(No Model.)

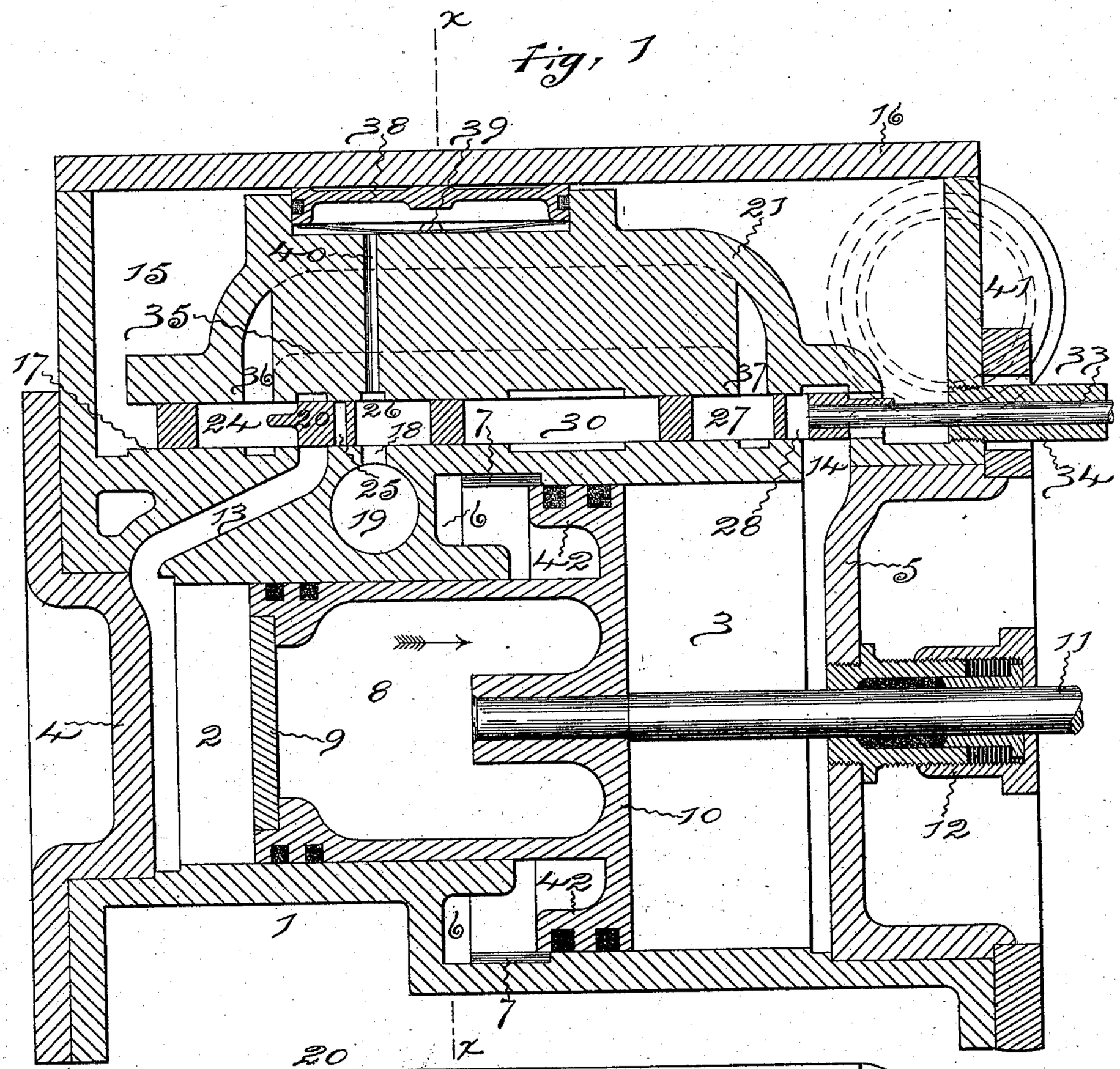
2 Sheets—Sheet 1.

R. H. MATHER.

STEAM ENGINE.

No. 559,395. Patented May 5, 1896.

Fig. 1



Witnesses:
C. E. Buckland.
J. R. Carroll

Inventor;
Richard H. Mather:
by Willard Eddy,
Atty.

(No Model.) 2 Sheets—Sheet 2.

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Fig. 3

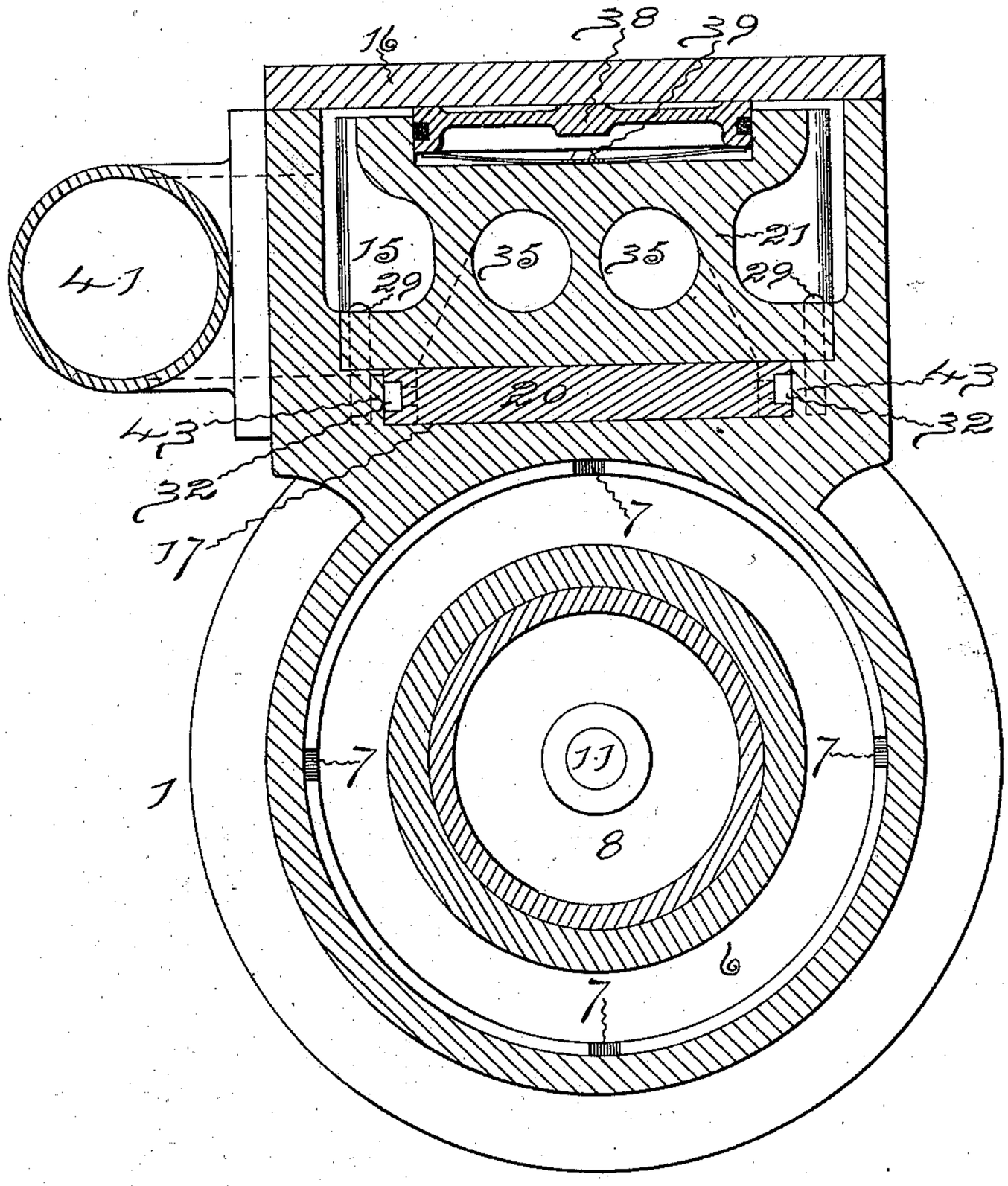
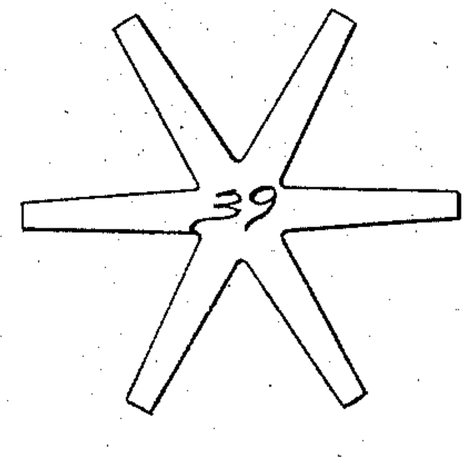


Fig. 4.



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UNITED STATES PATENT OFFICE.

RICHARD H. MATHER, OF WINDSOR, CONNECTICUT.

STEAM-ENGINE.

SPECIFICATION forming part of Letters Patent No. 559,395, dated May 5, 1896.

Application filed July 31, 1893. Serial No. 481,975. (No model.)

To all whom it may concern:

Be it known that I, RICHARD H. MATHER, of Windsor, Hartford county, Connecticut, have invented certain new and useful Improvements in Steam-Engines, which improvements are described in the following specification and are illustrated by the accompanying drawings.

My invention relates to double-acting compound engines; and its object is to simplify the construction and to increase the efficiency of engines of that class. To accomplish this object, I use a single steam-cylinder, which comprises two steam-chambers of unequal diameters and which is provided with an annular vacuum-chamber, a single piston working in both steam-chambers of the cylinder, a balanced valve, and a pressure-plate, having an opening through which steam passes from the high-pressure chamber to the low-pressure chamber of the steam-cylinder.

The best manner in which I have contemplated applying the principles of my invention is illustrated by the said drawings which accompany this specification.

In the drawings, Figure 1 is a central vertical longitudinal section through the steam-cylinder, the valve-chest, and the mechanism which is contained in the steam-cylinder and valve-chest of an engine which belongs to the specified class and which is constructed in accordance with those principles. Fig. 2 is a plan of the same valve which is shown in section in Fig. 1. Fig. 3 is a cross-section of Fig. 1 on the broken line x x. Fig. 4 is a plan of a certain spring which is shown in section in Figs. 1 and 3.

In Figs. 1 and 3 the numeral 1 denotes the steam-cylinder, which comprises two steam-chambers whose axes are in one and the same straight line and whose diameters are unequal—namely, the high-pressure chamber 2 and the low-pressure chamber 3. This cylinder is a single casting provided with terminal heads or covers 4 and 5, which are held in place in the usual manner by bolts, which are not shown in the drawings. In the middle part of the cylinder chamber 2 projects into chamber 3 in such a manner as to form at the inner end of chamber 3 and around the inner end of chamber 2 the annular vacuum-chamber 6, which is provided with vent-grooves 7. This chamber is particularly described below. Within cylinder 1 is a hollow piston 8, having two heads 9 and 10, which are of unequal areas and which work respectively in chambers 2 and 3. Connected integrally with the peripheral portion of head 10 is the annular flange 42, which is adapted to enter vacuum-chamber 6, and is large enough to occupy the principal part of that chamber. A piston-rod 11 passes through a stuffing-box 12 in the usual manner. Piston-rod 11 is connected with a crank, which is not shown in the drawings, by means of a connecting-rod, in the usual manner. The cylinder-chambers 2 and 3 are provided, respectively, with steam-passages or ports 13 and 14, communicating with the valve-chest 15. This valve-chest is formed in the same casting which comprises the steam-cylinder, and is provided with a cover 16, which is bolted on in the usual manner. Within this chest is formed the flat valve-seat 17, which is provided with the beforementioned ports 13 and 14, and with a supply-port 18, and is bounded on opposite sides by two parallel ledges 43. The supply-port 18 connects with a steam-passage 19, which leads from the boiler. (Not shown in the drawings.) Valve 20 is of the so-called "pressure-plate" type, and is shown separately in Fig. 2. This valve is a single casting, consisting of two coincidently-moving valve-sections 22 and 23. Section 22 includes ports 24, 25, and 26, which are adapted to serve ports 13 and 18 of the valve-seat 17, while the valve-section 23 includes ports 27 and 28, which are adapted to serve port 14 of the valve-seat. Valve-sections 22 and 23 are separated from each other by the intervening vacant space or chamber 30, whereby the valve-sections are located at precisely that distance from each other which is rendered necessary by the location of the said ports of the valve-seat. Chamber 30 is vented by holes 31 to grooves 32, which are indicated by broken lines in Fig. 2, and are shown in cross-section in Fig. 3. These grooves extend the entire length of valve 20 along the opposite edges of the same, contiguous to the ledges 43, and communicate with the exhaust. This valve is provided with a valve-rod 33, reciprocating through a stuffing-box 34 in the wall of the valve-chest

15 in the usual manner. The pressure-plate is shown in Figs. 1 and 3, where it is indicated by the numeral 21. This plate contains one or more internal passages 35. (Shown in cross-section in Fig. 3 and indicated by dotted lines in Fig. 1.) These passages communicate by openings 36 and 37 with valve-ports 24 and 27, and are of sufficient capacity to convey the steam readily from chamber 2 to chamber 3. The pressure-plate is prevented from moving lengthwise with the valve by means of two pins 29, which are set fast in ledges 43, respectively, and which pass loosely through the pressure-plate, as shown in Fig. 3. A relief-plate 38 is set in the back of pressure-plate 21, and between these two plates is a star-spring 39, which is shown separately in Fig. 4, and which operates to hold the pressure-plate normally in pressing contact with ledges 43. The cavity in which spring 39 is set in the back of plate 21 is connected with valve-port 26 by a small passageway 40. The exhaust-passage leading from the valve-chest is indicated by the numeral 41.

It is necessary to note with particularity the purpose and construction of chamber 6. In engines of the general character of that which is here presented a difficulty has been experienced in securing smoothness of running, by reason of the fact that when such engine is running with minimum load only the steam in the high-pressure cylinder is expanded to so low a pressure, by reason of early cut-off, that when communication is opened between the two cylinders there is not sufficient pressure acting upon the differential area of the low-pressure piston to start the piston at that speed which is required by the speed of the engine. By reason of this fact the piston at the beginning of the stroke receives additional speed from the effort of the crank. To prevent this mischievous and irregular action, it is necessary that the movement of the piston should be accelerated, and that the backlash should, by such acceleration, be taken up as soon as the beginning of the stroke. It is also necessary that such acceleration should be effected by the steam-pressure directly, and not at all by the effort of the crank. Accordingly it is the prime object of this part of my invention to secure smoothness in the running of the engine with a minimum load by accelerating the speed of the piston at the commencement of the upward stroke by the action of the steam. In order to accomplish this object, it is necessary that the size of the vacuum-chamber 6, which is operatively variable with the position of the piston, should be calculated or otherwise predetermined with particular reference to the proposed speed at which the engine is to run, the proposed boiler-pressure which is to be supplied to the engine, and the minimum load of the engine, for if the vacuum-chamber is too large the specified object is not attained, and if it is too small the engine is obliged to do work in compressing in the chamber such steam as leaks into it, and this work is lost by the venting of the chamber at the completion of the stroke. The determination of the size of the vacuum-chamber in my described engine is governed by these principles, namely: that the size of the chamber varies inversely with the boiler-pressure when the minimum load and the proposed speed are constant, that the same varies inversely as the speed when the minimum load and the boiler-pressure are constant, that the same varies directly with the minimum load of the engine when the boiler-pressure and the speed are constant, and that the inverse and direct variations here stated are severally disproportionate. To calculate the size of the vacuum-chamber in accordance with these principles is less simple than to determine the same experimentally. The following method is practically sufficient to predetermine the necessary and proper size of this chamber in any given engine of the general character which is here presented, namely: first complete the engine in all other respects, leaving chamber 6 by supposition too small to produce the desired effects when the engine is run under the proposed conditions of speed and boiler-pressure with minimum load; then adjust the governor so as to run somewhat faster—say five per cent. faster—than such proposed speed; then run the engine so regulated under the normal pressure and with the minimum load and observe the result. If the engine under these conditions runs with slight pounding, chamber 6 is already of the capacity which is required by the principles of my invention; but if the engine runs quietly under these conditions the vacuum-chamber is too small, and if it runs with considerable pounding the vacuum-chamber is too large. Then if the chamber is too large or too small diminish or increase its capacity by estimate accordingly. Then repeat the described operation as many times as are necessary to bring the chamber to such size that the engine runs with little noise at the described increased speed. The engine will then run quietly at the proposed normal speed. By this method that size of chamber 6 which is necessary to the stillness of the engine in running is determined experimentally with reference to its minimum load, its normal speed, and the given boiler-pressure, in accordance with those principles of variation which are stated above. The same size of chamber 6 so determined will be found sufficient to equalize approximately the work which is done by two successive strokes of the piston, according to the mode of operation which is given below.

The remaining particulars of construction of the described engine are sufficiently obvious from the drawings, the familiar principles of engine construction, and the mode of operation, which remains to be described.

The mode of operation of the described engine is in general similar to that of other dou-

ble-acting compound engines. Each steam-chamber of the described cylinder receives and discharges steam in the usual manner. The steam, which is admitted from the boiler, enters the engine by passage 19, and thence passes through port 18 to valve-port 26, thence both immediately and through valve-port 25 to port 13, thence to cylinder-chamber 2, thence by the same port 13 to the valve-port 24, thence successively through opening 36, passages 35, and opening 37 to valve-port 27, thence both immediately and by valve-port 28 to port 14, thence immediately to cylinder-chamber 3, thence by the same port 14 to the valve-chest 15, and thence out by the exhaust-passage 41.

Among the particulars of operation should be noted the functions of vacuum-chamber 6. In engines of this general type it is found in practice that with a normal load the work which is done by the high-pressure cylinder is greater than that which is done by the low-pressure cylinder. To obviate such inequality is a peculiar function of chamber 6, which equalizes the work between the forward and backward strokes of the piston by resisting the movement of the piston in the direction which is indicated by the arrow in Fig. 1 and by aiding its movement in the opposite direction. When the piston has completed its stroke in the last-mentioned direction, grooves 7 are so far uncovered in chamber 3 that steam escapes through them if there is any excess of pressure in chamber 6. At the beginning of the stroke of the piston in the direction of the arrow the vent-grooves 7 are slightly uncovered, as just described; but with the continuance of that stroke the vent is closed, and the increasing annular space behind flange 42, being unsupplied with steam, operates as a vacuum, resisting the continuance of that stroke of the piston and assisting its return. A second function of this chamber is to produce the above-described acceleration of the piston at the commencement of its upward stroke in order that the engine may run quietly. These two functions of the vacuum-chamber 6 should be sharply distinguished from the function which has sometimes been performed by a vacuum-chamber in single-acting engines where such a chamber has been used for the purpose of preventing lost motion between the piston and its connections by maintaining in the piston during the return stroke a tendency to move in the direction of the forward stroke.

As already indicated, it is the function of the valve-chamber 30 to produce the necessary spatial separation of the coincidentally moving valve-sections 22 and 23. It is the function of the vent holes and grooves 31 and 32 in valve 20 to permit steam, which would otherwise accumulate in chamber 30 by leakage, to escape into the exhaust portion of valve-chest 15 and thus to prevent the pressure-plate from being disturbed by any pressure in chamber 30.

By means of the described construction and mode of operation of this engine the steam distribution is effected by a single valve, and the work, which is done by the forward and backward strokes of the piston, is approximately equalized and in other respects the structure of the engine is simplified and its practical efficiency is increased.

Such being the construction, operation, and practical advantages of my improved engine, I claim as my invention and desire to secure by Letters Patent—

1. In a compound engine, a steam-cylinder, comprising two steam-chambers, whose axes are in one and the same straight line, and whose diameters are unequal, and provided with an annular vacuum-chamber, which is formed between the walls of the steam-chambers respectively, is vented solely into the larger of said chambers, and constitutes an integral part of said cylinder, substantially as and for the purpose specified.

2. In a double-acting compound engine, two steam-chambers, whose axes are in one and the same straight line, and whose diameters are unequal, and a single piston, having two heads, of unequal areas, working in said steam-chambers respectively, in combination with an annular vacuum-chamber, which is closed against all admission of steam, except leakage, and is provided with means of discharging the leakage, substantially as and for the purpose specified.

3. In a compound engine, a single steam-cylinder, comprising two steam-chambers, whose axes are in one and the same straight line, and whose diameters are unequal, and provided with an annular vacuum-chamber, which is formed between the walls of said chambers, and communicates solely with the larger of said chambers, in combination with a single piston, having two heads, which are of unequal areas, and are exposed to steam-pressure in opposite directions respectively, substantially as and for the purpose specified.

4. In a compound engine, a single steam-cylinder, comprising two steam-chambers, whose axes are in one and the same straight line, and whose diameters are unequal, and provided with an annular vacuum-chamber, having vent-grooves, in combination with a single piston, having two heads and a peripheral flange, substantially as and for the purpose specified.

5. In a compound engine, a single steam-cylinder, comprising two steam-chambers, whose axes are in one and the same straight line, and whose diameters are unequal, and provided with an annular vacuum-chamber, which is formed between the walls of said steam-chambers, and is vented to the larger of said chambers, in combination with a single piston, having two heads, which are of unequal areas, and are exposed to steam-pressure in opposite directions respectively, one of said heads being provided with a peripheral flange, which is fitted to enter said vacu-

um-chamber, substantially as and for the purpose specified.

6. In a compound engine, a balanced flat valve, comprising two complete valve-sections, which are united in one piece, and are spatially separated from each other by an intermediate valve-chamber, which is provided with vent-holes 31 and edge grooves 32, substantially as and for the purpose specified.

7. A balanced flat valve, comprising two coincidently-moving valve-sections, which are separated from each other by an intervening chamber, provided with one or more vent-holes 31, and with one or more edge grooves 32, in combination with a pressure-plate, and a flat valve-seat, which is provided with parallel ledges 43, located along the opposite edges of the valve, substantially as and for the purpose specified.

8. In a compound engine, a balanced flat valve, having edge grooves 32 and a spatial chamber 30, which is vented to said grooves, in combination with a flat valve-seat having raised ledges at either edge of the valve, substantially as and for the purpose specified.

9. A cylinder, having two terminal steam-chambers, a pressure-plate, and a valve-seat, having ports for each of said chambers, in combination with a balanced flat valve, comprising two valve-sections and a vented chamber between said sections substantially as and for the purpose specified.

10. In a compound engine, a valve-seat, and a valve, which comprises two valve-sections, in combination with a pressure-plate, which has an internal steam-passage from one valve-section to the other, substantially as and for the purpose specified.

11. In a compound engine, a steam-cylinder, comprising two steam-chambers, whose axes are in one and the same straight line, and whose diameters are unequal, and provided with a vented annular vacuum-chamber, in combination with a piston, having two heads, which are exposed to steam-pressure in opposite directions, substantially as and for the purpose specified.

12. In a compound engine, a steam-cylinder, comprising two steam-chambers, whose axes are in one and the same straight line, and whose diameters are unequal, one of said steam-chambers being partly within a cylindrical extension of the other, so that an annular vacuum-chamber is formed around the inward end of the smaller steam-chamber, in combination with a piston, having two heads, which are of unequal areas, and are exposed to steam-pressure in opposite directions respectively, substantially as and for the purpose specified.

13. In a compound engine, two steam-chambers, whose axes are in one and the same straight line, and whose diameters are unequal, and a single piston, having two heads, of unequal areas, working in said steam-chambers respectively, in combination with an annular vacuum-chamber, which is provided with means of venting the same intermittently, substantially as and for the purpose specified.

In testimony whereof I hereunto set my name in the presence of two witnesses.

RICHARD H. MATHER.

Witnesses:

WILLARD EDDY,

JOHN H. WHITE.