(No Model.) 3 Sheets—Sheet 1.

E. W. HARDEN.

COMPOUND ENGINE.

No. 553,463. Patented Jan. 21, 1896.

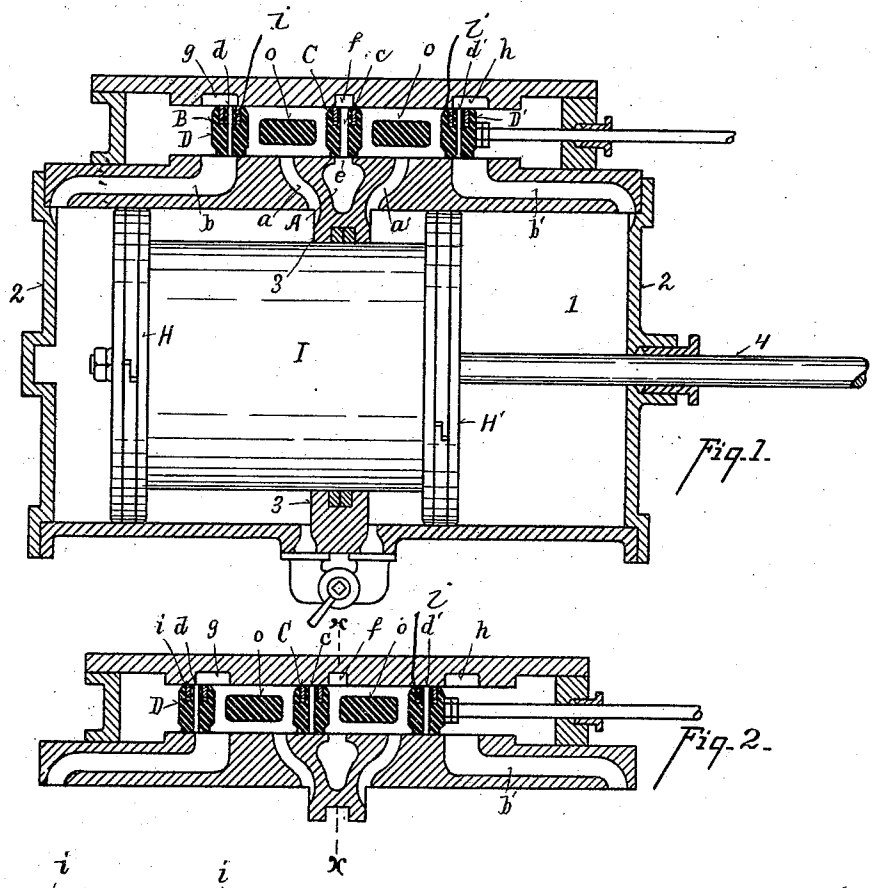

Fig. 1.

Fig. 2.

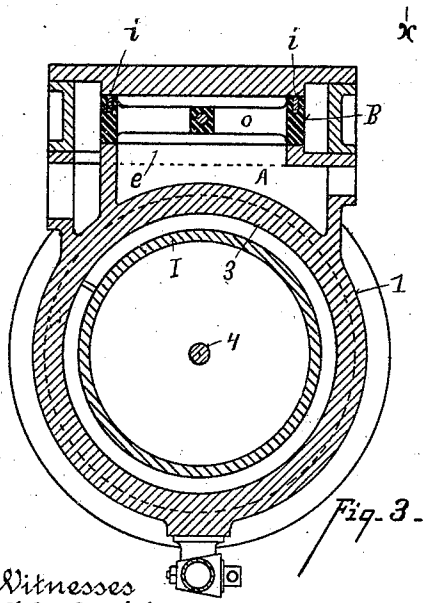

Fig. 3.

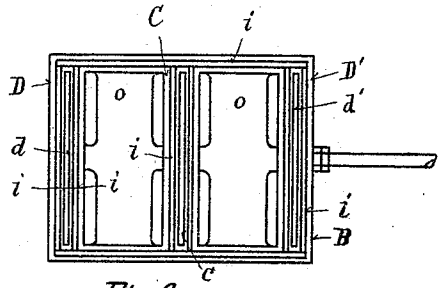

Fig. 4.

Witnesses
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(No Model.) 3 Sheets—Sheet 2.

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COMPOUND ENGINE.

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Fig. 5.

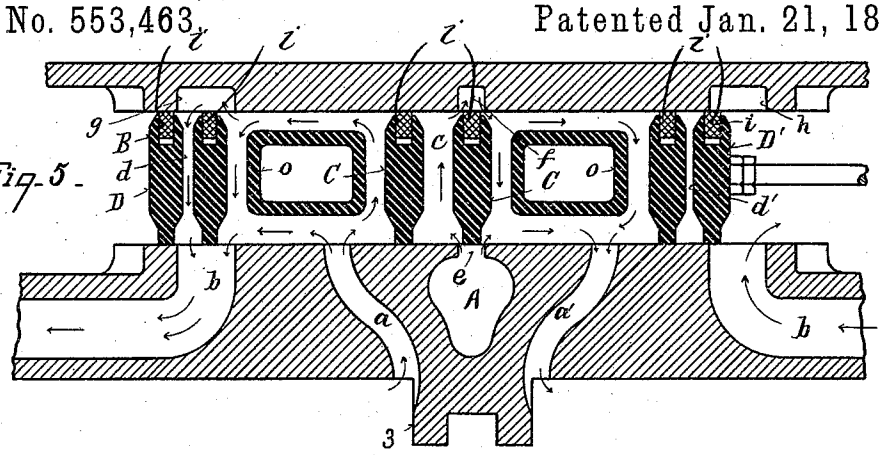
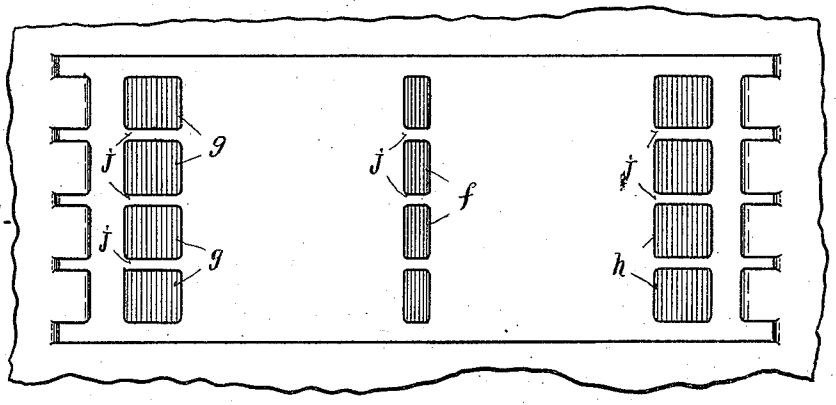


Fig. 6.



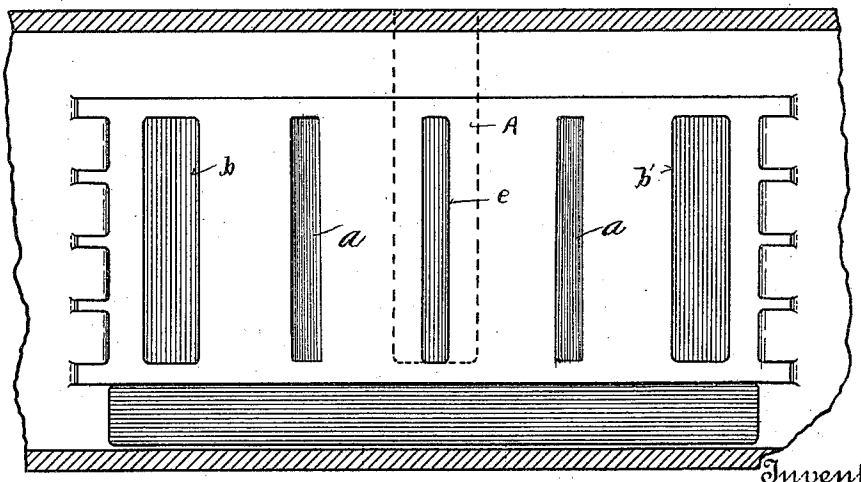


Fig. 7.

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(No Model.) 3 Sheets—Sheet 3.

E. W. HARDEN.

COMPOUND ENGINE.

No. 553,463. Patented Jan. 21, 1896.

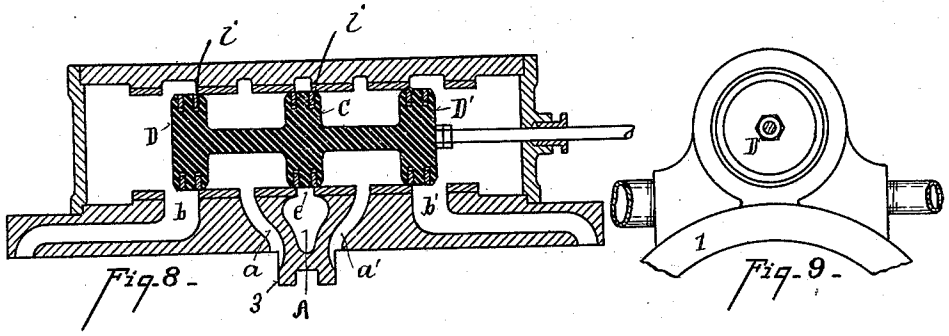

Fig. 8.

Fig. 9.

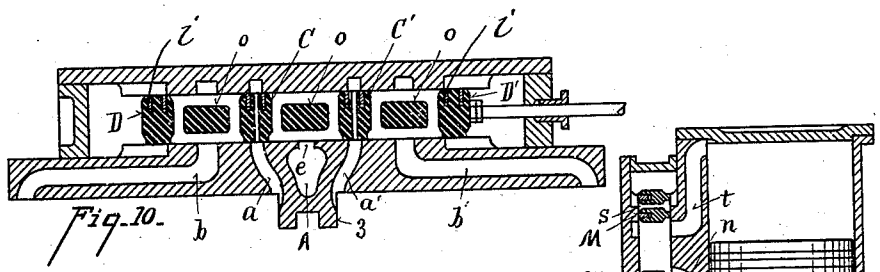

Fig. 10.

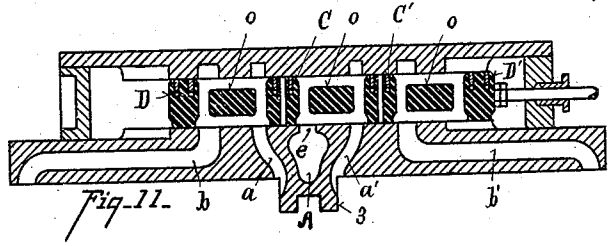

Fig. 11.

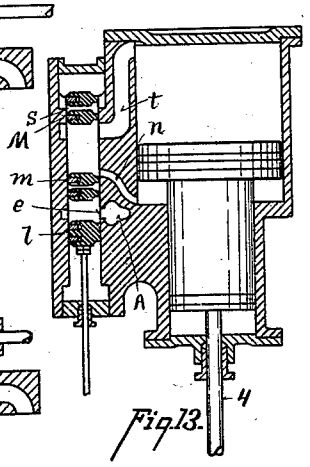

Fig. 13.

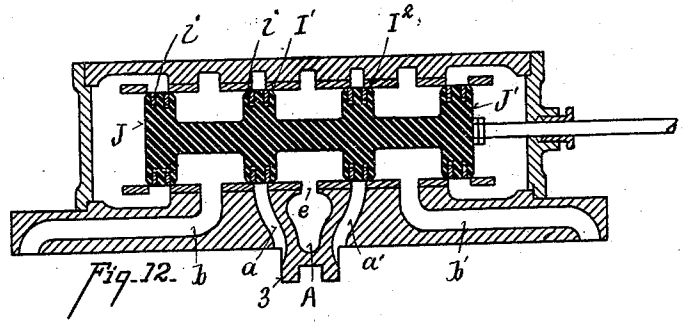

Fig. 12.

Witnesses,
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UNITED STATES PATENT OFFICE.

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

COMPOUND ENGINE.

SPECIFICATION forming part of Letters Patent No. 553,463, dated January 21, 1896.

Application filed April 8, 1895. Serial No. 544,952. (No model.)

To all whom it may concern:

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

My invention relates to a valve for a compound engine of the type shown in Letters Patent No. 490,384, granted January 24, 1893, and No. 507,433, granted October 24, 1893, employing one or more pistons, the faces of each piston having different areas, the smaller area being acted upon by the high-pressure steam, which is compounded onto the larger piston area.

The object of my invention is, first, to provide a valve controlling the induction steam-ports of the cylinder, and the high and low pressure ports for admission and exhaust of the cylinder which is provided with cut-off sections controlling each port, and a steam port or passage through each cut-off section, and a passage on one side of said cut-off section, thereby forming two supply and two exhaust passages through the valve for each port; second, to provide a valve for a duplex compound engine which has three or more cut-off sections, the outside sections controlling the low-pressure ports and the central section or sections controlling the induction and high-pressure steam-ports, each of said sections having a port or passage pierced through it, and passages through the valve at the side of said sections so that each port has two passages through the valve for supplying and exhausting steam; third, to provide a valve of skeleton form for a duplex compound engine with three or more cut-off sections, the central sections of which are pierced with ports or passages for the passage of the steam, and the steam-passage at the side of said sections, whereby the high-pressure steam-ports are supplied by two steam-passages through the valve; fourth, to provide a valve with three or more cut-off sections the two outer sections of which control the low-pressure and exhaust ports at the end of the cylinder, and have an exhaust and supply passage through said sections, and a supply-passage for compounding steam at one side, and adapted to exhaust at the opposite side of said cut-off sections; fifth, to provide a valve controlling the ports of a duplex cylinder and piston-engine, which valve has three or more cut-off sections with steam ports or passages through each of said sections for balancing the valve, as well as for operating as ports to supply and exhaust steam; sixth, to provide the cylinder of a compound engine with an induction or supply passage in the cylinder itself and below the valve-seat at one side of or between the high-pressure steam-ports of the cylinder and adapted to supply steam to a cylinder by a series of passages through the valve; seventh, to provide a skeleton valve having cut-off sections for different ports of a cylinder, each section being provided with steam-passages through it, and a passage on one side of each section, which are adapted to cover the high-pressure steam passages or ports and the exhaust-ports, and enabling the same to be used as a variable steam cut-off for both the high and low pressure parts of the compound piston.

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

Figure 1 is a central vertical section of my improvement in position for use. Fig. 2 is a section of the valve and a top section of the cylinder, showing the position of the valve on one side of the central position. Fig. 3 is a central vertical cross-section of Fig. 1. Fig. 4 is a plan view of the valve shown in Figs. 1, 2, and 5. Fig. 5 is an enlarged section of Fig. 2, but with the valve just commencing to open the ports. Fig. 6 is a plan view of the upper seat of the valve. Fig. 7 is a plan view of the lower seat of the valve. Fig. 8 is a modification of the valve shown in Fig. 2. Fig. 9 is an end elevation of the steam-chest and top section of cylinder. Fig. 10 is another modification of the valve shown in Fig. 2. Fig. 11 is a similar view of Fig. 10, showing the valve in a different position. Fig. 12 is a modification of Fig. 10. Fig. 13 is a modification showing the valve applied to a compound engine of the single type.

1 represents a cylinder; 2, the heads thereof;

3, the collar journal-bearing which serves as a partition to divide the central portion of the cylinder into two compartments.

H H′ represent the piston-heads.

I represents the cylinder interposed between and connecting the heads H H′ together. Said cylinder has its bearing in the partition 3. 4 represents a piston-rod to which the said piston and cylinders are securely connected.

a represents the high-pressure steam-port for the piston H; *a′*, the high-pressure steam-port for the piston H′.

b represents the low-pressure and exhaust port for the piston H, and *b′* a similar port for the piston H′.

A represents the live-steam supply and induction port, which is preferably located in the cylinder and between the high-pressure steam-ports *a a′*. It is shown as placed below the valve B instead of above it, chiefly for convenience; but I do not wish to limit my invention to this construction, except in clauses of the claim, where the same is made a specific element.

In Figs. 1, 2, 3, 4, and 5 B represents the main valve as constructed for the double compound engine. It is provided with a central cut-off section C, which covers port *e* of the steam-passage in chamber A. Said section is pierced to provide a port or steam-passage *c*.

D D′ represent the ouside cut-off sections. They are each provided with ports or passages *d d′*. These ports extend the whole length of said sections, as shown in Fig. 4. In order to facilitate the passage of steam through said ports the faces of the cut-off sections are beveled off on each side at the top and bottom thereof.

The lower valve-seat is formed on the face of the cylinder and its upper seat is shown as formed on the inside of the steam-chest cover. The upper valve-seat is provided with recesses *f g h*, which are of nearly the same area as the respective ports A *b b′*, in the lower valve-seat with which they are in opposition. There are provided in the upper surfaces of the cut-off sections C D D′ suitable packing-strips *i* to serve as flexible cut-offs for the recesses *f g h* and connecting passages of the valve cut-off sections. In order to hold the packing-strips *i* in their seats formed within the cut-off sections I provide ribs *j*, as shown in Figs. 5 and 6, extending across the said recesses *f g h* and against which the packing-strips *i* bear.

The main valve B is preferably of skeleton form, having cut-off sections extending horizontally across the face of the cylinder, said sections and the seats thereof being horizontal; but I do not wish to limit myself to this form of construction, as these sections may be of the piston form shown in Fig. 8.

The valve packing-strips *i* are to be located in the upper face of each cut-off section, one to be located on each side of the steam-passage pierced through the center of said cut-off section, and the outside edge or portion of each packing-strip is to be in line with or opposite the lower edge of the cut-off section. By this arrangement of packing-strips there is formed on the upper surface of each cut-off section a flexible cut-off for each recess *f g h* and ports or passages *c d d′*.

My valve for the double compound engine in the preferred form has only one central cut-off section, but may be provided with two central cut-off sections C C′, as shown in Figs. 10 and 11. When constructed as shown in said figures, the cut-off section C controls the high-pressure steam-port *a*, and the cut-off section C′ controls the port *a′*. The piston form of valve shown in Fig. 12 may also be provided with four cut-off sections, two central sections I′ I², and two outside piston-sections J J′. In Fig. 12 the two oustide sections J J′ control the high-pressure and exhaust ports, and the central section or sections I′ I² control the high-pressure steam-ports.

If it is desired to construct the engine of the single compound type, which modification is shown in Fig. 13, the valve is provided with three cut-off sections the same as shown in Figs. 1 and 5, and the cut-off section *l* simply serves to prevent the escape of the steam into the chest. The cut-off section *m* controls the port *e* of the steam passage or chamber A and the high-pressure port *n*, and the cut-off section M controls the low-pressure and exhaust port *t*. The cut-off section M moves forward past the port *t* and the exhaust is outside of the cut-off section M. Said section is also pierced with a steam-passage *s*, through which the supply and exhaust is partly accomplished. It will be observed that the sections M *m* are provided with recesses in the same manner as shown for the corresponding part in Fig. 1. The outer section does not control either of the ports and no such recess is required. It is simply provided to prevent the escape of the live steam into the exhaust-chamber and to form one boundary of the steam-passage through the valve. In the type of valve shown herein the steam-chest all around the valve is an exhaust-chamber and the live steam only occupies the space within the valve and between the outside sections thereof. I have shown the space between the cut-off sections as partially filled with strengthening-bars *o*. This is to reduce the clearance or amount of steam-space within the valve, and passages are formed on each side of bars *o*. These passages must be sufficiently large to allow the steam to readily pass through the valve as the respective ports are uncovered.

Mode of operation: The mode of operation will be understood by reference to Fig. 5 of the drawings. The valve is shown as having moved off of the center toward the left and is taking steam from port *e* through the passage *c* of the cut-off section C. It passes thence into the recess *f* to the valve-seats, and thence down between the cut-off section and

the bar *o* to the high-pressure steam-port *a'*, and live steam is also passing from the port *e* outside of the cut-off section to said port *a'*, as indicated by arrows. Port *b'* is exhausting steam outside of the cut-off section D', as indicated. Port *a* is conveying steam for compounding direct to port *b*, as well as through the passages *d*, as indicated in arrows. Of course when the valve moves in the opposite direction a similar action takes place, except that the high-pressure steam is admitted onto the smaller area of the opposite piston and being compounded upon the larger area of the opposite piston. The operation of the other form of valve is analogous to this except in a valve having four cut-off sections instead of three, each high-pressure port is being controlled by its respective cut-off section instead of having one cut-off section common to the two ports. In the modification shown in Fig. 13 the live steam is used on the face of the smaller piston area to propel the piston in one direction, and it is propelled in the opposite direction solely by compounding the steam from the smaller area onto the opposite face of the larger area piston, so that the forward stroke of the piston is made by the high-pressure steam and the return stroke by the compounding of the low-pressure steam.

I obtain very important advantages by employing a main valve pierced with passages, one through the cut-off section and the other passage at the side thereof, as I obtain a full port-opening for one-half the distance of valve travel over what could be obtained by having a steam-passage at only one side of the cut-off section. By this form of construction the valve is practically balanced under pressure in all positions. By the construction herein shown I am enabled to obtain any desired amount of variable cut-off for both the high, low, and exhaust ports, and I am enabled to use my valve with the compound type of engine at one-fourth cut-off and obtain the required amount of steam expansion.

The construction of the valve and ports is such that the steam is quickly admitted onto the face of the piston and freely exhausted by reason of the plurality of steam-passages, and in consequence I am enabled to use cylinder-ports of large area, obtaining a maximum amount of steam to the minimum amount of valve-movement.

By making the steam-chamber in the cylinder below the valve and an induction-port leading therefrom upwardly into the valve-chamber I obtain important advantages. The live-steam chest is formed wholly within the cylinder and between the cut-off sections of the valve. The steam-chest or valve-chamber cover forms the upper bearing-seat of the valve and it can be taken off and the valve adjusted without disturbing the steam-pipes. Again, the valve is balanced in the chest and is surrounded only by the exhaust-steam and no downward pressure except in the recesses of the valve-seat opposite to and balanced by the cylinder-ports.

I claim—

1. The combination with the cylinder of a compound engine, and a piston the faces of each side of which are of different areas, and working in said cylinder which is provided with an induction steam port, a high pressure port and a low pressure and exhaust port, of a valve having a cut-off section with a steam passage through it, and a steam passage on one side thereof, taking steam from the same supply port and controlling the induction and high pressure ports, and a cut-off section with steam passage pierced through it and steam passages on both sides thereof for controlling a low pressure and exhaust port, and a steam chest recessed to provide communication between the steam passages of each cut-off section, substantially as specified.

2. In a compound engine, the combination with a piston the opposite faces of which are of different areas, and a cylinder having an induction steam port below the valve seat and a high pressure port and a low pressure and exhaust port, of a steam chest and a valve located therein, the said valve having a cut-off section pierced with a steam supply passage and a cut-off section pierced with a steam passage for controlling low pressure and exhaust, and the said steam chest being provided with a recess in the valve seat opposite the induction port and a recess in the valve seat opposite the low pressure and exhaust port, substantially as specified.

3. In a compound steam engine composed of a duplex cylinder provided with duplex piston, the opposite faces of each side of which are of different areas and working in the same cylinder, a high and low pressure port for each section of the cylinder and an induction port common to both cylinder sections, the combination with said ports, of a steam chest, and a valve located therein having two outside cut-off sections controlling the low pressure and exhaust ports, and a central cut-off section having a central steam passage and a steam passage at one side thereof for controlling the induction port and the high pressure ports of each cylinder section, the said valve chest having a recess in the upper valve seat opposite the high pressure port to provide communication between the steam passages of said central cut-off section, substantially as specified.

4. In a compound steam engine composed of a duplex cylinder provided with duplex piston, the opposite faces of each side of which are of different areas and working in the same cylinder, a high and low pressure port for each cylinder section and a steam chamber having an induction port between the high pressure ports and common to both of said ports, and a low pressure and exhaust port at the end of each cylinder section, the combination with a steam chest provided with

recesses *f*, *g*, *h*, of a valve located in said chest and provided with two outside cut-off sections, a central cut-off section, a steam passage through each of said cut-off sections, and steam passages at each side thereof, substantially as specified.

5. In a compound steam engine the combination of a duplex cylinder provided with ports and a duplex piston, the opposite faces of each side of which are of different areas, a valve chest having an upper valve seat provided with recesses opposite the high pressure ports of the cylinder, a valve located in said chest, and having central cut-off sections pierced with steam passages communicating with the recesses in the upper valve seat for controlling the high pressure steam ports of the cylinder, and outside cut-off sections for controlling the low pressure and exhaust ports, substantially as specified.

6. The combination with a duplex cylinder for a compound engine having a duplex piston the opposite faces of which are of different areas and provided with a steam supply chamber in the cylinder, an induction port leading to the steam chest, a high pressure port for each cylinder section outside of the induction port, an outer low pressure and exhaust port in each of the cylinder sections adapted to exhaust into the steam chest, of a steam chest having recesses in the upper valve seat opposite each cylinder port, and a valve having two outside cut-off sections and a central cut-off section each pierced with steam passages communicating with a recess in the upper valve seat, for controlling the said cylinder ports, substantially as specified.

7. The combination with a compound steam engine, composed of a cylinder employing a piston the opposite faces of each side of which are of different areas, and working in the same cylinder, which cylinder is provided with an induction port, a high pressure port, and a compound and exhaust port, of a skeleton valve provided with a cut-off section controlling each cylinder port, and each of which is pierced with a steam passage and a steam passage at each side thereof, and a steam chest recessed to correspond with the steam passages of the cut-off sections, whereby a double admission and exhaust passage is provided for each port through the valve, substantially as specified.

8. The combination with the steam chest having recesses *f*, *g*, *h*, in its upper valve face, the duplex cylinder having ports opposite said recesses, and a duplex piston the opposite faces of each side of which are of different areas and working in the same cylinder of a skeleton valve having two outside cut-off sections and one or more central cut-off sections which are divided or pierced to form a passage through each of said cut-off sections, and packing strips *i* located in the upper faces of said cut-off sections at the sides of said passages and adapted to serve as flexible cut-offs for the said recesses and passages, substantially as specified.

9. In a compound steam engine, the combination of a duplex cylinder having a high pressure port and a low pressure port for each cylinder section, a duplex piston the opposite faces of each side of which are of different areas, working in said cylinder, a steam chest having in its lower valve seat an induction steam port and provided in its upper valve seat with combined balance and steam supply recesses located opposite the low pressure cylinder ports, and a single valve located in said steam chest and having two outside cut-off sections controlling the low pressure ports and the recesses opposite thereto and one or more central cut-off sections controlling the induction port and high pressure ports, substantially as specified.

In testimony whereof I have hereunto set my hand.

EDWARD W. HARDEN.

Witnesses:
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E. E. WOOD.