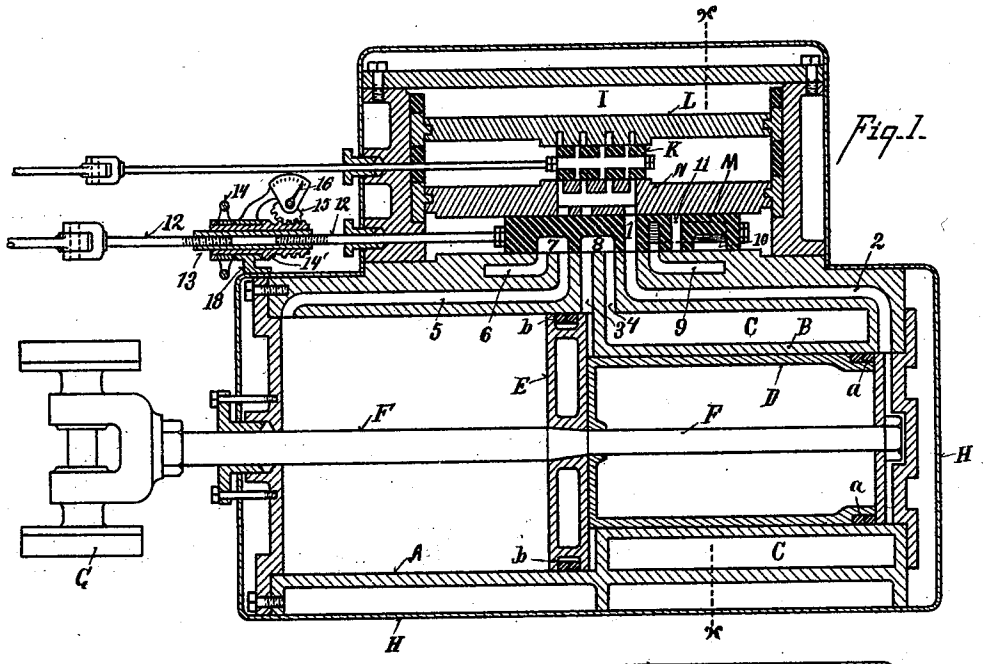

Fig. 1.

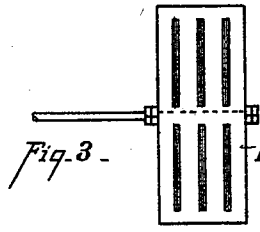

Fig. 3.

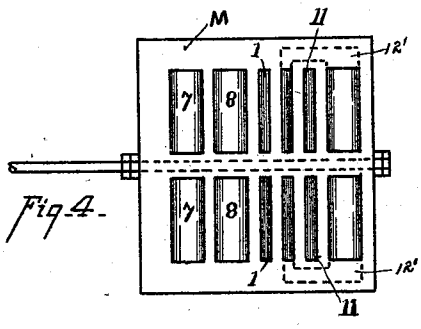

Fig. 4.

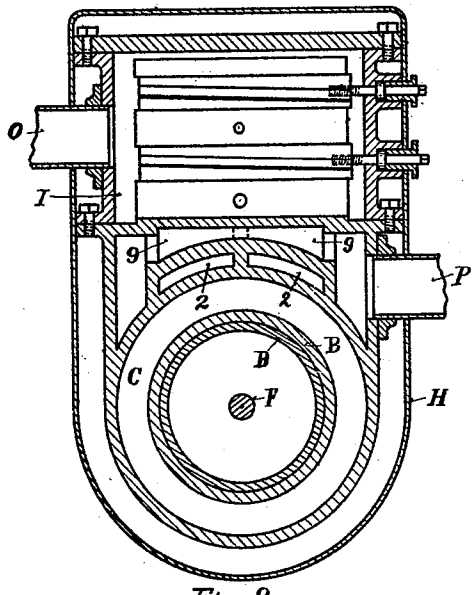

Fig. 2.

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(No Model.) 2 Sheets—Sheet 2.

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TRIPLE EXPANSION ENGINE.

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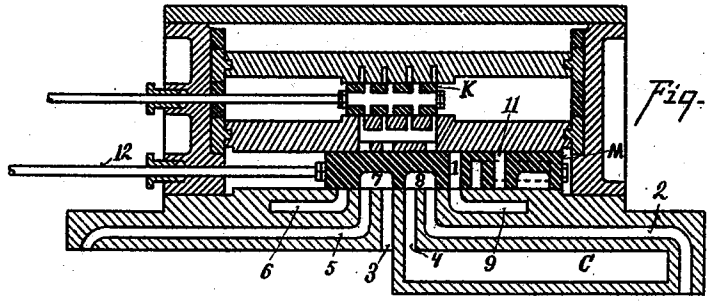

Fig. 5.

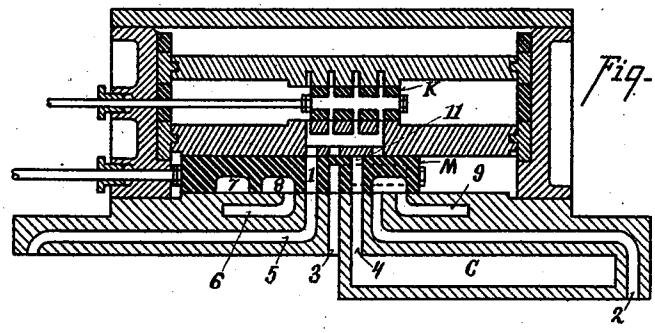

Fig. 6.

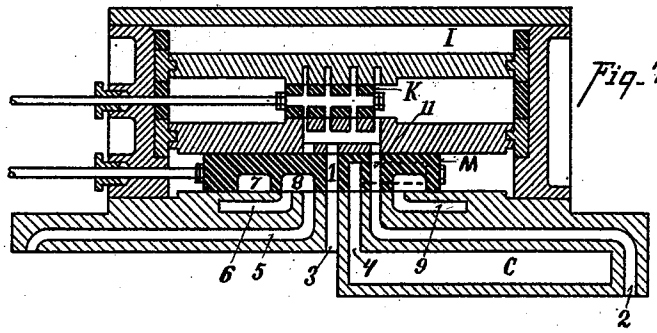

Fig. 7.

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UNITED STATES PATENT OFFICE.

EDWARD W. HARDEN, OF CINCINNATI, OHIO, ASSIGNOR TO FREDRIC C. WEIR, OF SAME PLACE.

TRIPLE-EXPANSION ENGINE.

SPECIFICATION forming part of Letters Patent No. 516,434, dated March 13, 1894.

Application filed March 30, 1893. Serial No. 468,349. (No model.)

To all whom it may concern:

Be it known that I, EDWARD W. HARDEN, a citizen of the United States, residing at Cincinnati, in the county of Hamilton and State of Ohio, have invented certain new and useful Improvements in Triple-Expansion Engines, of which the following is a specification.

The object of my invention is to provide a progressively expansion steam engine; it is shown of the triple expansion type. I employ a differential piston constructed on the general principle shown in my application, Serial No. 421,034, filed February 10, 1892.

The various features of my invention are fully set forth in the description of the accompanying drawings making a part of this specification, in which—

Figure 1 is a longitudinal central section of my improvement. Fig. 2 is a section on line *x*, *x*, Fig. 1. Fig. 3 is a plan view of the auxiliary valve. Fig. 4 is a bottom plan view of the main valve. Figs. 5, 6 and 7 are views similar to Fig. 1, showing different positions of the valves.

The cylinder is of the differential form.

A represents the larger cylinder, B the smaller cylinder.

C represents a reservoir or chamber; it is shown as an annulus around the cylinder B, its inner periphery forms a bearing for the smaller piston D.

E represents the larger piston; both pistons are united and form a differential piston.

F represents the piston rod, G the cross head. H a casing inclosing the engine. I the steam chest. K the auxiliary valve. M a main valve; L the upper seat of the auxiliary valve; N the lower seat of the auxiliary valve and the upper seat of the main valve.

O represents the pipe for admitting steam into the steam chest.

P represents the exhaust pipe.

I have shown the differential piston constructed of two pieces connected to the piston rod F, but they may be cast in one piece. The cylinder B supports the smaller piston D.

a represents a packing at the rear end; the piston E is packed in the usual manner by rings *b*. The main valve is provided with the main port 1 by which steam is admitted through port 2 to the rear face of piston D, in position shown in Fig. 1. It is also shown as exhausting steam from the cylinder A through port 5 to exhaust port 6. Ports 5 and 6 communicate through port 7 of the main valve. When the valve moves forward into the position shown in Fig. 5 it cuts off the admission of steam to port 2, port 8 of the valve connects with port 4, and the steam is exhausted through port 2 and port 8 of the valve and port 4 of the steam chest into the annulus C, where it is stored for being compounded when the valve is moved back again into the normal position shown in Fig. 1; the steam stored in the annulus C is passed by ports 4, 8 and 3, on to the smaller area of piston E, acting thereon by expansion in unison with the direct steam admitted by port 2 on to the rear end of the smaller piston B. When the valve is again moved forward into position shown in Fig. 5, ports 3 and 5 are connected by port 7 of the valve, and the steam is exhausted from the smaller area of the piston E through ports 3, 7 and 5, over on to the larger area of piston E, where it is utilized by expansion to make the return stroke. Thus the steam is used first directly upon the smaller area of piston B, thence passed in the annulus C, thence expanded upon the smaller area of piston E, and then expanded from the smaller on to the larger area of piston E making a triple expansion. I have shown the main valve adjustable on its seat so that the engine may be used as a direct acting engine. To do this I provide an additional port 11 in the main valve and adjust it on the seat as shown in Fig. 6, instead of being adjusted as shown in Fig. 1. Port 1 of the main valve supplies live steam by port 5 to the larger area piston. The position of the valve for making the opposite or return stroke is shown in Fig. 7; in this position port 1 communicates with port 3, admitting live steam on to the smaller area of piston E and port 11 admits live steam through port 2 on to the rear end of piston B. As these two areas are about equal to the area of the large piston E, the engine is balanced or driven relatively by the same amount of pressure on either stroke. When the engine is being thus used the port 4 is cut off at all times so that the annulus C is not

brought into use. I have shown as a means of adjusting this valve the valve stem 12 divided in two parts and connected by a coupling sleeve 13 which is threaded right and left at each end connecting the valve stem sections.

14 represents a hand wheel for turning a sleeve 14′ splined to the sleeve 13 and journaled in bracket 18, and through which the sleeve 13 is rotated.

15 represents a worm segment engaging with worm threads on the outer periphery of sleeve 14′ operating an indicator hand 16, so that the operator can see the exact position of the main valve; and this is the preferred form of adjusting mechanism employed for converting the engine from the triple expansion into the direct acting engine. I have likewise shown the valve seats adjustable by the means shown in my said former application. When used as a direct engine steam is exhausted from port 3 through side ports 12′ in the main valve, as shown in dotted lines in Fig. 4.

Having described my invention, what I claim is—

1. In a compound engine, the combination of the differential cylinder A, B, with the differential double acting piston E, D, the reservoir C formed within the shell of the cylinder and steam chest, and a valve provided with suitable ports and passages for expanding the steam progressively on succeeding piston faces, substantially as described.

2. In a compound engine, the combination of the differential cylinder A, B, with the differential double acting piston E, D, the reservoir C formed within the shell of the cylinder and steam chest, and a valve provided with suitable ports and passages for expanding the steam progressively on succeeding piston faces, the last expansion driving the piston in the opposite direction from the preceding one, substantially as described.

3. In a compound engine consisting of the differential cylinders A, B, the storage reservoir C, the steam chest provided with the ports 2, 3, 4, 5, and 6, and the main valve provided with a main and branch ports and cut offs for opening and closing the said chest ports for progressively compounding the steam, substantially as specified.

4. In combination with the progressive expansive steam engine composed of two cylinders of different area, and pistons of different areas working therein, the live steam port 2, and storage reservoir C, a port 4 communicating alternately with ports 2 and 3, and the port 5 for supplying steam to the larger cylinder, and a suitable valve for operating said piston by cutting in and out the respective ports at each alternate stroke of the valve, substantially as specified.

5. In combination with the compound steam cylinders A, B, the ports 2, 3, 4, 5 and 6, and a main valve provided with ports 1, 7 and 8, adapted to open and close the said chest ports, whereby the direct steam is admitted on the smallest piston and progressively expanded upon the successive faces of the larger pistons, substantially as specified.

6. In combination with the compound cylinders A, B, and pistons D, E, the storage reservoir C, the main valve provided with ports 1 and 11, and branch ports 7, 8 and 10, and mechanism for adjusting said valve on its seat and adapted to communicate with the respective ports of the cylinder whereby the engine may be used as a direct or compounding engine by the adjustment of said valves, substantially as specified.

7. In combination with the progressive compound engine, composed of unequal cylinders and pistons having three communicating supply ports 2, 3 and 5, and main valve provided with the supply ports 1 and 11, and the branch ports 7 and 8, substantially as specified.

In testimony whereof I have hereunto set my hand.

EDWARD W. HARDEN.

Witnesses:
T. SIMMONS,
C. W. MILES.