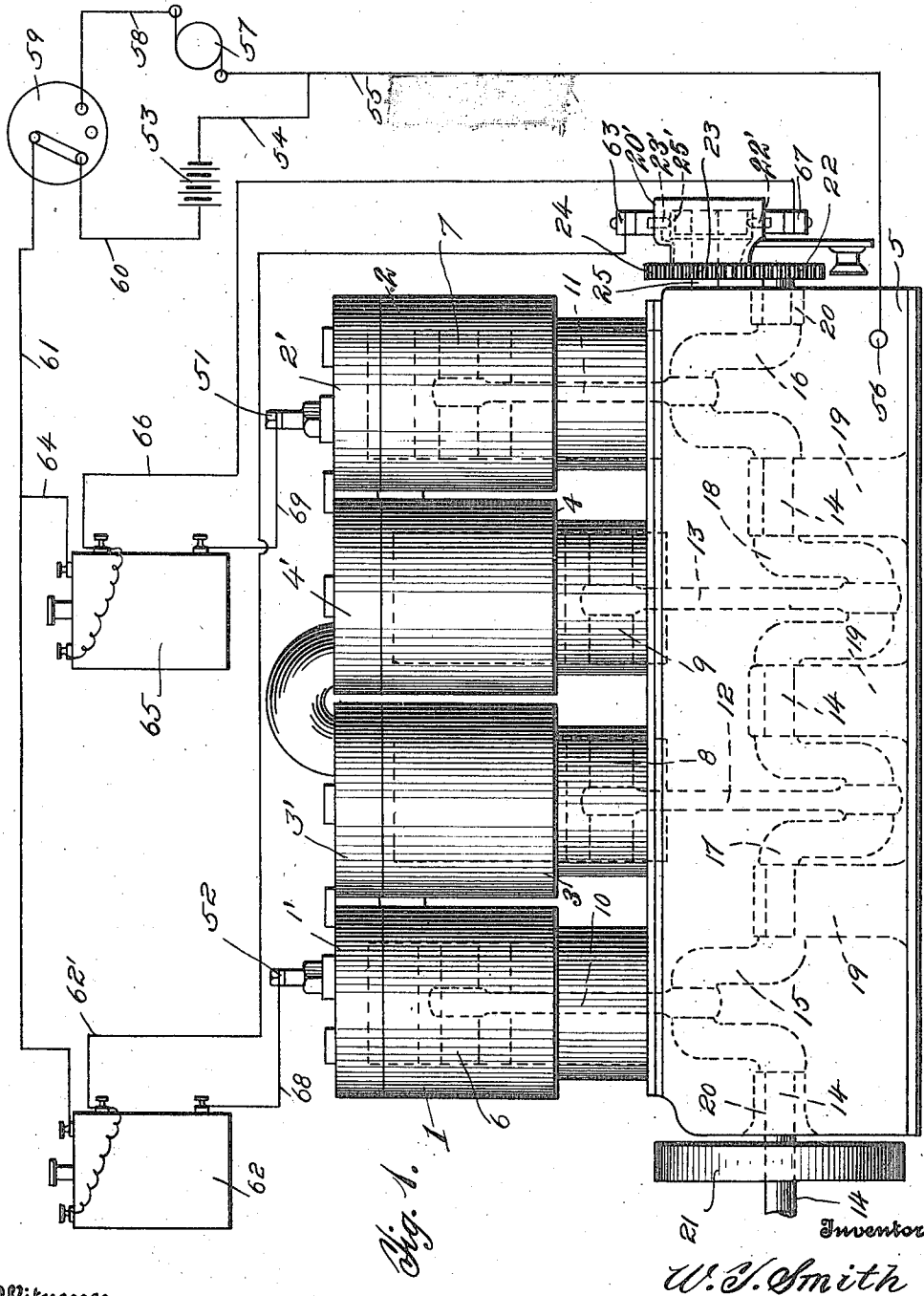


W. T. SMITH.
INTERNAL COMBUSTION ENGINE.
APPLICATION FILED JUNE 27, 1913.

1,152,386.

Patented Aug. 31, 1915.
3 SHEETS—SHEET 1.



Witnesses
M. P. McKee
R. Kirluck

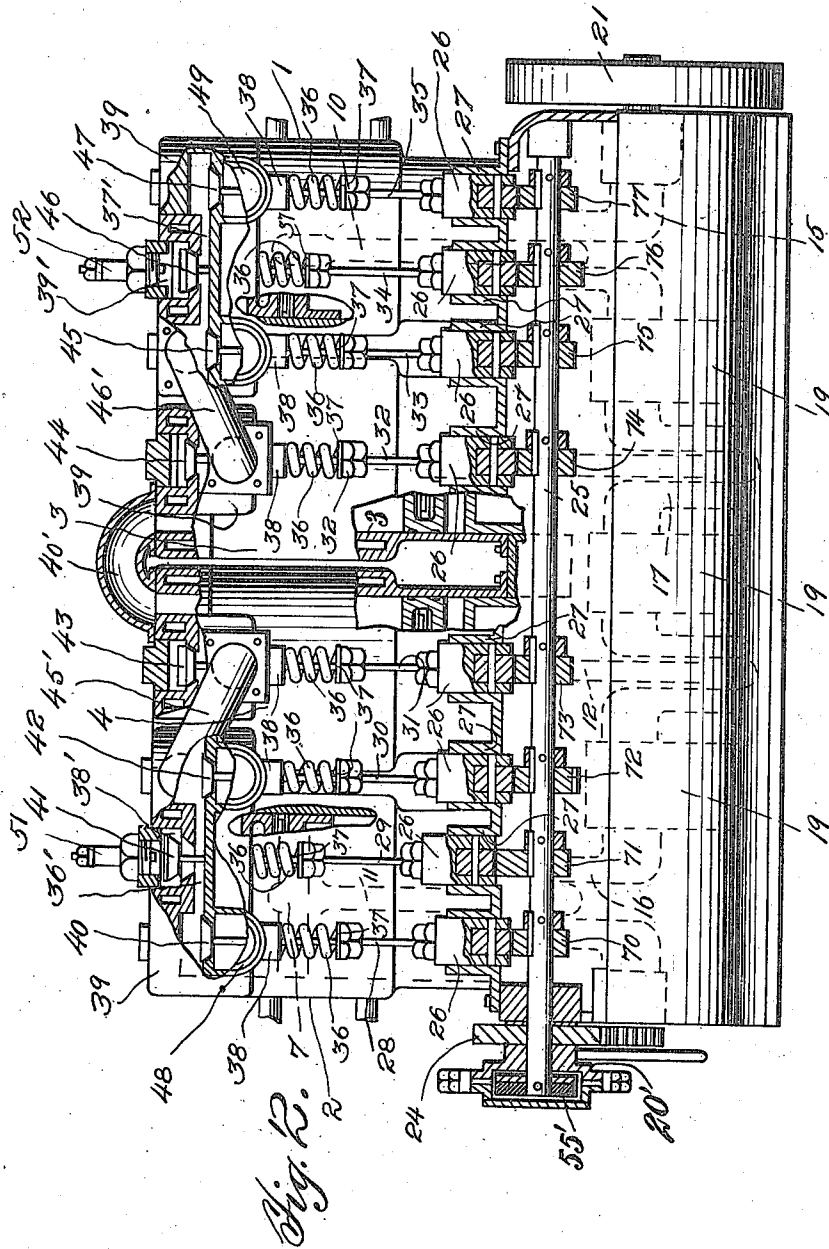
By Alex. J. Wedderburn, Jr.
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3 SHEETS—SHEET 2.



Witnesses

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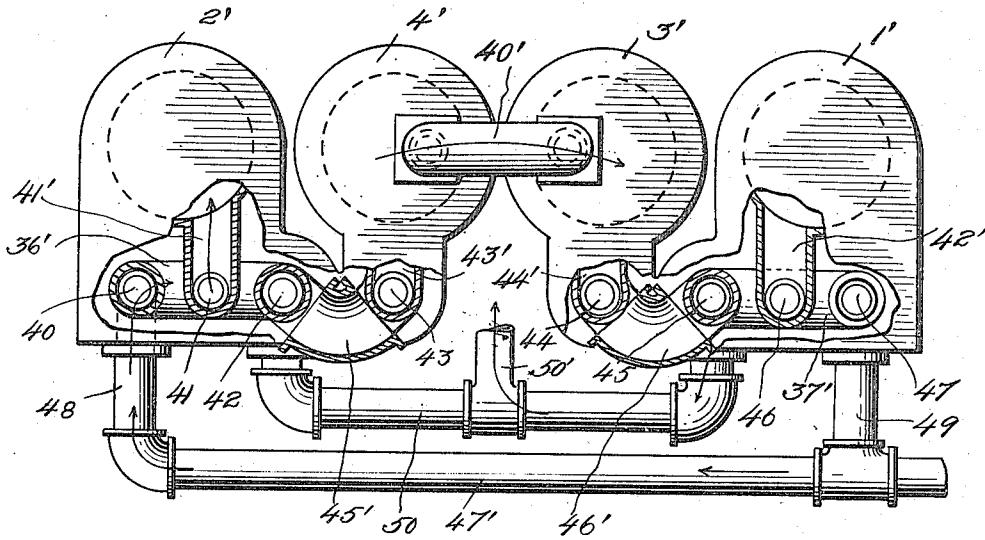


Fig. 3

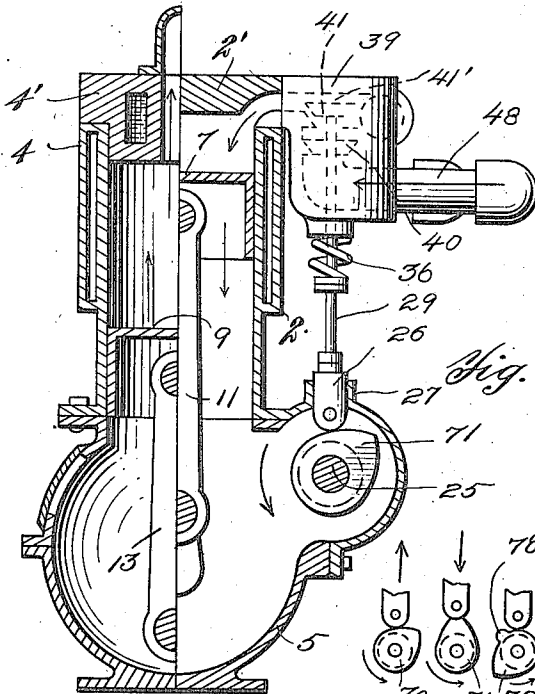
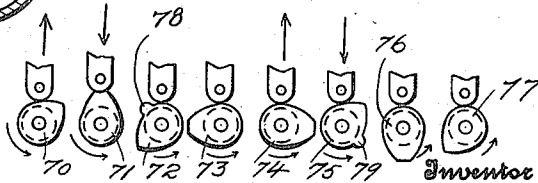


Fig. 4.



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UNITED STATES PATENT OFFICE.

WILLIAM T. SMITH, OF CINCINNATI, OHIO.

INTERNAL-COMBUSTION ENGINE.

1,152,386.

Specification of Letters Patent.

Patented Aug. 31, 1915.

Application filed June 27, 1913. Serial No. 776,164.

To all whom it may concern:

Be it known that I, WILLIAM T. SMITH, a citizen of the United States, residing at Lockland, Cincinnati, in the county of Hamilton and State of Ohio, have invented certain new and useful Improvements in Internal-Combustion Engines, of which the following is a specification.

This invention relates to improvements in internal combustion engines and is designed to increase the number of expansions of the products of combustion to insure greater economy by the use of more than two cylinders.

The primary object of my invention is to use the products of combustion of the explosive mixture to the fullest advantage by increasing the number of expansions thereof.

Another object of the invention relates to certain improvements in an engine of the character described of which certain of the strokes of certain pistons are more powerful than strokes of other of its pistons, so that the energy transmitted by the crank shaft will be as near as practical the same during each succeeding one half revolution of said crank shaft, so as to give a steady, powerful, and economical running of the engine.

For the purpose mentioned use is made of more than two cylinders in which reciprocate pistons, means for allowing some of the pistons to make longer strokes than others, means for conducting an explosive mixture into the high pressure cylinders, means for exploding the said mixture in the said cylinders, means for conducting the products of combustion into the low pressure cylinder or cylinders to use the said products of combustion expansively therein, means for exhausting the expanded products of combustion from the low pressure cylinder or cylinders to the atmosphere, and means for exhausting the products of combustion remaining in the clearance space or combustion chamber of the high pressure cylinders to the atmosphere just prior to admission of a new charge therein.

With the above and other objects in view my invention consists in the combination, arrangement, and details of construction disclosed in the drawings and specification, and then more specifically pointed out in the appended claims.

Referring to the drawings, wherein similar reference characters designate similar parts throughout the respective views, Figure

1 is a rear side elevation of an engine, constructed in accordance with my invention, and partly in diagram, Fig. 2 is a longitudinal front elevation of said engine, partly in section, Fig. 3 is a top plan view of said engine, partly broken away to disclose the passage of fluid into and from the cylinders of said engine, at one stage of operation, Fig. 4 is a vertical sectional elevation of the engine designed to show the relative positions of certain of the pistons, during the same stage of operation, and end views of each of the cams in their relative position to each other during said stage of operation.

Referring to the drawings which are merely illustrative of my invention an engine is shown provided with four cylinders, two high pressure cylinders and two low pressure cylinders. The high pressure cylinders are designated 1 and 2, and the low pressure cylinders are designated 3 and 4, all of which are mounted upon any support such as bed plate 5, and the other end of the cylinders 1, 2, 3 and 4 are closed by the cylinder heads 1', 2', 3' and 4' respectively. Pistons 6 and 7 slide in cylinders 1 and 2, and pistons 8 and 9 slide in cylinders 3 and 4. The connecting rods 10 and 11 are connected to pistons 6 and 7, and connecting rods 12 and 13 are connected to pistons 8 and 9. The crank shaft 14 is formed with four cranks, two cranks 15 and 16, connected to pistons 6 and 7, being preferably of a shorter stroke and disposed in a diametrically opposite direction with respect to cranks 17 and 18, connected to the pistons 8 and 9, so that while cranks 15 and 16 move down, cranks 17 and 18 will move up, cranks 15 and 16 are connected to connecting rods 10 and 11 while cranks 17 and 18 are connected to connecting rods 12 and 13, said crank shaft 14 being mounted in the standards 19 and brasses 20, carried by the bed plate 5. Exteriorly of said bed plate 5 and on one end of crank shaft 14 is mounted the fly-wheel 21, and at its other end is mounted a relatively small spur wheel 22, meshing with a spur wheel 23, which last-named wheel meshes with the larger spur wheel 24 mounted upon a cam shaft 25 extending longitudinally in bed plate 5. Mounted upon the cam shaft are eight cams arranged to operate suitable puppet valves at different times that control the flow and exhaust of the motive fluid. Each puppet valve op-

erates in the same way and is similarly mounted in position. Blocks 26, eight in number, are slidably mounted in the guides 27, and operated by said eight blocks 26 are the valve rods, 28, 29, 30, 31, 32, 33, 34, and 35, coiled around each of which is a spring 36 resting on a member 37 fixed on the rod. Suitable stops 38 are mounted upon the valve chests 39 of each of the cylinder heads 1', 2', 3', and 4' of the engine, against which said springs bear when they are pressed upward.

The valve rods extend into the valve chests as shown more clearly in Fig. 2, and valves 40, 41, 42, 43, 44, 45, 46, and 47 are mounted respectively upon rods 28, 29, 30, 31, 32, 33, 34, and 35. Valves 40, 42, 45 and 47 are seated substantially at the same level, and valves 41, 43, 44 and 46 are also disposed on the same level but are seated higher than valves 40, 42, 45 and 47. A fluid passageway 36' is formed at one end and another fluid passageway 37', at the other end of the engine structure, and opening respectively into passageways 36' and 37' are the mixing chambers 38' and 39', valves 41 and 46 controlling the access of fluid into said mixing chambers, and valves 40 and 42 are arranged to control the fluid in either end of passageway 36' while the valves 45 and 47 control the fluid in either end of passageway 37'. Communication is established between cylinders 3 and 4 by means of the pipe 40'. The mixing chamber 38' connects by a channel way 41' with cylinder 2 and mixing chamber 39' connects by a similar channel way 42' with cylinder 1. Valves 43 and 44 control the passage of fluid through channel ways 43' and 44' connecting respectively with cylinders 4 and 3, and communication between channel way 43' and passageway 36' is established by pipe 45', which as shown, is disposed obliquely, while a similarly disposed pipe 46' establishes communication between passageway 37' and channel way 44', when valve 43 in one case, and valve 44 in the other case, is in open position. A fluid supply pipe 47' connects by branch pipes 48 and 49 with the opposite valve chests 39, said branch pipes 48 and 49 opening into said valve chests at points below valves 40 and 47 respectively. A pipe 50 opens respectively into said valve chests at points below valves 42 and 45, and this pipe has a branch 50' opening into the atmosphere. The sparking plugs 51 and 52 are connected over the mixing chambers 38' and 39', and may be caused to ignite the combustible fluid by any suitable electrical device in use, and said ignition can be properly timed by means of any suitable moving part of the engine.

The wiring leading from a source of current supply or batteries 53 will now be described.

Wires 54 and 55 connect one of the poles of batteries 53 and a generator 57 respectively, with a binding post 56, the other poles of the batteries 53 and generator 57 are connected respectively with the wires 60 and 58 to separate contacts of a two point switch 59, the switch arm of switch 59 is adapted to connect either of wires 58 and 60 with wires 61 and 64 to one of the poles of primary coils in both boxes 62 and 65, the other poles of the primary coils are connected respectively, by wire 62' to binding post 63 and wire 66 to binding post 67, one of the poles of the secondary coil in box 62 is also connected to wire 62', while the other pole of same coil is connected by wire 68 to ignition device 52, the secondary coil in box 65 is similarly connected to wire 66 and wire 69 to ignition device 51.

The eight cams mounted upon the cam shaft 25 are designated respectively 70, 71, 72, 73, 74, 75, 76, and 77, and have bearing surfaces arranged to engage blocks 26 operating the valve rods 28, 29, 30, 31, 32, 33, 34, and 35 to alternately lift and depress said rods for the purpose of opening and closing the puppet valves. It is to be noticed, however, that cams 72 and 75 are formed with protuberances 78 and 79, respectively, which may be said to be neutral points because they are located between the surfaces of these cams and are adapted to gradually lift, and to gradually allow said valve to be depressed. The cams are heart-shaped in contour and are so timed in their action that they will operate the proper valves for the purpose of allowing the combustible fluid to enter the high pressure cylinders, or either the expanding fluid or the exhaust fluid to flow through the high pressure or low pressure cylinders respectively.

The engine will operate as follows, during one cycle of four strokes: It will of course be evident that cranks 15 and 16 will move together in one direction while cranks 17 and 18 are moving in an opposite direction. Figs. 1, 2, 3 and 4 show the moving and stationary parts of the engine in their relative positions at the starting of the first stroke of the cycle. It will be observed that the wires 54 and 55 are always in contact with the bed of the engine at 56, while at this time the electric current is flowing from contact 56 through the metal parts of the engine to the metal member 25' connected to the cam shaft 25, and held embedded in a disk of insulating material 55' also connected to said cam shaft. A spring pressed pin 23', held insulated on the upper end of a turntable shell 20', supported by the cam shaft 25, will be in contact with said metal member 25', which will cause a spark at the plug 52. When this takes place the previously drawn in and compressed charge of combustible fluid in cylinder 1 will be ig-

nited, causing piston 6 to move downward and moving piston 7 in the same direction, and pistons 8 and 9 in an opposite direction. This downward movement of piston 6 also causes the cam shaft 25 to rotate, which will cause the cams to move as shown to the right of Fig. 4, and cams 74 and 75 will cause valves 44 and 45 to open to allow the previously expanded products of combustion to pass out of cylinders 4 and 3, through pipe 40', channel way 44', pipe 46', pipe 50 and to the atmosphere through pipe 50'. This rotation of the cam shaft also causes cam 70 to start to open valve 40 to allow a fresh charge of the combustible fluid to be drawn into cylinders 2 through pipe 48, connected to pipe 47', leading to a source of supply of said combustible fluid. Valve 41 will be open at the time valve 40 is being opened, owing to the position of cam 71 which is allowing valve 41 to gradually close. When piston 6 has reached the end of its downward stroke the second stroke of the cycle will begin and the cams will have moved 90 degrees from the position in which they are shown in Fig. 4 while the cranks of the crank shaft will have assumed a position diametrically opposite to that shown in Fig. 1 moving the connecting rods and pistons in position to start on said second stroke. As the cam shaft 25 continues to rotate cam 76 will begin to open valve 46, allowing the products of combustion in cylinder 1 to pass out through channel 42', and passageway 37', through pipe 46' and channel 44', into cylinder 3, and a part of it through pipe 40' into cylinder 4, where it will continue to expand, forcing pistons 8 and 9 downward, and forcing pistons 6 and 7 upward, the turning of cam 74 allowing valve 44 to gradually close by the action of spring 36. During this stroke the previously drawn in charge of the combustible fluid is compressed in cylinder 2. Before the end of this second stroke, and before the pistons have reached the positions shown in Fig. 1 it becomes necessary to exhaust the expanding products of combustion remaining in the combustion zone of cylinder 1, directly to the atmosphere, so that a new charge of combustible fluid can be drawn into said cylinder 1 from the supply pipe 49. To enable this to be accomplished cam 74 is timed so that valve 44 will close before the pistons are in the positions shown in Fig. 1. Cam 75, by means of its protuberance 79 will cause valve 45 to start to open to connect the channel 42' and passageway 37', and pipes 50 and 50' with the atmosphere, and thereupon the exhaust fluid from the combustion zone of cylinder 1 may escape during the remainder of the stroke.

The moving parts of the engine except the gears 23 and 24, shaft 25 and contact member 25' will now be as indicated in Fig.

1, which also represents the beginning of the third stroke of the cycle and the gears, shaft and contact member mentioned have moved 180 degrees from the positions indicated in said Fig. 1, while the cams also have moved 180 degrees from the positions indicated on Fig. 4.

The metal contact member 25' will cause the third stroke of the cycle to take place, causing an induced electric current to make a spark at the spark plug 51, said member and said spark plug being connected to their respective terminals in coil-box 65, but this time the spring-pressed pin 22', held insulated on the bottom arm of the turnable shell at 67, will make contact with said metal contact member 25', said turnable shell being held in adjusted position, as shown in Fig. 1. The other spark plug 51 now having ignited the previously drawn in and compressed charge of combustible fluid in cylinder 2, pistons 6 and 7 will be forced downward, while pistons 8 and 9 will be mechanically forced up. While this is taking place cam 73 is about to open valve 43, while cam 72 is about to open valve 42, and thereupon channel 43' will connect with pipes 45', 50 and 50', thereby enabling the exhaust fluid to escape to the atmosphere from cylinders 3 and 4. While piston 6 is moving downward, cam 77 will be opening valve 47, while cam 76 will be allowing valve 46 to close by the action of the spring 36, and while valve 47 is open, a fresh charge of combustible fluid will be drawn into cylinder 1. When the pistons, connecting rods and cranks of the crank shaft of the engine have reached positions one stroke in advance of those indicated in Fig. 1 and the cams have advanced 270 degrees from their position indicated in Fig. 4, they will be in position to start the fourth stroke of the cycle of the engine. It will be seen that cam 71 will completely open valve 41, while the products of combustion will pass out of cylinder 2, through channel 41', passageway 36', and pipe 45', then before cam 73 has closed valve 43, through channel 43', into cylinder 4 and thence, by way of pipe 40', to cylinder 3, and thereupon pistons 8 and 9 will be forced downward, by the action of the expanding products of combustion, forced out of cylinder 2 in the manner set forth. The previously drawn-in charge of the combustible fluid in cylinder 1 will be gradually compressed. During this stroke and before the pistons have about reached the positions indicated in Fig. 1, it becomes necessary to close valve 43 by action of cam 73 so that the expanded products of combustion remaining in the clearance space or combustion zone of cylinder 2 can be reduced to about that of the atmosphere. From Figs. 2 and 4 it will be seen that after the cams have moved about

345 degrees from the positions in which they are shown in said Fig. 4 the protuberance 78 on cam 72 will cause valve 42 to open, the cam 71 will cause valve 41 to open, the cam 71 will cause valve 41 to open more, and thus the exhaust fluid from cylinder 2 may pass out of channel 41', passageway 36', and thence through pipes 50 and 50' out to the atmosphere. When the pistons have reached the end of the fourth stroke they will again be in the positions indicated in Figs. 1, 2, 3, and 4, and after ignition has taken place, the pistons 6 and 7 will be ready to move down again.

It will thus be seen that in the illustrated four-cylinder type of engine, the motive fluid employed in the high pressure cylinders to operate the pistons therein is employed expansively in the low pressure cylinders of the engine, so that while the pistons in the high pressure cylinders are driven in one direction those in the low pressure pistons will be driven in the same direction by said motive fluid in the low pressure cylinders. Of course, the same principle may be carried out in engines having a greater or smaller number of cylinders than that illustrated in the drawings. For example, it can easily be seen that by using one cylinder having the same piston displacement or working area of cylinders 3 and 4 combined, we would have a three-cylinder engine. By using three cylinders in place of cylinders 3 and 4 we would have a five cylinder engine. In this same way, a six, seven, eight, etc., cylinder engine may be had by using two or more high pressure cylinders in combination with one or more low pressure cylinders. It will be understood, from the description, that after the cams have moved with their surfaces of greatest radii beyond the piston rod blocks described, the valve which has thereupon been lifted will be gradually lowered, as this is substantially the practice with valves of this nature.

The cylinders and cylinder heads are water jacketed.

While I have shown an engine which carries out the principle of my invention I do not mean to be limited to the exact details of construction hereinbefore disclosed, except by the purview of the following claims:

1. An engine comprising two high pressure cylinders, two low pressure cylinders, a pipe connecting the two low pressure cylinders at the top, a motive fluid pipe connecting said high pressure cylinders laterally at their upper ends, valves seated over the inlet ends of said motive fluid pipe, two oppositely slanting pipes connecting respectively, each low pressure cylinder to the adjacent high pressure cylinder, valves disposed under the upper ends of said slanting pipes, said high pressure cylinders formed with passageways arranged to communicate with

the inlet ends of said motive fluid pipe and said slanting pipe respectively, an exhaust pipe having branches arranged to communicate with said passageways when said last-named valves are open, each of said high pressure cylinders formed with a channel way arranged to communicate with only one of said passageways, valves arranged to close communication between said channel ways and said passage ways, valves disposed above the lower ends of said slanting pipes, each of said low pressure cylinders formed with a channel way arranged to communicate with said slanting pipe when said last named valves are open, a crank shaft, four cranks on said shaft, pistons in said cylinders, the two inner cranks being disposed in diametrically opposite positions to the outer cranks, pitmen connecting the cranks and said pistons, a cam shaft, means controlled by said crank shaft for rotating said cam shaft, cams on said cam shaft operatively connected to said valves, and means for igniting the motive fluid in the channel ways of said high pressure cylinders.

2. An engine comprising four cylinders, two cylinders being low pressure and two cylinders being high pressure cylinders, a pipe connecting the low pressure cylinders at their upper ends, each of said cylinders being formed with a channel way, an igniting plug disposed over the channel way of each high pressure cylinder, valves controlling the outer ends of said channel ways, each of said high pressure cylinders formed with passage ways communicating with its channel way, a motive fluid pipe having two branches connecting respectively with the passageway of each high pressure cylinder, two pipes arranged to communicate with the opposite ends of said passageways and with the channel ways of the low pressure cylinders, when the valves controlling the latter are open, an exhaust pipe having branches arranged to communicate with said last named pipes and said passageways respectively, valves closing communication between the exhaust branch pipes and said passageways, a crank shaft, pistons in said cylinders, two cranks on said shaft connected operatively to the pistons in the low pressure cylinders, two cranks on said shaft disposed diametrically opposite said first named cranks, a cam shaft, means controlled by said crank shaft for rotating said cam shaft, spring controlled rods attached to said valves, eight cams on said cam shaft bearing operatively against said valve rods, the cams controlling the valves in the channel ways of the high pressure cylinders having their eccentric portions respectively relatively disposed vertically in opposite directions, and the cams controlling the valves in the channel ways of the low pressure cylinders having their eccentrics relatively disposed

horizontally in opposite directions, the cams controlling the valves disposed at one end of said passageways having their eccentric portions relatively disposed diagonally opposite with respect to the cams controlling the valves disposed at the other end of said passageways, and protuberances formed upon said last-named cams between their concentric and eccentric portions.

3. An engine comprising two high pressure cylinders, two low pressure cylinders, a pipe connecting the two low pressure cylinders at the top, a motive fluid pipe connecting said high pressure cylinders laterally at their upper ends, valves seated over the inlet ends of said motive fluid pipe, two oppositely slanting pipes connecting respectively, each low pressure cylinder to the adjacent high pressure cylinder, valves disposed under the upper ends of said slanting pipes, said high pressure cylinders formed with passageways arranged to communicate with the inlet ends of said motive fluid pipe and said slanting pipe respectively, an exhaust pipe having branches arranged to communicate with said passageways when said last-named valves are open, each of said high pressure cylinders formed with a channel way arranged to communicate with only one of said passageways, valves arranged to close communication between said channel ways and said passageways, valves disposed above the lower ends of said slanting pipes, each of said low pressure cylinders formed with a channel way arranged to communicate with said slanting pipe when said last-named valves are open, a crank shaft, four cranks on said shaft, pistons in said cylinders, the two inner cranks being disposed in diametrically opposite positions to the outer cranks, pitmen connecting the cranks and said pistons, a cam shaft, means controlled by said crank shaft for rotating said cam shaft, cams on said cam shaft operatively connected to said valves, and means for igniting the motive fluid in the channel ways of said high pressure cylinders, said high and low pressure cylinders being of the same diameter.

4. An engine comprising two high pressure cylinders, two low pressure cylinders, a pipe connecting the two low pressure cylinders at the top, a motive fluid pipe connecting said high pressure cylinders laterally at their upper ends, valves seated over the inlet ends of said motive fluid pipe, two oppositely slanting pipes connecting respectively each low pressure cylinder to the adjacent high pressure cylinder, valves disposed under the upper ends of said slanting pipes, said high pressure cylinders formed with passageways arranged to communicate with the inlet ends of said motive fluid pipe and said slanting pipe respectively, an exhaust pipe having branches arranged to communicate with said passageways when said last-

named valves are open, a crank shaft, four cranks on said shaft, pistons in said cylinders, the two inner cranks being disposed in diametrically opposite positions to the outer cranks, pitmen connecting the cranks and said pistons, a cam shaft, means controlled by said crank shaft for rotating said cam shaft, cams on said shaft operatively connected to said valves, and means for igniting the motive fluid in the channel ways of said high pressure cylinders, said high and low pressure cylinders being of the same diameter, certain of said pistons having longer strokes than other of said pistons.

5. An engine comprising two high pressure cylinders, two low pressure cylinders, a pipe connecting the two low pressure cylinders at the top, a motive fluid pipe connecting said high pressure cylinders laterally at their upper ends, valves seated over the inlet ends of said motive fluid pipe, two oppositely slanting pipes connecting respectively, each low pressure cylinder to the adjacent high pressure cylinder, valves disposed under the upper ends of said slanting pipes, said high pressure cylinders formed with passageways arranged to communicate with the inlet ends of said motive fluid pipe and said slanting pipe respectively, an exhaust pipe having branches arranged to communicate with said passageways when said last-named valves are open, each of said high pressure cylinders formed with a channel way arranged to communicate with only one of said passageways, valves arranged to close communication between said channel ways and said passage ways, valves disposed above the lower ends of said slanting pipes, each of said low pressure cylinders formed with a channel way arranged to communicate with said slanting pipe when said last named valves are open, a crank shaft, four cranks on said shaft, pistons in said cylinders, the two cranks being disposed in diametrically opposite positions to the outer cranks, pitmen connecting the cranks and said pistons, a cam shaft, means controlled by said crank shaft for rotating said cam shaft, cams on said cam shaft operatively connected to said valves, and means for igniting the motive fluid in the channel ways of said high pressure cylinders, said high and low pressure cylinders being of the same diameter, certain of said pistons having longer strokes than other of said pistons, said longer stroke pistons being in said low pressure cylinders.

6. An engine consisting of high pressure cylinders and a series of low pressure cylinders, a pipe connecting the low pressure cylinders at their upper ends, each of said cylinders being formed with a channel way, an igniting plug disposed over the channel way of each high pressure cylinder, valves controlling the outer ends of said

channel ways each of said high pressure cylinders formed with passage ways communicating with its channel way, a motive fluid pipe having two branches connecting
5 respectively with the passageway of each high pressure cylinder, two pipes arranged to communicate with the opposite ends of said passageways and with the channel ways of the low pressure cylinders, when the
10 valves controlling the latter are open, an exhaust pipe having branches arranged to communicate with said last-named pipes and said passageways respectively, valves
15 closing communication between the exhaust branch pipes and said passageways, a crank shaft, pistons in said cylinders, two cranks on said shaft connected operatively to the pistons in the low pressure cylinders, two cranks on said shaft disposed diametrically
20 opposite said first named cranks, a cam shaft, means controlled by said crank shaft for rotating said cam shaft, spring controlled rods attached to said valves, eight cams on said cam shaft bearing operatively

against said valve rods, the cams controlling the valves in the channel ways of the
25 high pressure cylinders having their eccentric portions respectively relatively disposed vertically in opposite directions, and the
30 cams controlling the valves in the channel ways of the low pressure cylinders having their eccentrics relatively disposed horizontally in opposite directions, the cams controlling the valves disposed at one end of
35 said passageways having their eccentric portions relatively disposed diagonally opposite with respect to the cams controlling the valves disposed at the other end of said
40 passageways, and protuberances formed upon said last-named cams between their concentric and eccentric portions, all of said cylinders being of a common diameter.

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

WILLIAM T. SMITH.

Witnesses:

R. M. McVAY,
C. W. SKILLMAN.