W. J. WRIGHT.

EXPLOSIVE ENGINE.

APPLICATION FILED FEB. 7, 1906. RENEWED FEB. 27, 1911.

1,006,168. **Patented Oct. 17, 1911**

4 SHEETS—SHEET 1.

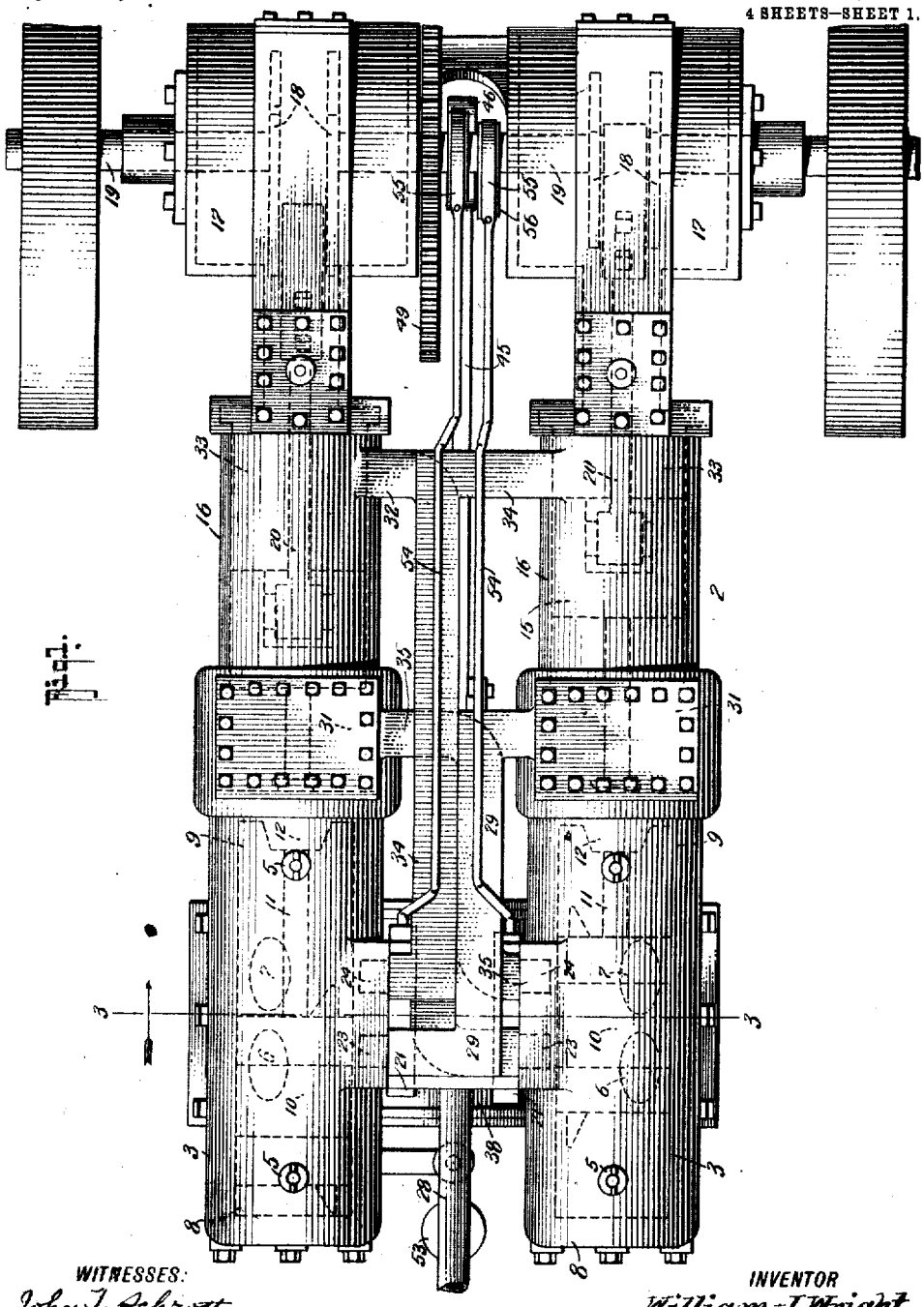

Fig. 1.

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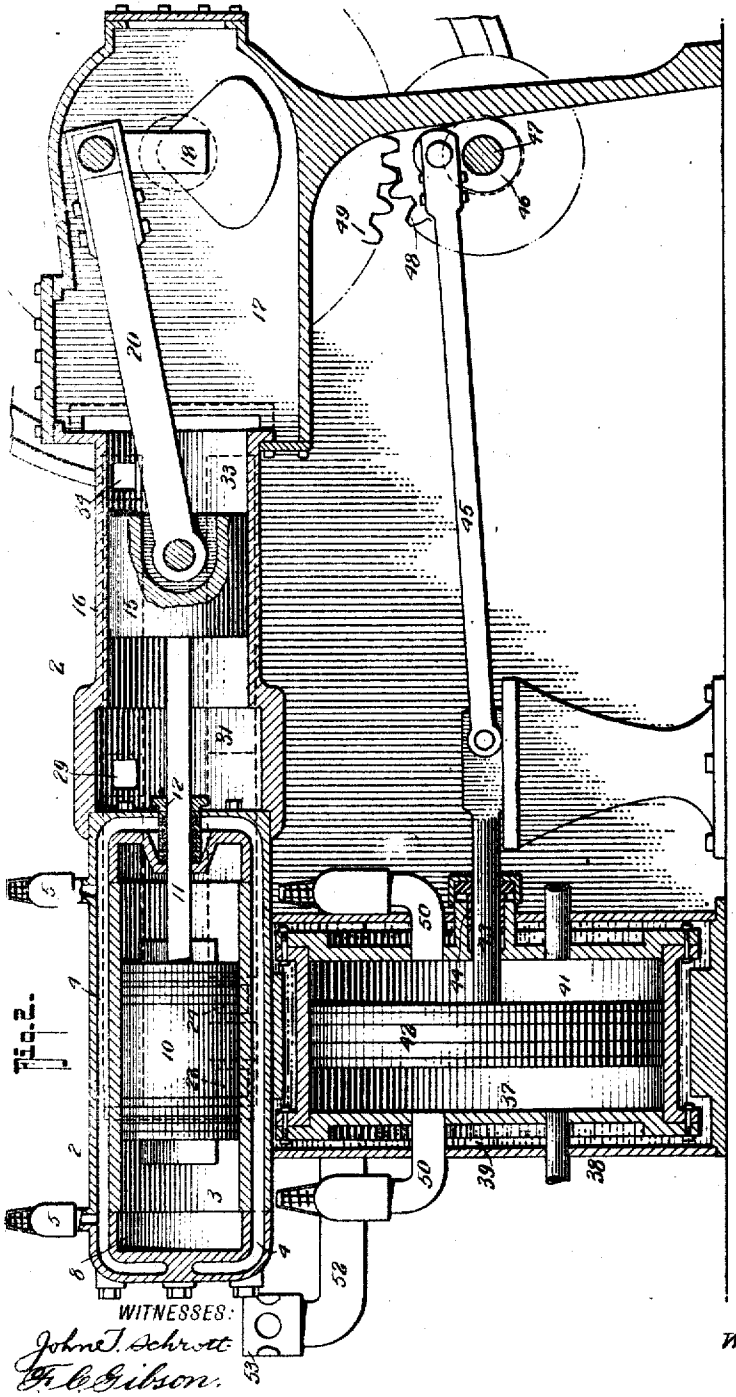

Fig. 2.

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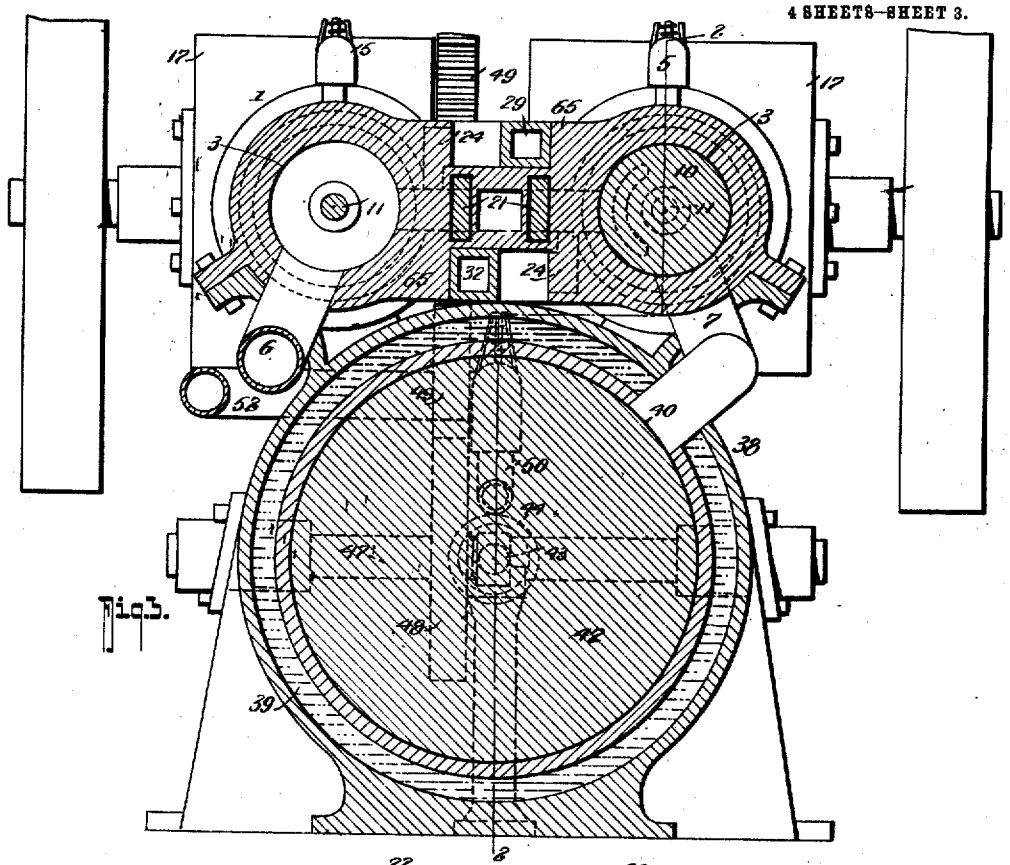

Fig. 3.

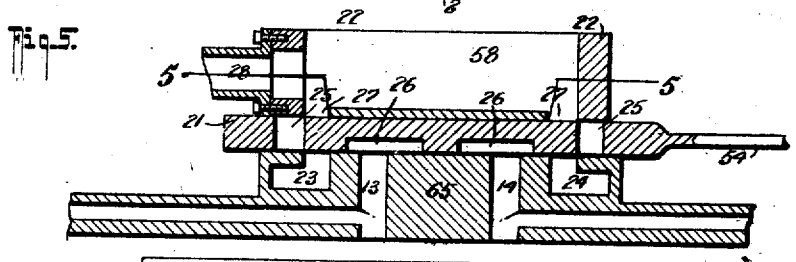

Fig. 5.

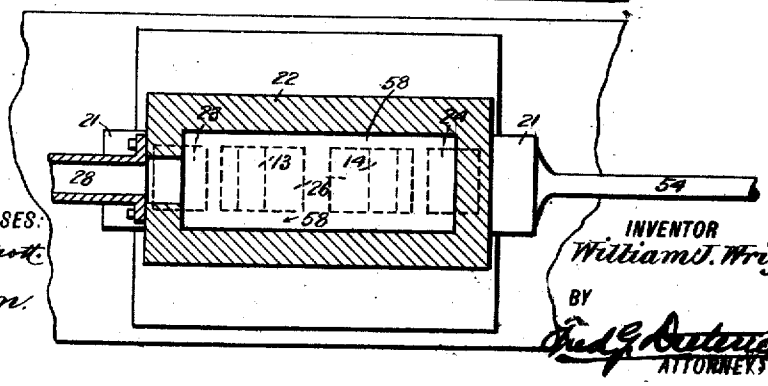

Fig. 6.

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4 SHEETS—SHEET 4.

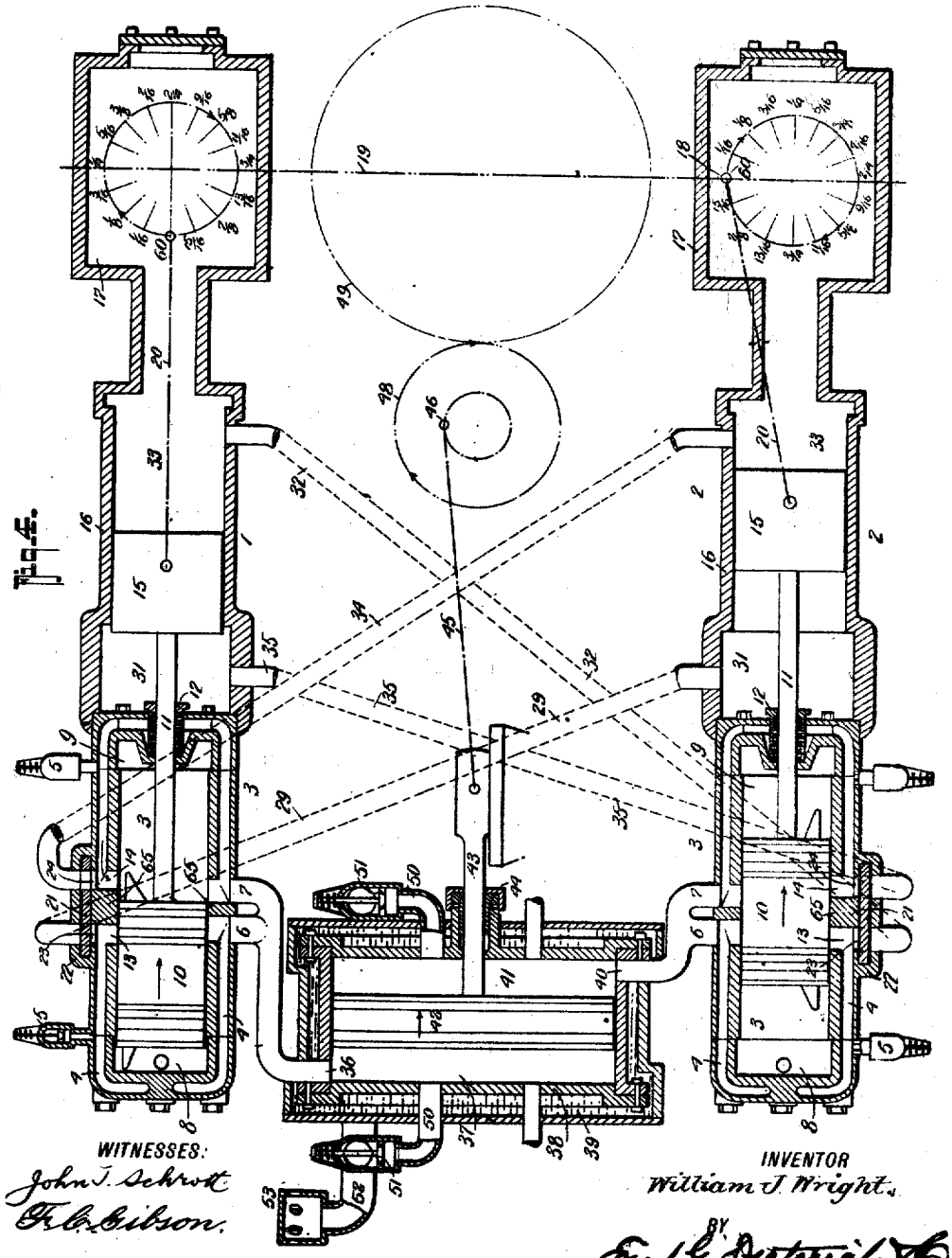

Fig. 4.

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EXPLOSIVE-ENGINE.

1,006,168. Specification of Letters Patent. Patented Oct. 17, 1911.

Application filed February 7, 1906, Serial No. 299,897. Renewed February 27, 1911. Serial No. 611,234.

To all whom it may concern:

Be it known that I, WILLIAM J. WRIGHT, residing at Franklin, in the county of Venango and State of Pennsylvania, have invented certain new and useful Improvements in Explosive-Engines, of which the following is a specification.

My invention relates to certain new and useful improvements in explosive engines of the compound type embodying a pair of double acting two cycle high pressure engines and a third engine operable by the partially spent charges from the double acting two cycle engines, and means for connecting the several ports of the engines together so that the pump of one of the double acting two cycle engines will cooperate with the working cylinders and pistons of the opposite double acting two cycle engine and vice versa.

With other objects in view than have heretofore been specified, the invention comprises certain novel construction, operation and arrangement of parts, all of which will be first described in detail and then be specifically pointed out in the appended claims, reference being had to the accompanying drawings, in which,

Figure 1, is a top plan view of my invention. Fig. 2, is a vertical longitudinal section thereof on the line 2—2 of Fig. 3. Fig. 3, is a vertical cross section on the line 3—3 of Fig. 1, looking in the direction of the arrow. Fig. 4, is a diagrammatic view of the engine. Fig. 5, is a detail view of one of the slide valves for controlling the working agent feed for the high pressure engines. Fig. 6, is a section on the line 5—5 of Fig. 5.

Referring now to the accompanying drawings in which like numerals and letters indicate like parts in all of the figures, the high pressure engines are designated respectively by 1 and 2, and as each of the high pressure engines is of the same construction, a detail description of one of such engines will suffice.

Each high pressure engine comprises a working cylinder 3 provided with a cooling jacket 4 for a purpose presently explained. The cooling jacket 4 is provided with relief valves 5 of any approved type, as the same *per se* form no part of my present invention.

Each working cylinder of the high pressure engines is provided with a pair of centrally disposed exhausts 6 and 7 serving to discharge the partially spent mixture from the ends 8 and 9 respectively of the working cylinder. These exhaust outlets 6 and 7 of the working cylinder are controlled by the high pressure piston 10 whose piston rod 11 passes through a suitable gland or stuffing box 12 and connects with the pump piston 15, hereinafter again referred to. The high pressure cylinder is also provided with a pair of centrally disposed working agent inlets 13 and 14 for the ends 8 and 9 respectively of the working cylinder. Each high pressure engine also includes a pumping cylinder 16 in which the pumping piston 15 operates and the cylinder 16 is in communication with the closed housing 17 forming a housing for the crank 18 on the drive shaft 19 to which the pitman rod 20 connects and the pitman rod 20 also connects with the pump piston 15, as shown.

Each high pressure cylinder has its inlet ports 13—14 controlled by a slide valve 21 shown in detail in Fig. 5, and the valve 21 operates in a suitable valve casing 22, as shown.

23—24 designate supplemental ports controlled by the valve 21, as shown. The valve 21 has a pair of ports 25—25 which register with the ports 23—24 respectively at times, and also register with the working agent inlet ports 27—27 respectively that are in communication with the source of working agent supply through the opening 28 in the valve casing. The valve 21 is also provided with ports 26 to open communication between the ports 23 and 13 and the ports 24 and 14 at times.

29 designates a cross pipe which connects with the port 23 of the valve that controls the inlet ports of the high pressure engine 1, connecting so as to communicate at times with the chamber 8 of the engine 1 and the pipe 29 has its other end connected with the chamber 31 of the pump cylinder 16 of the opposite high pressure engine 2, as shown. The port 23 of the high pressure engine 2 connects through a pipe 32 to the chamber 33 of the pump cylinder 16 of the high pressure engine 1 as shown, it being understood that the end 8 of the working cylinder of the engine 1 is charged by the chamber 31 of the pump cylinder 16 of the opposite engine 2, while the end 8 of the engine 2 is supplied from the chamber 33 of the engine 1, as shown. 34 designates another cross pipe which has one end in communication with the chamber 33 of the

pump cylinder 16 of the engine 2 and has its other end in communication with the port 24 of the slide valve controlling the engine 1 so that the chamber 9 of the engine 1 is supplied from the chamber 33 of the pump of the engine 2. 35 designates another cross pipe connecting at one end with the chamber 31 of the pump cylinder 16 of the engine 1 and is connected at its other end through the port 24 of the slide valve controlling the engine 2 with the end 9 of the working cylinder of the engine 2 so that the end 9 of the working cylinder of the engine 2 is supplied from the chamber 31 of the pump cylinder 16 of the engine 1 as shown.

The exhaust ports 6 and 7 of the engines 1 and 2 communicate with a port 36 in the end 37 of the low pressure cylinder 38, which is suitably water jacketed at 39, as shown. The exhaust ports 6 and 7 of the engine 2 communicate with the port 40 of the low pressure cylinder 38 at the end 41 thereof, the port 36 opening into one end of the low pressure cylinder, while the port 40 opens into the other end of the low pressure cylinder.

A low pressure piston 42 operates in the low pressure cylinder and has its piston rod 43 passing through a suitable stuffing box 44 and connecting with the pitman rod 45 that joins with the crank 46 on the shaft 47 that carries a gear 48 which meshes with a master gear 49 on the drive shaft 19 of the engine, the gears 49 and 48 being so arranged that the shaft 47 will revolve twice to every one revolution of the shaft 19.

50—50 designate a pair of exhausts communicating with each end of the low pressure cylinder 38 in which outlet valves 51 are connected and these valves 51 discharge into a common discharge pipe 52 which enters through the outlet head 53, to atmosphere.

In the practical arrangement of my invention, one of the high pressure engines, say the engine 2, is connected one-fourth revolution of the drive shaft in advance of the other high pressure engine 1, as shown diagrammatically in Fig. 4.

The valve 21 has a pair of elongated ports 26—26 which, during certain positions of the valve 21 open up communication between the ports 23 and 13 respectively and between the ports 14 and 24 at other times. The valve 21 connects with an operating rod 54 that extends toward the drive shaft 19 and is provided with a band 55 that passes over a cam 56 on the drive shaft 19, it being understood that the slide valve 21 of the engine 2 is set one-fourth ahead of that of the engine 1 to cause the proper co-relative operation to take place in a manner presently to be indicated.

From the foregoing description, taken in connection with the accompanying drawings it is thought the complete construction of the invention will be readily understood, and by reference to Figs. 4 and 5 of the drawings, the operation thereof can be best explained as follows: Assume the parts to be in the position shown in Fig. 4, the pistons 10 just having reached their position, and an explosion about to take place in the chamber 8 of the high pressure cylinder of the engine 1 to move its piston in the direction of the arrow and an explosion having already taken place in the chamber 8 of the high pressure cylinder of the piston 2, which is moving its piston 10 in the direction of the arrow. The partially spent mixture from the chamber 9 of the high pressure cylinder of the engine 1 has passed out through the port 7 of the engine 1 into the chamber 37 of the low pressure cylinder 38 and has moved the piston 42 to the position indicated in full lines in Fig. 4. As soon as the shaft 19 has rotated $\frac{1}{16}$ of a revolution until the point 60 is on the line $\frac{1}{16}$, the pump 15 of the engine 2 will begin forcing the charge from the chamber 33 of the pump of the engine 2 through the pipe 34 and port 14 into the chamber 9 of the high pressure cylinder of the engine 1 to take the place of the exploded mixture that has passed into the low pressure cylinder, the valve 21 opening up communication between the working agent inlet chamber 58 and the port 14 of the engine 1, and the port 14 of the engine 1 will remain in communication with the chamber 58 until the shaft 19 has rotated $\frac{3}{16}$ of a revolution from the starting position or until the point 60 has reached the line marked $\frac{3}{16}$. Just prior to the time the point 60 reaches the line marked $\frac{3}{16}$ in Fig. 4, the piston 10 in the high pressure cylinder of the engine 1 will have closed the port 7 as well as the port 14 of the engine 1. While the piston 10 of the engine 1 is moving from the position shown in full lines in Fig. 1, through the first quarter of its movement until the point 60 arrives on the line marked $\frac{1}{4}$, the piston 10 of the engine 2 will have completed its stroke in one direction and the charge from the chamber 33 of the pump of the engine 2 will have been forced into the chamber 9 of the engine 1. The piston 42 of the low pressure engine will also have completed its movement in the direction of the arrow and return to the position shown in Fig. 4 moving in the direction opposite to the direction of the arrow in Fig. 4, the low pressure piston 42 being moved from its extreme right hand position back to the position shown in Fig. 4, by the exploded mixture from the chamber 8 of the engine 2, which passes through the ports 6 and 40 into the low pressure cylinder as soon as the port 6 is opened up by the piston 10 of the engine 2. After the piston 10 of the engine 1 has covered its

ports 7 and 14, then the charge ahead of it will be compressed until the piston has reached the limit of its stroke in the direction of the arrow. As soon as this occurs an explosion takes place in the chamber 9 of the engine 1 and the piston 10 of the engine 1 is moved in the direction opposite to the arrow in Fig. 4. Now assume the parts to have moved through ¼ revolution of the shaft 19 until the points 60 are on the lines marked ¼, then the piston 10 of the engine 1 will be centrally located in its chamber, while the piston 10 of the engine 2 will be at the limit of its stroke in the direction of the arrow, and the charge from the chamber 33 of the engine 1 will be just about ready to be forced into the chamber 8 of the engine 2 to take the place of the exploded charge which has passed from such chamber 8 into the chamber 41 of the low pressure cylinder. As the parts continue their movement through $\frac{5}{16}$ of a revolution of the shaft 19 from the position shown in Fig. 4, then the valve 21 of the engine 2 will open up communication between the pipe 32 and the end 8 of the high pressure cylinder of the engine 2 and such valve will remain in a position to permit communication between the pipe 32 and the port 13 of the engine 2 through one more eighth revolution of the shaft 19 or in other words, until the shaft 19 has rotated $\frac{7}{16}$ revolution from the position shown in Fig. 4, or until the point 60 is on the line marked $\frac{7}{16}$ and just prior to the shaft 19 having completed $\frac{7}{16}$ of its revolution, the piston 10 of the engine 2 will have closed off the port 13 of its cylinder and the charge in the chamber 8 of the engine 2 will be compressing at the same time the charge of the chamber 9 of the engine 1 will have exploded and be forcing the piston 10 of the engine 1 in the direction opposite to that indicated by the arrow compressing a charge in the chamber 8 of the engine 1 ahead of the piston 10. After the parts have moved $\frac{9}{16}$ of a revolution of the shaft 19 from the position shown in Fig. 4, until the point 60 arrives on the line marked $\frac{9}{16}$, the pump piston 15 of the engine 1 will begin forcing the new charge from the chamber 31 of the engine 1 into the chamber 9 of the engine 2 prior to the ports 14 of the engine 2 being closed by the piston 10 as just mentioned. The piston 42 of the low pressure cylinder on its return movement in either direction after the piston 10 has cut off communication with the ports 6 and 7, forces the spent mixture from the chambers 37 and 41 respectively out through the outlets 50 and valves 51 and common discharge 52—53 to the atmosphere.

The valve 21 is so arranged that communication is effected between the chamber 58 of the valve in which the working agent is led from the source of supply, and the ports 23—24 at proper intervals, so that the pumping pistons 15 can draw in new charges of working agent into the respective chambers 31 and 33 after they have pumped out the prior charge into the working cylinder of the high pressure engines, as will be clearly understood by reference to diagrammatic Fig. 4, and the detail figure, Fig. 5.

From the foregoing, it will be seen that I first pump a working charge into one end of the high pressure cylinder of one of the high pressure engines by the pump connected with the other high pressure engine, then compress such mixture, then explode the same to operate the piston, then exhaust said exploded charge into the low pressure cylinder to expend its residual energy on the low pressure piston to move the low pressure piston and then exhaust said spent charge from the low pressure cylinder to the atmosphere, the same cycle of operations taking place at each end of each high pressure cylinder in regular order, as will be clearly understood by those skilled in the art to which this invention appertains.

By reference to the drawings, and particularly to Figs. 4 and 3, it will be noticed that the jacket 4 around the high pressure cylinders is divided centrally by a solid web 65 and each end of the jacket 4 is respectively in communication with the respective ports 13 and 14 so that when the new charge of working agent is pumped to the high pressure cylinder it will enter the jacket 4 at the respective end to which it is pumped and serve to cool the cylinder, the charge also entering the working chamber as also clearly understood by reference to the drawings.

To compensate for any explosions of the working agent within the jacket 4, I provide relief valve 5, before mentioned.

By the use of my engine, I am enabled to obtain 16 impulses during two complete revolutions of the main crank shaft from the three cylinders, while with the ordinary type of three cylinder four-cycle engine, as now on the market, only three impulses are obtained during two complete revolutions of the main crank shaft.

When I speak of a "one stroke cycle" engine, in this specification, I desire it understood that I mean an engine wherein an explosion occurs at each reciprocation or stroke of the piston.

From the foregoing description taken in connection with the accompanying drawings, it is thought the complete construction, operation and many advantages of my invention will be readily apparent to those skilled in the art to which it appertains.

What I claim is:—

1. In an apparatus of the class described, a pair of double acting two cycle high pressure explosive engines, pumps connected in tandem with each of said engines, connec-

tions between one of said pumps and a working cylinder of the opposite engine and vice versa, of a single low pressure engine operable by the exhaust from the cylinders of each of said high pressure engines, and means for controlling the admission of working agent to said engines.

2. A compound internal combustion engine comprising the combination with a pair of double acting two cycle high pressure engines and their pumps, of a double acting low pressure engine operable by the exhaust from the high pressure engines, substantially as shown and described.

3. In an internal combustion engine, two double acting two cycle high pressure engines, a single double acting low pressure engine, port connections between said engines, and means for controlling the admission and exhausting of working agent to said engines to obtain eight impulses during each revolution of the engine shaft, substantially as shown and described.

4. A compound engine comprising in combination with a pair of high pressure engines and a pair of pumps one operated by each high pressure engine, cross connections between the pump operated by one high pressure engine and the working cylinder of the other high pressure engine and vice versa, of a low pressure engine and means for operating said low pressure engine from the exhaust charge from the high pressure engines.

5. In a compound gas engine, the combination with a pair of high pressure engines and their pumps, of a low pressure engine operable by the exhaust charge of the high pressure engines, and means for feeding the working agent into the high pressure cylinders from the pump of the opposite engines, substantially as shown and described.

6. An engine of the class described, comprising in combination with a pair of high pressure cylinders and their pistons, of a low pressure cylinder and its piston, a pump connecting with each high pressure engine, means for admitting working agent into the pumps, and means for conveying the working agent from the pumps to the working cylinders of the opposite engines, piston controlled means for feeding the exhaust from the high pressure cylinders into the low pressure cylinder to operate the low pressure piston.

7. An engine of the class described, comprising in combination with a pair of high pressure cylinders and their pistons, of a low pressure cylinder and its piston, a pump connecting with each high pressure cylinder, means for admitting working agent into the pumps, and means for conveying the working agent from the pumps to the working cylinders of the opposite engines, piston controlled means for feeding the exhaust from the high pressure cylinders into the low pressure cylinder to operate the low pressure piston, and automatic valve devices for the high pressure cylinders for controlling the admission of the working agent into the high pressure cylinders and for controlling the admission of working agent into the pumps, substantially as shown and described.

8. In an engine of the class described, the combination with a pair of high pressure cylinders and their pistons, of a low pressure cylinder and its piston, said high pressure cylinders having piston controlled exhausts in communication with the low pressure cylinder and having valve controlled inlet ports, a pump connected with each of said high pressure cylinders, with its piston connected with the high pressure piston, means for admitting working agent into said pump and means for conveying the working agent from the pump to the valve controlled inlet ports of the high pressure cylinders.

9. In an engine of the class described, the combination with a pair of high pressure cylinders and their pistons, of a low pressure cylinder and its piston, said high pressure cylinders having piston controlled exhausts in communication with the low pressure cylinder and having valve controlled inlet ports, a pump connected with each of said high pressure cylinders, with its piston connected with the high pressure piston, means for admitting working agent into said pump and means for conveying the working agent from the pump to the valve controlled inlet ports of the high pressure cylinders, and a jacket surrounding said high pressure cylinders in communication with the inlet ports thereof to receive a fresh working agent to cool the cylinders, substantially as shown and described.

10. In an engine of the class described, the combination of a pair of high pressure cylinders and their pistons, of a low pressure cylinder and its piston, said high pressure cylinders having piston controlled exhausts in communication with the low pressure cylinder and having valve controlled inlet ports, a pump connected with each of said high pressure cylinders, with its piston connected with the high pressure piston, means for admitting working agent into said pump and means for conveying the working agent from the pump to the valve controlled inlet ports of the high pressure cylinders, a jacket surrounding said high pressure cylinders in communication with the inlet ports thereof to receive the fresh working agent to cool the cylinders and relief valves for said jackets, substantially as shown and described.

11. In an engine of the class described, the combination with a pair of high pres-

sure cylinders, and a high pressure piston operable in each of said cylinders, of a low pressure cylinder, a low pressure piston operable within said low pressure cylinder, said low pressure cylinder having valve controlled exhausts, said high pressure cylinder having outlets in communication with inlets of the high pressure cylinder, means for opening up communication between the high pressure cylinder and the low pressure cylinder to admit the exhausted charge from the high pressure cylinders into the low pressure cylinder to operate the low pressure piston, and means for admitting working agent into the high pressure cylinders to blow out the expanded mixture at times, and a crank shaft coöperatively connected with all of said pistons, substantially as shown and described.

12. In an engine of the class described, the combination with a pair of high pressure cylinders and their pistons, of a low pressure cylinder and its piston, said high pressure cylinders having piston controlled outlets in communication with inlets in the low pressure cylinder, said low pressure cylinder having valve controlled exhausts, of means for forcing working agent into said high pressure cylinders to force out the exploded mixture after the piston controlled outlets of the high pressure cylinders have been opened by the high pressure pistons and the exhausted charge has spent its energy on the high pressure piston, and a crank shaft coöperatively connected with all of said pistons, substantially as shown and described.

13. In a gas engine of the class described, a pair of high pressure cylinders, a pair of high pressure pistons operable within said high pressure cylinders, a low pressure cylinder, a low pressure piston operable within said low pressure cylinder, a crank shaft common to both of said high pressure pistons, a crank for operating said low pressure pistons and gear connections between said crank shaft and said low pressure piston crank to reciprocate the low pressure piston twice to every one reciprocation of each high pressure piston, means for forcing working agent into the high pressure cylinders, at times, and means for opening up communication between the high pressure cylinders and the low pressure cylinders at times, substantially as shown and described.

14. In a gas engine of the class described, a pair of high pressure cylinders, a pair of high pressure pistons operable within said high pressure cylinders, a low pressure cylinder, a low pressure piston operable within said low pressure cylinder, a crank shaft common to both of said high pressure pistons, a crank for operating said low pressure pistons and gear connections between said crank shaft and said low pressure piston crank to reciprocate the low pressure piston twice to every one reciprocation of each high pressure piston, means for forcing working agent into the high pressure cylinders at times, means for opening up communication between the high pressure cylinders and the low pressure cylinder at times, and prior to the admission of a new charge of working agent to the high pressure cylinders to permit the partially spent charge from the high pressure cylinders to expend itself on the low pressure piston substantially as shown and described.

15. An engine of the class described, comprising a pair of high pressure cylinders, high pressure pistons operable within said cylinders, a pump cylinder connected in tandem with each of said pistons, a pump piston operable in each of said pump cylinders and connected in tandem with the respective high pressure pistons, a crank shaft, a pitman connecting each of said pump pistons to said crank shaft, said high pressure cylinders having piston controlled exhaust ports and having inlet ports, one of said pump cylinders having communication with the inlet ports of the opposite high pressure cylinder, and the other pump cylinder having ports in communication with the inlet ports of the other high pressure cylinder, a valve for each of said high pressure cylinders, having provisions for controlling the communication between the pump and the high pressure cylinder and having provisions for controlling the communication between the pump and the source of working agent supply, a low pressure cylinder having ports in communication with the exhaust ports of the high pressure cylinders, and having valve controlled exhaust ports, a low pressure piston operable in said low pressure cylinder, said low pressure piston being coöperatively connected with said drive shaft, all being arranged substantially as shown and described.

16. An engine of the class described, comprising a pair of high pressure cylinders having piston controlled exhausts, of a high pressure piston operable within each of said high pressure cylinders, of a low pressure cylinder having inlet ports in communication with the exhaust ports of the high pressure cylinder, and having valve controlled exhaust ports, a low pressure piston operable within said low pressure cylinder, said high pressure cylinders having valve controlled inlet ports, a pump cylinder connected in tandem with each of said high pressure cylinders, a pump piston in each of said pump cylinders connected in tandem with each of said high pressure pistons, one of said pump cylinders having ports in communication with the inlet ports of the opposite high pressure cylinder and the other pump cylinder having communication with

the inlet ports of the other high pressure cylinder, a working agent inlet for each of said pumps, a valve for each of said high pressure cylinders for controlling the admission of working agent thereto, said valve being in communication with the source of working agent supply and having provisions in virtue of which the feed of working agent to the pump is controlled, a crank shaft, pitman connections between said crank shaft for each of said pump pistons, said low pressure piston being coöperatively connected with said crank shaft, all being arranged substantially as shown and described.

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