No. 892,790.

PATENTED JULY 7, 1908.

J. A. WILLIAMS.

COMPOUND EXPLOSIVE ENGINE.

APPLICATION FILED JUNE 7, 1905.

2 SHEETS—SHEET 1.

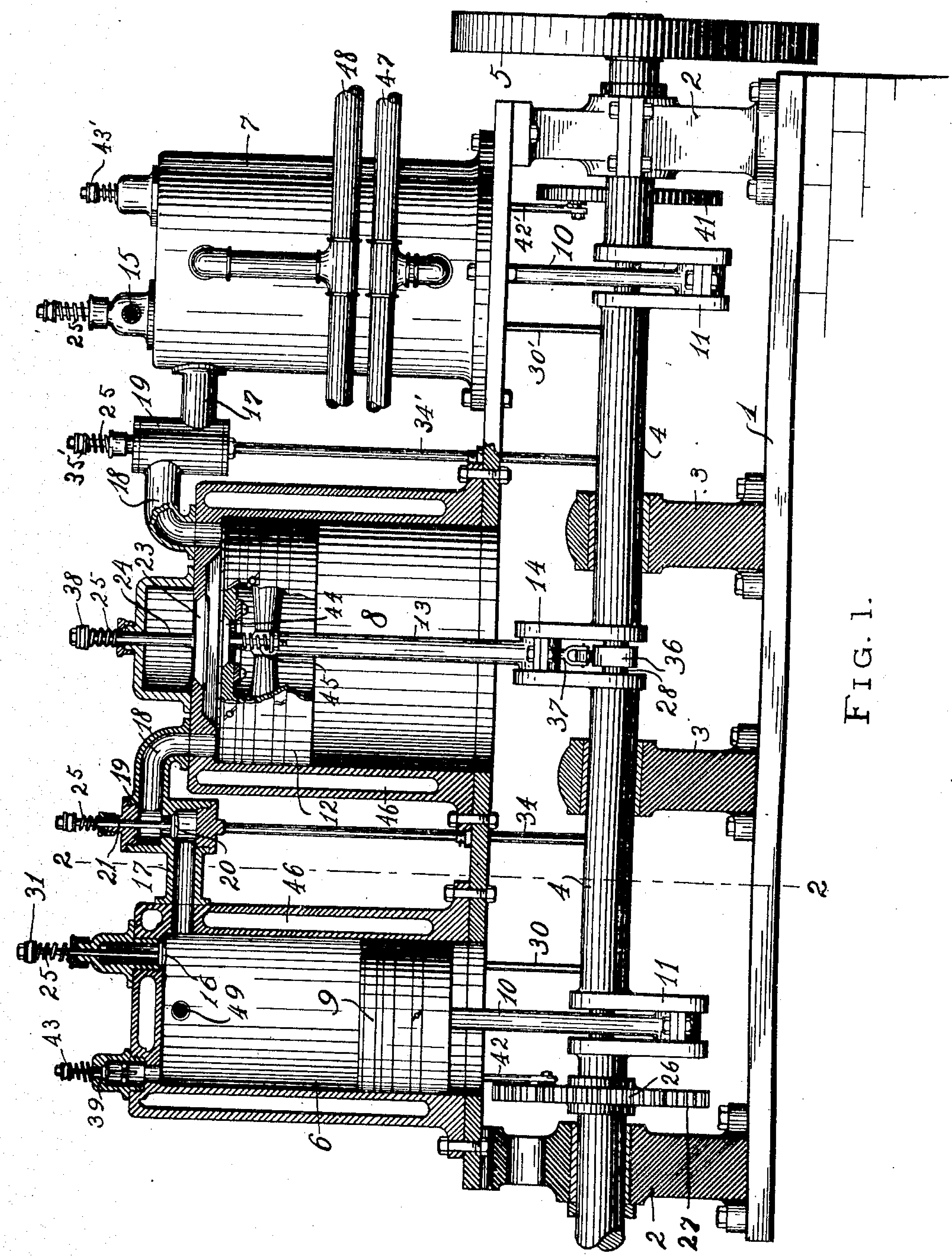


FIG. 1.

WITNESSES:

Brennan B. West.

C. McElroy.

Joseph A. Williams, INVENTOR.

BY

Foulo & Hull, ATTORNEYS.

No. 892,790. PATENTED JULY 7, 1908.

J. A. WILLIAMS.

COMPOUND EXPLOSIVE ENGINE.

APPLICATION FILED JUNE 7, 1905.

2 SHEETS—SHEET 2.

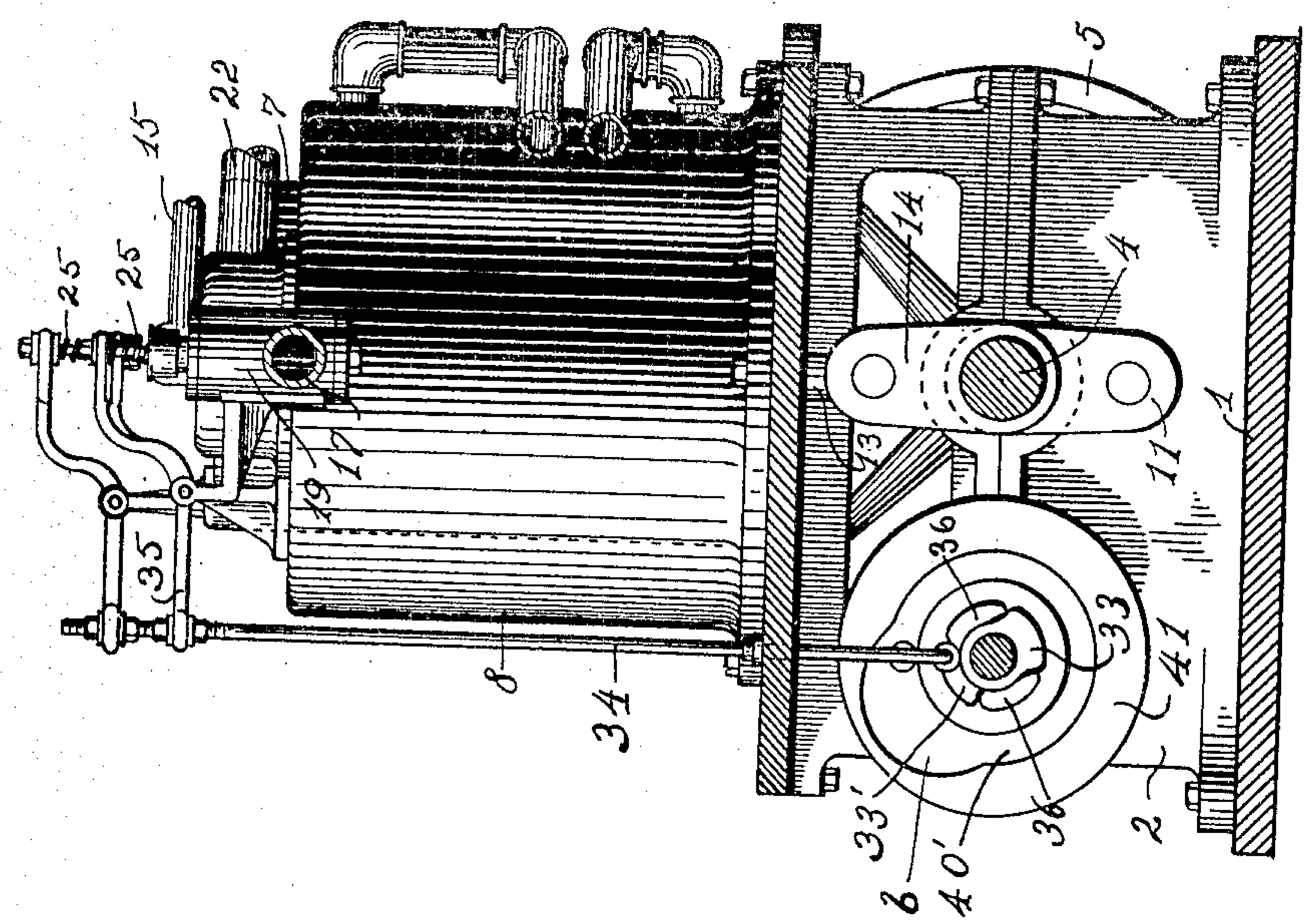

FIG. 3.

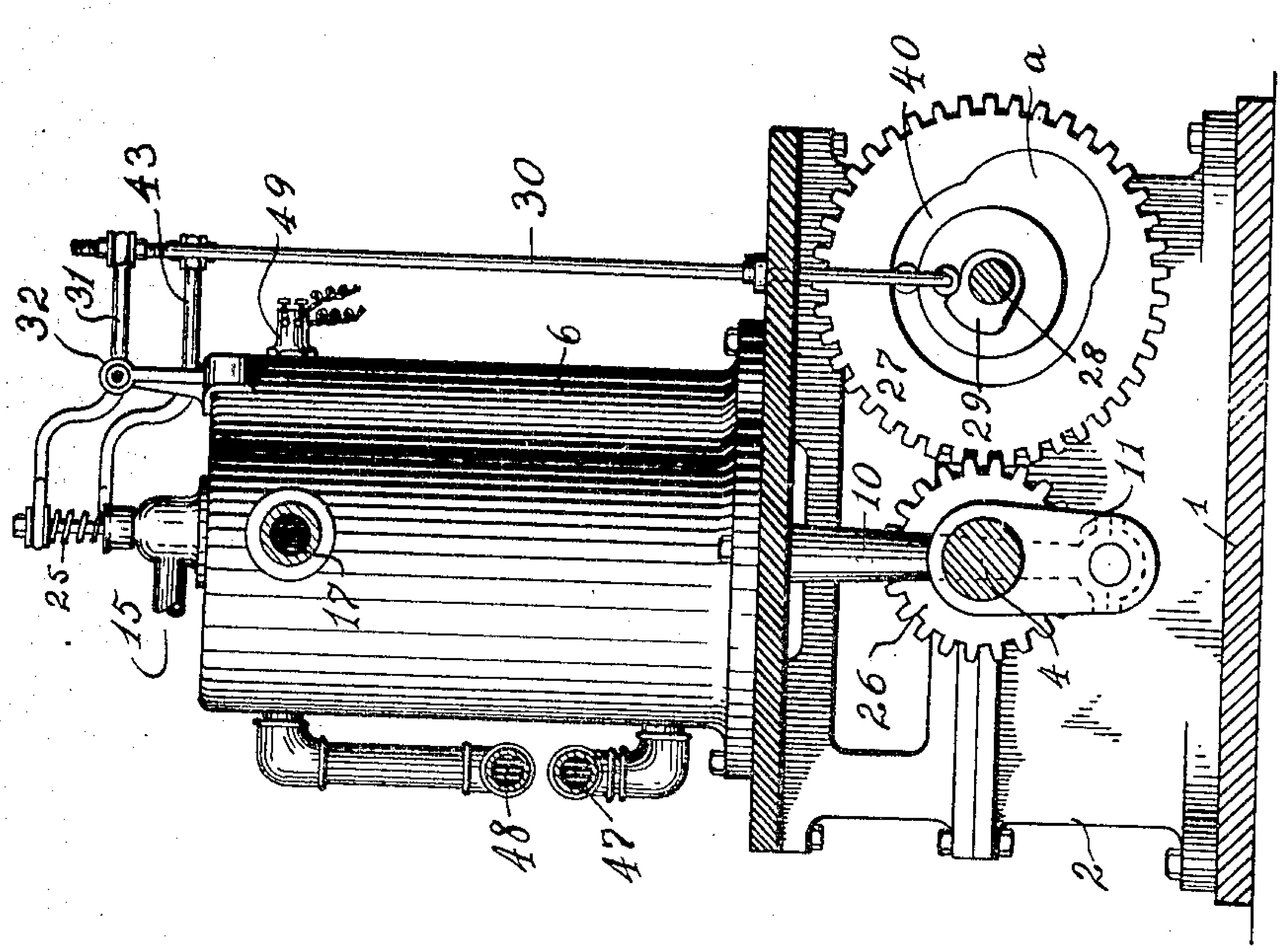

FIG. 2.

WITNESSES:

Brennan B. West.

C. McElroy.

Joseph A. Williams, INVENTOR.

BY

Fouts & Hull, ATTORNEY.

# UNITED STATES PATENT OFFICE.

JOSEPH A. WILLIAMS, OF CLEVELAND, OHIO.

## COMPOUND EXPLOSIVE-ENGINE.

**No. 892,790.** Specification of Letters Patent. Patented July 7, 1908.

Application filed June 7, 1905. Serial No. 264,035.

*To all whom it may concern:*

Be it known that I, JOSEPH A. WILLIAMS, residing at Cleveland, in the county of Cuyahoga and State of Ohio, have invented a certain new and useful Improvement in Compound Explosive-Engines, of which the following is a full, clear, and exact description, reference being had to the accompanying drawings.

My invention relates to compound explosive engines of the four-cycle type, and has particular reference to means for scavenging the high-pressure cylinders by means of air which is drawn through said cylinders by suction produced by the advance movement of the piston in the low pressure cylinder. Various details of construction by which the above stated operation is effected are also employed, which details will be hereinafter set forth in the specification, and particularly pointed out in the claims.

In the accompanying drawings forming part of this application:—Figure 1 is a view partly in section and partly in elevation of a compound explosive engine provided with my invention, one of the high pressure cylinders and the low pressure cylinder being shown in section; Fig. 2 is a sectional view taken on the line 2—2 of Fig. 1 and looking toward the left; and Fig. 3 is a similar view taken on the line 2—2 and looking toward the right.

In compound explosive engines, the quantity of the explosive mixture employed, and also the richness thereof, varies with the condition of service. When a large quantity of normal mixture is used in the ordinary engine of this type, the exhaust from the low-pressure cylinder is at a comparatively high pressure, which represents a considerable waste and loss in efficiency. Or, if the engine be so designed that the exhaust under the conditions stated is at a low pressure, then, when a smaller quantity of mixture, or a more dilute mixture, is employed, the final exhaust will be below atmospheric pressure; and a consequent loss of efficiency results due to a back pressure upon the low pressure piston. Also, the ordinary compound explosive engine is non-scavenging, a portion of the burned gases remaining in the cylinder after the completion of the exhaust stroke of the engine; and, when the quantity of mixture used is small, these burned gases dilute the explosive mixture and, in extreme cases, may so weaken it as to prevent explosion altogether.

In the engine shown in this application I have provided means for scavenging the high-pressure cylinders and for relieving or supplying the vacuum which the low-pressure cylinder tends to create, by placing upon the high-pressure cylinders inlet air valves, which admit air to these cylinders whenever the pressure therein falls materially below the atmosphere. In case a comparatively small amount of the explosive mixture or dilute mixture is employed, the pressure during the exhaust from the high pressure cylinders will quickly be reduced below the atmosphere, and, consequently, a large amount of air must be supplied. As the low-pressure piston will move very rapidly, it will not be possible in all cases for the necessary air to enter through the air valves on the high pressure cylinders; and, to prevent back pressure under these conditions, I also provide an auxiliary air valve in the low pressure piston.

Referring now to the drawings, in which similar reference characters designate corresponding parts throughout the several views, 1 represents the base plate of the engine, upon which are mounted at its opposite ends the frame pieces 2, and near the center, the pillow blocks 3. Journaled in said frames and pillow blocks is the main or crank shaft 4, upon one end of which is the ordinary fly-wheel 5.

Suitably supported upon the end frames are the cylinders of the engine, the high-pressure cylinders being represented at 6 and 7, and the low-pressure cylinder at 8, said low pressure cylinder being situated between the high-pressure cylinders. The high-pressure cylinders are provided with pistons 9, but one of these pistons being shown, said pistons being connected by rods 10 to cranks 11 on the shaft 4. Within the low-pressure cylinder is a piston 12, which is connected by a piston rod 13 with cranks 14, also upon the main shaft 4. The cranks 11 for the high-pressure cylinders extend from the main shaft in the same direction, while the cranks 14 extend in the opposite direction therefrom, or at an angle of 180 degrees from the cranks 11.

The explosive mixture is admitted to the high-pressure cylinders through the pipes 15, leading from a suitable carbureter, not shown, and through the valves 16, which valves are caused to open and close at appropriate times by means hereinafter described. From the high-pressure cylinders the exploded gases are exhausted through pipes 17 and 18 into the low-pressure cylinder 8. The pipes 17 and 18 are connected at their adjacent ends to valve casings 19, within which are mounted for reciprocation valves 20, said valves having upwardly extending stems 21, by which they can be operated at the proper time by means hereinafter described. From the low-pressure cylinder the gases are exhausted through a pipe 22, admission of the gases to said pipe being controlled by a valve 23, having an upwardly extending stem 24, the operation of said valve being controlled by means engaging with said stem, said means being hereinafter described. All of the valves hereinbefore referred to are normally maintained in closed position by means of springs 25 which surround the valve stems, and lift the same upwardly.

Keyed or otherwise secured to the main or crank shaft is a pinion 26 which meshes with a gear 27 on the cam shaft 28. The shaft 28 is journaled in the end frames of the engine, and is provided with a series of cams for controlling the operation of the various valves heretofore described. The gear 27 is provided with twice as many teeth as the pinion 26, so that the crank shaft 4 makes two rotations for a single rotation of the cam shaft.

The valve 16, which controls the admission of the explosive mixture to the cylinder 6, is operated by a cam 29 on the shaft 28, said cam being of the form shown in Fig. 2. This cam is adapted to lift a rod 30, which is properly guided in the frame of the engine, and is secured at its upper end to one end of a lever 31, said lever being pivoted at 32 and engaging at its opposite end with the stem of the valve 16. When the rod 30 is lifted, the valve stem will be pushed downwardly against the tension of its spring 25, and the valve will be thus opened. The exhaust valve 20 is similarly operated through the medium of a cam 33 on the cam shaft, said cam being adapted to lift a rod 34 that is connected at its upper end to a pivoted lever 35, said lever engaging the stem of the valve 21 to force it from its seat when the rod is lifted. The cam 33 is similar in shape to the cam 29, but it is placed at an angle of 90 degrees therefrom. The valve 23 is operated by the cam 36 on the shaft 28, said cam having two diametrically opposite lobes, said lobes extending from said shaft substantially in line with the cam 29. This cam serves to lift a rod 37, see Fig. 1, which rod is connected at its upper end to a pivoted lever 38 that engages with the stem 24 of the valve 23 in the same manner as the lever 31 engages its valve stem, as heretofore described. The valve within the casing 19 to the right is operated by a rod 34′ and a lever 35′, exactly like the rod 34 and lever 35 heretofore described, and by a cam 33′ like the cam 33, except that it is arranged 180 degrees about the shaft from the cam 33, so that the two exhaust valves 20 are lifted during different rotations of the crank shaft. Similarly, the inlet valve for the cylinder 7 is operated by a rod 30′, and by a cam 3, not shown, like the cam 29 except that it is also arranged 180 degrees about the shaft from the latter cam. By this arrangement, the inlet and the exhaust valves for one of the high-pressure cylinders are operated during that rotation of the crank shaft following the one when these corresponding valves for the other high-pressure cylinders are operated.

From the above description it will be understood that when the low-pressure piston 12 descends, the exploded mixture in one or the other of the high-pressure cylinders will be exhausted into the low-pressure cylinder. As the capacity of the low-pressure cylinder is much greater than that of either of the high-pressure cylinders the pressure in the latter falls during exhaust, and before the low-pressure piston has reached the end of its downward movement, the pressure has dropped below that of the atmosphere. When this occurs a valve 39 on one or the other of the high-pressure cylinders is opened, so that air is admitted into this cylinder at the latter part of its exhaust, said air passing through the cylinder that is exhausting and the pipes 17 and 18 into the low-pressure cylinder. This blast of air coming through the high pressure cylinders sweeps out all of the burned gases and also tends to cool the high pressure cylinders.

The valves 39 for the cylinders 6 and 7 are respectively controlled by cam grooves or races 40 and 40′ which are cut in the faces of the gear wheel 27 and the cam disk 41 respectively, said cam disk being mounted on the cam shaft. These valves are opened by the atmosphere, if permitted, when the pressure in their respective cylinders falls materially below atmospheric pressure. There will, of course, be no tendency for them to open during the compression or the explosion of the gases; but, in case a comparatively small amount of the mixture is admitted, the pressure in the cylinder may fall so far below that of the atmosphere as to open the valves 39, which would admit too much air during the intake and thus weaken the mixture. The valves are, therefore, held shut normally, and are only permitted to open during the period of exhaust from the high-pressure cylinders. For this purpose rollers on the ends of rods 42 and 42′ travel within the cam races 40 and 40′, said rods being connected to rocking levers 43. The cam races are concentric with the cam shaft throughout three quarters of their lengths, and this part of the race is only wide enough to permit their respective rollers to work freely therein. In the remaining quarter of the length of the grooves or races they are enlarged, as at *a* and *b*, so as to give the rollers freedom to lift. When the pressure in the cylinders falls materially below that of the atmosphere during the exhaust, the valves 39 may open to admit air, after which they are again held shut by the cam grooves until the next period of exhaust is reached.

When small charges of the explosive mixture are employed, the pressure in the cylinders 6 and 7 quickly falls below that of the atmosphere during exhaust, and there is danger of the production of a partial vacuum in these cylinders, which would diminish the efficiency of the engine. To provide against such contingency, I place a valve 44 in the piston 12 of the low pressure cylinder, said valve being held normally against its seat by a spring 45. In case the pressure above the piston should become too low during exhaust this valve 44 opens and admits air through the piston into the cylinder. At such time, the valve 23 which controls the exhaust from the low pressure cylinder may also open backwardly and permit the exhausted gases to return to the low pressure cylinder.

All of the cylinders of the engine are provided with water jackets 46 to prevent them from becoming too hot, the water being preferably supplied to said jackets through the pipes 47, and being conducted from the cylinders through the pipes 48.

At 49, see Fig. 2, is shown a sparking device by which the charges in the high pressure cylinders may be ignited. Any suitable form of device of this character can be adopted and it is not deemed necessary to show or describe the same any more fully.

The piston 9 in the cylinder 6 is shown at the end of its intake stroke, and compression of the gases is ready to begin. The cam 29 has just passed the end of the rod 30, and the valve 16 has closed. As the piston moves upwardly to compress the gases in the cylinder 6, the piston 12 in the cylinder 8 moves downwardly, said latter cylinder receiving the exploded gases from cylinder 7, which is now exhausting, its piston moving upwardly in unison with the piston in cylinder 6. Consequently, the valve 20 between cylinders 7 and 8 must be opened at substantially the same instant that valve 16 on cylinder 6 closes, and the cams 29 and 33′ must be so placed as to effect this operation. Following the compression stroke of the piston in cylinder 6 comes the explosion in this cylinder, which drives the pistons in the high-pressure cylinders downward, and causes the piston 12 to rise. As the latter starts upwardly the main exhaust valve 23 is opened by its cam 36, and, at the same instant, the intake valve 16 for cylinder 7 opens. The cams for operating these valves must therefore, be so arranged as to open the valves at substantially the instant the piston in cylinder 6 starts on its explosion stroke. Following this stroke comes the upward stroke of exhaust, at the beginning of which the valve 20, between cylinders 6 and 8, must be opened by its cam 33 to permit the exploded gases to pass into the latter cylinder, the piston in which is driven downwardly thereby. The cylinder 8 being of much greater capacity than cylinder 6, the pressure in the latter rapidly falls until it drops below that of the atmosphere, when the air valve 39 opens to scavenge and cool the cylinder 6, the enlargement *a* in the cam race 40 having reached the roller on the rod 42 so as to permit of this operation. While the exhaust in cylinder 6 is taking place, the mixture in cylinder 7 is being compressed. At the completion of the exhaust, the piston in cylinder 6 starts on its intake stroke, at which instant valves 20 and 39 communicating with said cylinder must be closed and the valve 16 opened. The enlargement *a* in the cam race 40, must, therefore, have passed the roller on the rod 42, and said roller must have entered the narrow and concentric part of the cam-race. Also, the cam 33 must have passed the rod 34, and the cam 29 must have opened the valve 16. During the intake for cylinder 6 the piston in cylinder 7 is driven downwardly by the explosion therein, while the piston 12 moves upwardly to drive out the gases from cylinder 8, the main exhaust valve 23 having again opened to permit this operation. At the end of the intake movement of the piston in cylinder 6, the engine has completed its cycle of operation.

Having thus described my invention what I claim as new and desire to secure by Letters-Patent is:—

1. In a compound explosive engine, a high-pressure cylinder, a valve connected with said high-pressure cylinder through which air may be admitted thereto during the exhaust from the said cylinder, means for preventing said valve from opening except during the exhaust from the high-pressure cylinder, and a second valve through which the air is drawn from the cylinder, said air scavenging and cooling the cylinder.

2. In a compound explosive engine, a high-pressure cylinder, a low-pressure cylinder connected therewith, a valve connected with said high-pressure cylinder opposite the connections with the low-pressure cylinder through which air may be admitted into said cylinder during the exhaust therefrom, whereby the said cylinder is scavenged and cooled, a grooved cam, means for operating said cam, and connections from said cam to said valve whereby the latter is operated, the groove in the cam preventing the opening of

the valve except during the exhaust from the high-pressure cylinder.

3. In a compound explosive engine, a high-pressure cylinder, a low pressure cylinder, an exhaust passage for gases connecting said cylinders, a valve controlling said passage, means for opening said valve, a valve for admitting air into said high pressure cylinder whereby the latter is scavenged and cooled the latter valve being opposite the said passage, and means for preventing the said air valve from opening except when the valve in the exhaust passage is opened.

4. In a compound explosive engine, a high-pressure cylinder, a low-pressure cylinder, an exhaust passage for gases connecting said cylinders, a valve controlling said passage, means for opening said valve, a valve for admitting air into said high pressure cylinder whereby the latter is scavenged and cooled the latter valve being opposite the said passage, a driven cam, and means connecting said cam and air valve whereby the latter is operated, said cam being adapted to hold the air valve closed except when the valve in the exhaust passage is opened.

5. In a compound explosive engine, a high-pressure cylinder, a low-pressure cylinder, an exhaust passage for gases connecting said cylinders, a valve controlling said passage, means for opening said valve, a valve for admitting air into the high-pressure cylinder whereby the said cylinder is scavenged and cooled, a grooved cam, and connections between the groove in the cam and the air valve for operating said valve, said groove being adapted to hold the air valve closed except during the exhaust from the high-pressure cylinder.

6. In a compound explosive engine, a plurality of high-pressure cylinders, a low-pressure cylinder, and passageways between each of said high-pressure cylinders and the low-pressure cylinder through which the exhaust from the high-pressure cylinders into the low-pressure cylinder may take place, valves controlling the said passages, valves for admitting air into the respective high-pressure cylinders at points opposite their respective passageways during the exhausts therefrom, whereby the high-pressure cylinders are scavenged and cooled, mechanism for alternately opening the valves in the said passageways, and cams for controlling the air valves, said cams being adapted to hold the valves closed except during the exhausts from their respective high-pressure cylinders.

7. In a compound explosive engine, a high-pressure cylinder, a low-pressure cylinder connected therewith, the low-pressure cylinder being of so much greater capacity than the high-pressure cylinder that the suction therefrom reduces the pressure in the high-pressure cylinder below that of the atmosphere, a valve connected with the high-pressure cylinder opposite its connection with the low-pressure cylinder for admitting air to said high pressure cylinder during its exhaust, whereby said cylinder is scavenged and cooled, and means for preventing said valve from opening except during the exhaust from the high-pressure cylinder.

8. In a compound explosive engine, a plurality of high-pressure cylinders, a low-pressure cylinder connections between the low-pressure cylinder and each of the high-pressure cylinders, the low-pressure cylinder being of so much greater capacity than either of the high-pressure cylinders that the suction from the low-pressure cylinder reduces the pressure in the high-pressure cylinder that is exhausting below that of the atmosphere, valves connected with each of the high-pressure cylinders at points opposite their respective connections with the low pressure cylinder, said valve being adapted to open by air pressure when the pressure in their respective high-pressure cylinders has fallen below the atmosphere, whereby said cylinders are scavenged and cooled during exhaust, and means to prevent said air valves from opening except during the exhaust from their respective high-pressure cylinders.

9. In a compound explosive engine, a high-pressure cylinder, a low-pressure cylinder connected therewith into which the high-pressure cylinder is adapted to exhaust, said low-pressure cylinder being of such a capacity that the gases within said cylinders during exhaust falls below that of the atmosphere, a piston in said cylinders, a valve connected with the high-pressure cylinder through which air may be admitted to said cylinder when the pressure thus falls to scavenge and cool the cylinder, and a relief valve in the piston of the low-pressure cylinder that is adapted to open by air pressure to prevent excessive back pressure on said low-pressure piston.

10. In a compound explosive engine, a high-pressure cylinder, a low-pressure cylinder connected therewith into which the high-pressure cylinder is adapted to exhaust, said low-pressure cylinder being of such a capacity that the pressure of the gases within said cylinders during exhaust falls below that of the atmosphere, pistons in said cylinders, a valve connected with the high-pressure cylinder, through which air may be admitted to said cylinder when the pressure thus falls to scavenge and cool the cylinder, a cam, connections between said cam and the valve for holding the latter closed except during the exhaust from the high-pressure cylinder, and a relief valve in the piston of the low-pressure cylinder that is adapted to open by air pressure to prevent excessive back pressure on said low-pressure piston.

11. In a compound explosive engine, a high-pressure cylinder, a low-pressure cylinder connected therewith into which the high-

pressure cylinder is adapted to exhaust, said low-pressure cylinder being of such a capacity that the pressure of the gases within said cylinders during exhaust falls below that of the atmosphere, pistons in said cylinders, a valve connected with the high-pressure cylinder through which air may be admitted to said cylinder when the pressure thus falls to scavenge and cool the cylinder, a grooved cam, connections between the groove of said cam and the said valve for controlling the latter, the groove in the cam being adapted to hold the valve closed except during the exhaust from the high-pressure cylinder, and a relief valve in the piston of the low-pressure cylinder that is adapted to open by air pressure to prevent excessive back pressure on said low-pressure cylinder.

12. In a compound explosive engine, a plurality of high-pressure cylinders, a low-pressure cylinder connected with each of said high-pressure cylinders into which the high-pressure cylinders are adapted to exhaust, said low-pressure cylinder being of so much greater capacity than either of the high-pressure cylinders that the pressure of the gases within the exhausting cylinder and the low-pressure cylinder falls below that of the atmosphere, pistons in all of said cylinders, valves connected with the high-pressure cylinders during the exhaust to scavenge and cool the exhausting cylinder, and a relief valve in the piston of the low-pressure cylinder that is adapted to open by air pressure to prevent excessive back pressure on the piston.

13. In a combined explosive engine, a high pressure cylinder connected thereto, a crank shaft, a valve for admitting air to said high pressure cylinder during the exhaust from the high pressure cylinder into the low pressure cylinder, and means controlled by the crank shaft for preventing said valve from opening except during the exhaust from the high pressure cylinder.

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

JOSEPH A. WILLIAMS.

Witnesses:
S. E. FOUTS,
B. W. BROCKETT.