W. O. BARNES.

INTERNAL COMBUSTION ENGINE.

APPLICATION FILED JAN. 11, 1907.

1,048,482.

Patented Dec. 31, 1912.

5 SHEETS—SHEET 1.

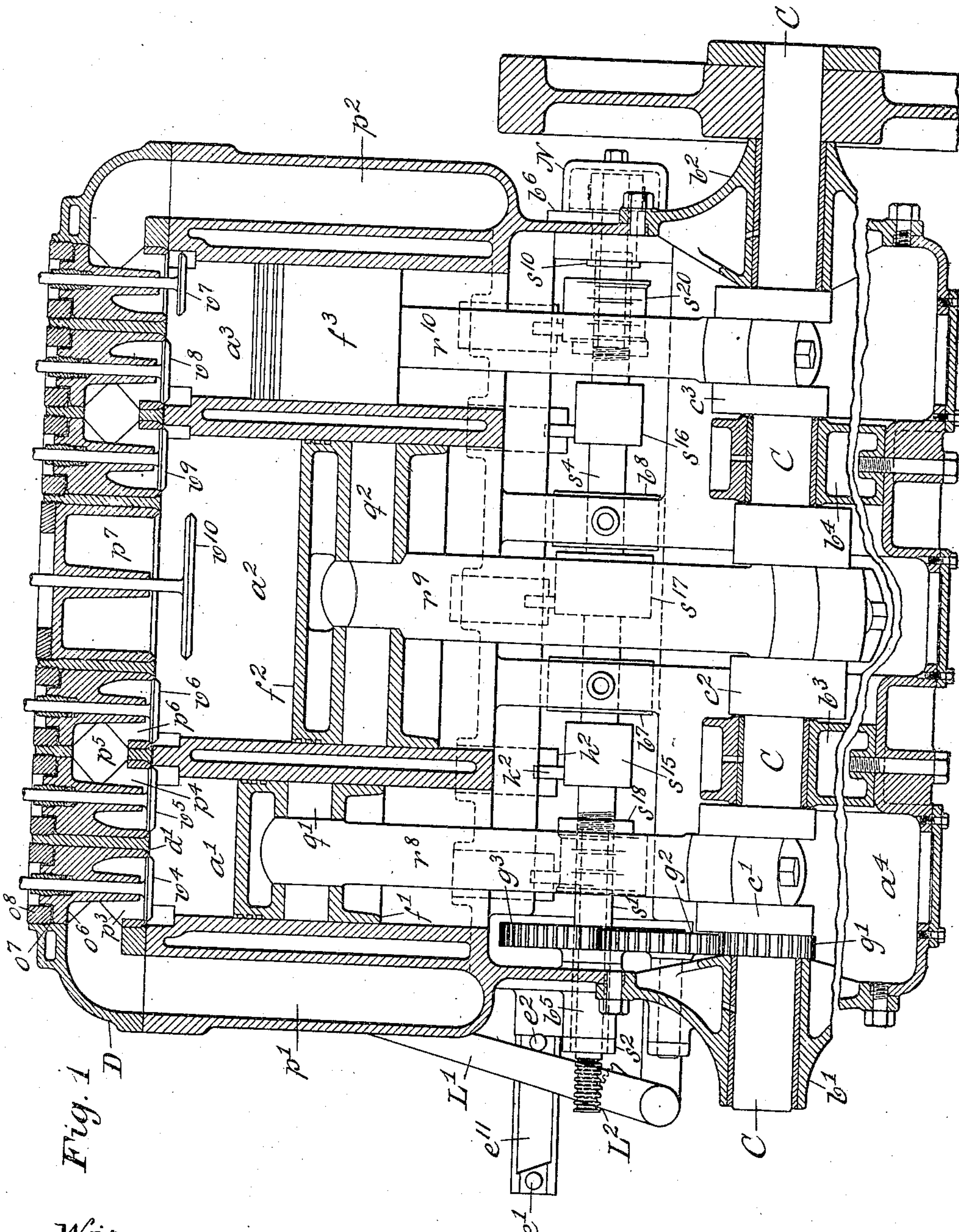

Fig. 1

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5 SHEETS—SHEET 2.

Fig. 2

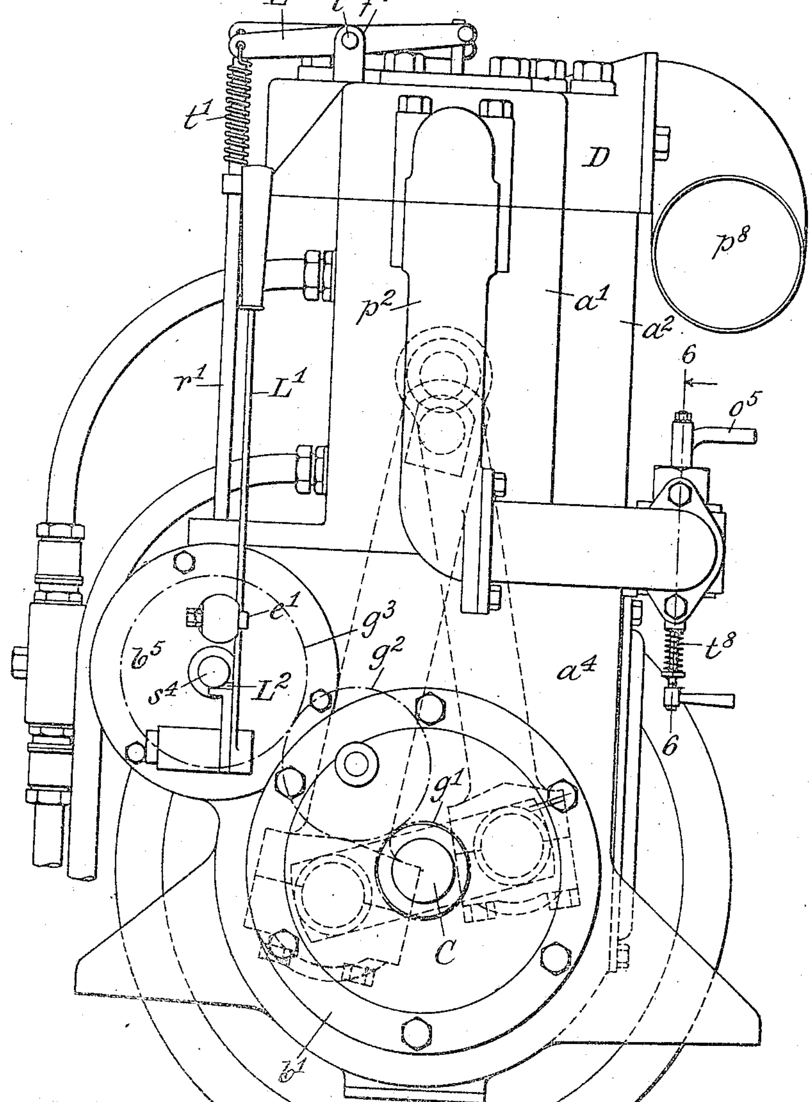

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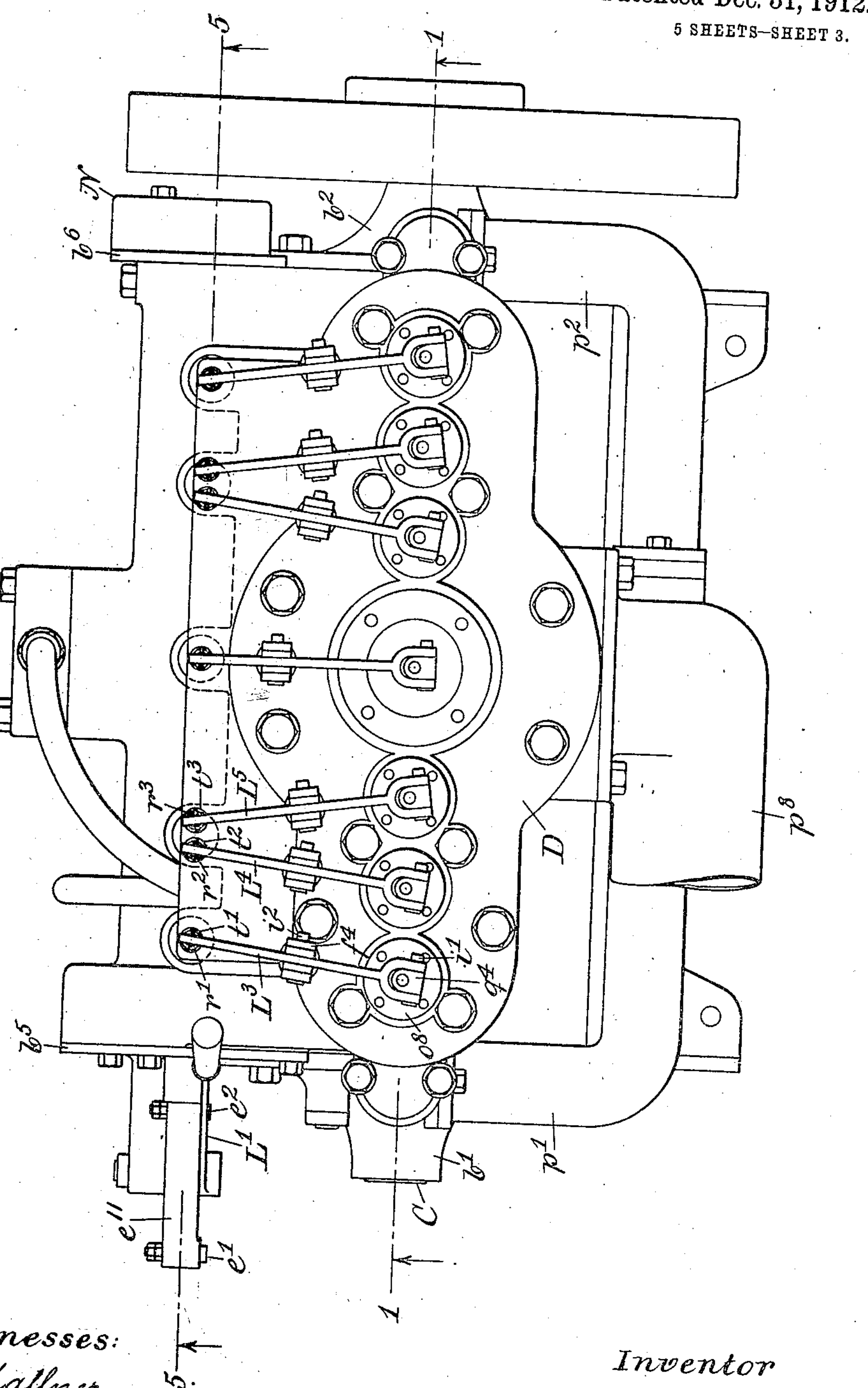
Fig. 3



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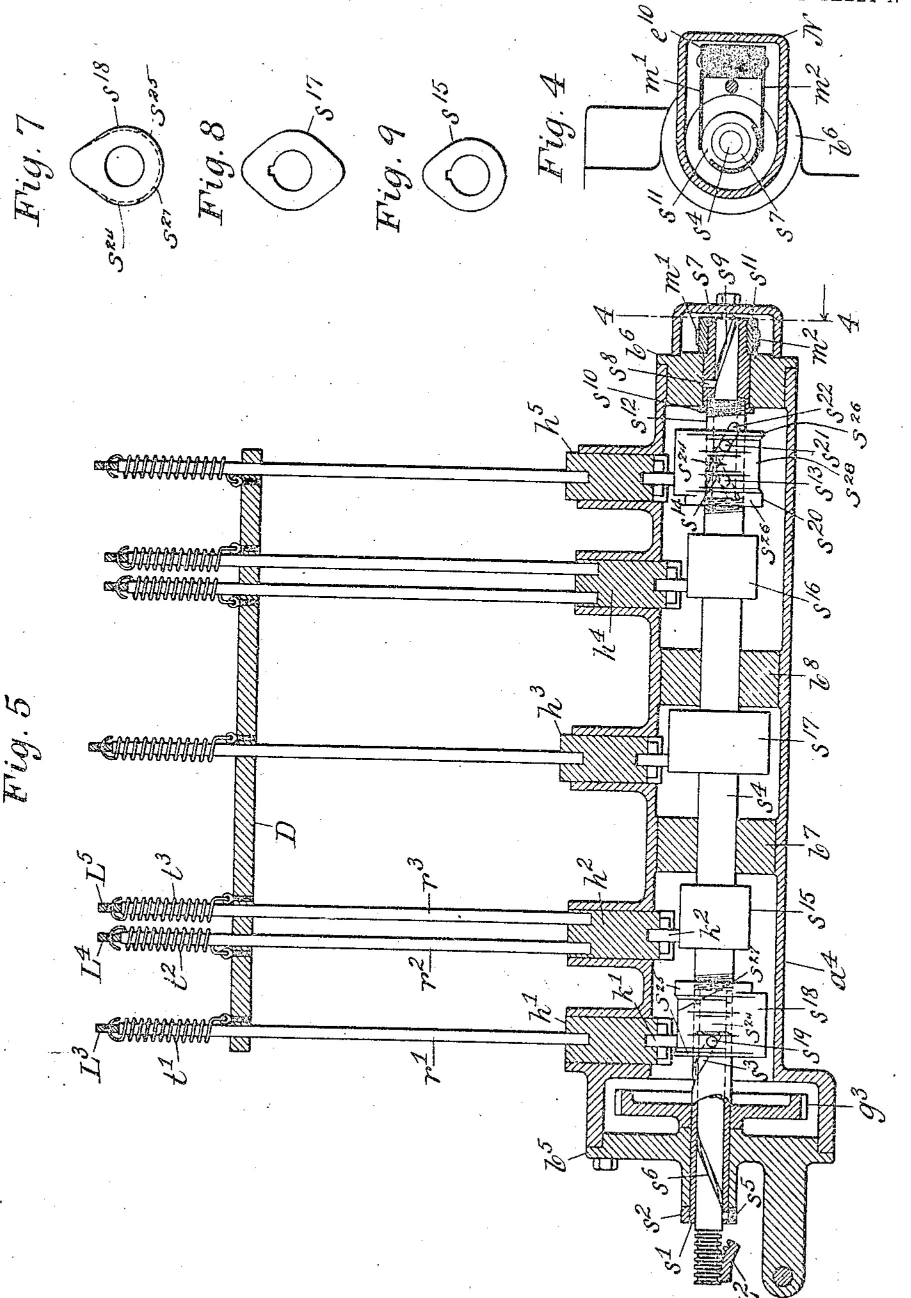

Fig. 7

Fig. 8

Fig. 9

Fig. 4

Fig. 5

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5 SHEETS—SHEET 5

Fig. 6

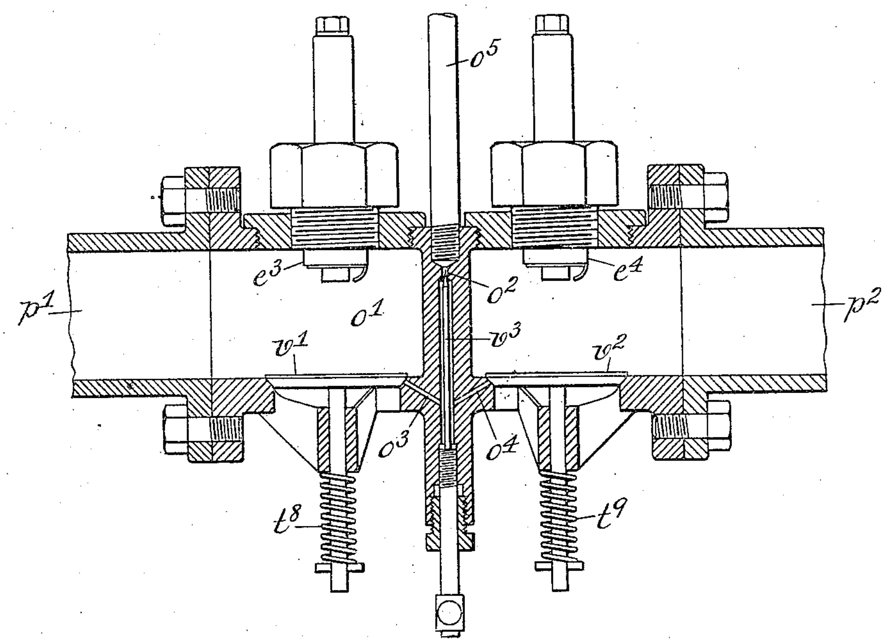
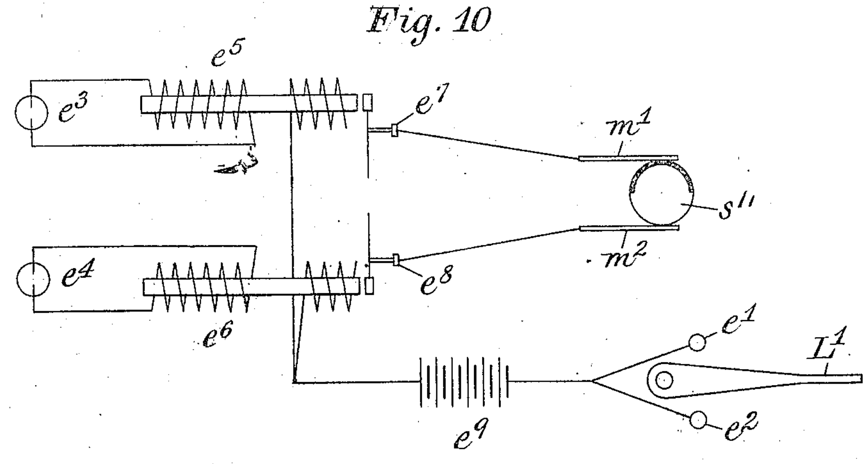


Fig. 10



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UNITED STATES PATENT OFFICE.

WILLIAM O. BARNES, OF PHILADELPHIA, PENNSYLVANIA.

INTERNAL-COMBUSTION ENGINF

1,048,482. Specification of Letters Patent. Patented Dec. 31, 1912.

Application filed January 11, 1907. Serial No. 351,849.

To all whom it may concern:

Be it known that I, WILLIAM O. BARNES, a citizen of the United States, and resident of Philadelphia, State of Pennsylvania, post-office address 4642 Penn street, Frankford, Philadelphia, Pennsylvania, have invented certain new and useful Improvements in Internal-Combustion Engines, of which the following is a full, clear, and exact specification.

This invention relates to internal combustion engines, and is herein shown and described as being embodied in a three-cylinder compound engine, although obviously some of its features are susceptible of use in single engines or in non-compound multiple cylinder engines.

Figure 1 of the drawings is a side view in section taken along the line 1—1 of Fig. 3. Fig. 2 is an end view looking from the left in Fig. 1. Fig. 3 is a plan view. Fig. 4 is an end view of the circuit closer in section taken on the line 4—4 of Fig. 5. Fig. 5 is a side view in section taken on the line 5—5 of Fig. 3. Fig. 6 is a side view in enlarged scale in section taken through the line 6—6 of Fig. 2, showing the carbureter and parts of the induction pipes leading to the high pressure cylinders. Fig. 7 is a profile view of one of the cams controlling one of the induction valves of the high pressure cylinder. Fig. 8 is a profile view of the cam controlling the movement of the exhaust valve of the low pressure cylinder. Fig. 9 is a profile view of one of the cams controlling the valves between the high and low pressure cylinders. Fig. 10 is a diagrammatic view of a suitable electric circuit to be employed in starting the engine.

The frame or body of the engine is shown as a single casting comprising the three cylinders a^1, a^2, a^3 and the crank case a^4.

C is the crank shaft supported for rotation in bearings b^1, b^2 which are bolted to and form the ends of the crank case a^4, and also in suitable bearings b^3 and b^4 which are securely bolted to the inside of the crank case a^4. The crank shaft is formed with three cranks c^1, c^2 and c^3, the two outside cranks being placed 180 degrees from the inside or middle crank. Crank c^1 is connected by means of connecting rod r^8 and wrist pin q^1 with piston f^1 which is closely fitted in cylinder a^1 and reciprocates therein. Crank c^2 is connected by means of connecting rod r^9 and wrist pin q^2 with piston f^2 which is closely fitted and reciprocates in cylinder a^2. Crank c^3 is connected by means of connecting rod r^{10} and a wrist pin similar to q^1 with piston f^3 which is closely fitted and reciprocates in the cylinder a^3. A single casting D is bolted to the top of the cylinders and forms a cover for all the cylinders. Gear g^1 is mounted on the crank shaft so as to rotate therewith and meshes into and drives the idler gear g^2 which is mounted in a suitable bearing in b^1 and in turn meshes into and drives the gear g^3. Gear g^3 is securely fastened on the sleeve s^1, one end of which turns in a suitable bearing in the cover plate b^5 and is prevented from moving longitudinally in the plate by gear g^3 and the collar s^2 which is suitably fastened to the sleeve. The gears g^1 and g^3 are so proportioned that g^3 will make just half the number of revolutions made by the gear g^1.

The valve cam shaft s^4 passes through sleeve s^1 and is made to revolve with sleeve s^1 by means of the screw pin s^5, which projects into the spiral or helical groove s^6 formed in shaft s^4. Circuit closer sleeve s^7 is mounted on the other end of shaft s^4 and is made to revolve with the shaft by the pin s^8, which is securely fastened in the sleeve and enters the helical groove s^9 formed in the shaft s^4. Circuit closer sleeve s^7 is prevented from moving longitudinally in said bearing by the flange s^{10} and the circuit closer s^{11}, which is securely fastened to the sleeve s^7. Sleeve s^{12} is mounted on shaft s^4 and is made to revolve with the same by means of pin s^{13} which is securely fastened in the sleeve and enters the helical groove s^{14} formed in shaft s^4. Longitudinal movement of sleeve s^{12} is prevented by the threaded end of s^{12} which is screwed into the threaded end of sleeve s^7. Shaft s^4 is also supported by bearings b^7 and b^8, which are suitably secured to crank case a^4. Securely fastened to shaft s^4 are the two single lobed cams s^{15} and s^{16}, and the two lobed cam s^{17}. The cam s^{18} is mounted on sleeve s^1 and is made to rotate with the sleeve by the pin s^{19} which is securely fastened in cam s^{18} and projects into the helical groove s^3 formed on sleeve s^1. Lateral movement of cam s^{18} on shaft s^4 is prevented by the threaded part of shaft s^4 which is screwed into a corresponding thread in cam s^{18}. The one lobed cam s^{20} is mounted on sleeve s^{12} and is made to rotate with sleeve s^{12} by the pin s^{21} which is securely fastened in s^{20} and projects into a helical groove s^{22} formed on the outside of the sleeve s^{12}. The cams s^{18} and s^{20} are provided at the center of their length with enlarged portions s^{24} (see Figs. 5 and 7); and both ends of those cams are provided with enlarged portions s^{25} and s^{26}, the portions of the cams intervening between the said enlarged portions and upon which the roller k^1 is shown to be resting in Fig. 5, being designated by the numerals s^{27} and s^{28}, respectively. The enlarged middle portions s^{24} are for the purpose of opening the valves v^4 and v^7, respectively, to relieve the compression below the ignition point when the lever L^1 is at its middle or stopping position. The enlarged portions s^{25} and s^{26} are for the purpose of opening the same valves to relieve the compression when the lever L^1 is moved to its extreme positions for starting the engine. The lever L^1 is suitably fulcrumed on cover plate b^6 to swing in the notched or recessed side of the bar e^{11}. The segmental gear L^2 which is fastened to lever L^1 meshes into the annular rack-like grooves formed near the end of shaft s^4 so that the longitudinal position of shaft s^4 is determined by the position of lever L^1.

The circuit closer s^{11} is composed of a metallic portion subtending about 180 degrees of its circumference which is in electrical connection with the circuit closer sleeve and hence with the frame of the engine, and of an insulating portion subtending the rest of the circumference. Two brushes m^1 and m^2 of metal or other suitable material are mounted and suitably secured to insulating block e^{10} and bear against circuit closer s^{11} at diametrically opposite points: but are capable of adjustment so that if necessary an allowance can be made for variations in generating the secondary current which have been found to exist in induction coils.

N is a suitable cover or box which is bolted to cover plate b^6 and incloses the circuit closer and brushes.

The induction passage p^1 leading to cylinder a^1 is closed at its outer end by check valve v^1, Fig. 6, contained in valve body or carbureter o^1 and is normally kept on its seat by the spring t^8. The induction passage p^2 leading to cylinder a^3 is also closed at its outer end by the check valve v^2 which is normally kept on its seat by the spring t^9. Valve body o^1 is provided with a gasolene or petrol passage o^2 to which petrol is brought from a suitable source of supply by the pipe o^5. The passage o^2 communicates with the small passages o^3 and o^4, which pierce the seats of valves v^1 and v^2. The supply of gasolene to the passages o^3 and o^4 is controlled by the needle valve v^3. The construction is such that when rarefaction takes place in one of the induction passages the valve v^1 or v^2 covering that passage will lift off its seat and a quantity of air and gasolene will enter said induction passage. By throttling the supply of gasolene to the passages o^3 and o^4 the quality of the mixture of air and gasolene supplied to the induction passages can be varied.

A valve body or plug o^6 is fitted into a hole passing through the cylinder cover and is seated gas tight against a conical shoulder d^1 in the cylinder cover. The upper end of o^6 is chamfered or beveled and a ring o^7 of soft copper or other suitable material is placed on top of the chamfered portion of o^6. The follower o^8 is screwed into the cylinder cover D so as to force packing ring o^7 into intimate contact with o^6 and cover D and form a gas tight joint between the cover ring and valve plug and at the same time securely hold plug o^6 in contact with its seat d^1. A port p^3 formed in valve plug o^6 connects cylinder a^1 with induction passage p^1. A puppet valve v^4 seated in o^6 controls the communication between cylinder a^1 and port p^1. The stem of valve v^4 extends upward through a suitable guide and stuffing box in o^6. A crosshead q^4 is secured to the head of the stem of valve v^4 and is jointed or pivoted to lever L^3 by means of pin i^1. Lever L^3 is fulcrumed on pin i^2 which is held in suitable bracket f^4 secured to the cylinder cover. The valve v^4 is normally kept on its seat by the spring t^1, one end of which is secured to lever L^3 and the other end to the cylinder cover D. The upper end of rod r^1 bears against the lever L^3 and its lower end rests in a depression in the cam follower h^1. Follower h^1 slides freely in a suitable guide in the engine frame and carries at its lower end the roller h^1. The construction is such that when the cam s^{18} is revolving the valve will be alternately opened and closed by means of the roller k^1, cam follower h^1, valve rod r^1 lever L^3, crosshead q^4, pin i^1 and spring t^1.

Valves v^5 and v^6 are of similar construction and control the passage of gas between cylinders a^1 and a^2 by way of the ports p^4, p^5 and p^6, and are operated by cam s^{15} acting through roller k^2, cam follower h^2, valve rods r^2, r^3 and levers L^4, L^5, and springs t^2 and t^3. Communication between passage p^2 and cylinder a^3 is controlled by valve v^7 which is of similar construction to the valve v^4 and is operated by cam s^{20} through similar mechanism as that employed to transmit the motion of cam s^{18} to valve v^4.

Communication between the cylinders a^3 and a^2 is controlled by valves v^8 and v^9 which are of similar construction to valves v^5 and v^6 and are operated by cam s^{16} through similar mechanism as that employed to transmit motion to valves v^5 and v^6 from cam s^{15}. Communication between the cylinder a^2 and the exhaust port p^7 is controlled by valve v^{10} which is operated by cam s^{17} through similar mechanism as that employed to transmit motion from cam s^{18} to valve v^4.

The action of the engine is as follows:—If the parts are in the positions shown in Fig. 1 and a charge of gas and air filling the space in cylinder a^1 above piston f^1, the pressure due to the ignition will cause piston f^1 to descend and the crank shaft will rotate, consequently piston f^2 will ascend and the contents of cylinder a^2 will be pushed into the exhaust port and from thence into the exterior air through the exhaust pipe p^8. Piston f^3 moving in unison with piston f^1 will in descending cause a rarefaction in a^3 and p^2 and consequently valve v^2 will open and a mixture of gas and air will enter p^2 and a^3. Piston a^3 having completed its downward stroke and valve v^7 having seated while the piston was at the end of its downward stroke, the charge of air and gas confined in a^3 will be compressed by the piston a^3 during its upward stroke. The proportions of the cylinder are such that the compression will be carried to such an extent that the heat developed by the compression will be sufficient to ignite the charge of mingled gas and air when the piston is near the end of its upward stroke. The expansion of the ignited charge will drive piston f^3 downward on its next course. When piston f^3 reaches the end of its next downward stroke valves v^8 and v^9 open, establishing communication between cylinders a^3 and a^2, and valves v^5, v^6 and v^7 being shut the pressure acting on the larger piston f^2 will force that piston downward expanding the charge still further and compelling the piston f^3 to rise. When piston f^2 has reached the end of its downward stroke and piston f^3 the end of its upward stroke valves v^8 and v^9 close and valves v^{10} and v^7 open. Meanwhile piston f^1 moving in unison with piston f^3 will have compressed to the point of ignition a charge of gas and air in cylinder a^1. The ignited charge in a^1 will expand and drive piston a^1 on its next downward stroke and during that stroke piston f^2 will rise and expel the contents of a^2 through valve v^{10} which opens for that purpose. When piston f^1 reaches the end of its downward stroke valve v^{10} closes and valves v^5 and v^6 open so that the pressure acting on the larger piston f^2 will force that piston downward, still further expanding the charge and compelling piston f^1 and f^3 to rise. Thus it will be seen that during each downward stroke of pistons f^1 and f^3 an impulse is given to one or the other of pistons f^1 and f^3. Also during each upward stroke of f^1 and f^3 an impulse is given to piston f^2. The cam shaft is so geared to the crank shaft and the relations of the parts are such that when lever L^1 rests against one side of the notch in the bar e^{11} the valve cams are in the proper position so that the engine will run in one direction, but if the lever L^1 be moved so that it rests against the other side of the notch in the bar e^{11} the pitch and direction of the spiral grooves s^3, s^6, s^9 and s^{14} are such that the longitudinal movement of cam shaft s^4 due to such movement of L^1 will cause the cam shaft and cams s^{15}, s^{16} and s^{17} to be advanced 90 degrees, and the cams s^{18} and s^{20} to be retarded 90 degrees or any other suitable extent so that the cams will operate the valves in the proper manner when the engine is running in the opposite direction. These circumferential advancing and retarding movements of the said cams are accomplished by the action of the spiral grooves s^6, s^3, s^{14} and s^{22}. As the shaft s^4 is moved longitudinally to the left from the position shown in Fig. 5, for example, the groove s^6 engaging with the stationary pin s^5 determines the direction and extent of rotation of the shaft s^4. In the arrangement illustrated in the drawings, the groove s^6, being a left hand spiral, the top of the shaft s^4 will be turned toward the observer, viewed as in Fig. 5, carrying with it the cams s^{15}, s^{16} and s^{17}. The groove s^{14}, near the opposite end of the shaft coincides in contour with the groove s^6, so that the shaft practically unscrews through the sleeves s^1 and s^{12}, without changing the relative rotary positions of these two sleeves. But this endwise movement of the shaft s^4 carries the cams s^{18} and s^{20} lengthwise with the shaft, the rotary positions of those cams being, however, determined by the direction of the grooves s^3 and s^{22}, with which these cams are in engagement, by means of the pins s^{10} and s^{21}, respectively. As illustrated in the drawings, these grooves s^3 and s^{22} are shown as forming right hand spiral paths, so that in this instance the tops of these cams s^{18} and s^{20} would be turned away from the observer, as viewed in Fig. 5, which is a direction opposite to the rotary movement of the shaft s^4. The threaded connection between the shaft s^4 and the cams s^{18} and s^{20} permits the rotary movement of that shaft and those cams relative to each other. Obviously, these grooves s^6, s^3 s^{14} and s^{22} may be straight, or varied in direction and extent of spiral, so as to rotate the cams in the same direction or in opposite directions, to any desired position. The circuit closer s^{11} is at the same time and by the longitudinal movement of the shaft s^4 rotated to its proper position relative to that shaft and to the valve cams, by means of the pin s^8 engaging in the groove s^9, so as to bring the ignition period into proper relation to the reverse direction of running. The degree and direction of spiral may obviously be modified to adapt it to various conditions. If the engine be running in either direction and the lever L^1 be moved to middle position in the notch in bar e^{11}, the cams s^{18} and s^{20} are moved longitudinally so that their enlarged middle portions s^{24} bear against rollers of the corresponding cam followers causing the valves v^4 and v^7 to remain open during part of the compression stroke of pistons f^1 and f^3, thereby reducing the amount of compression in the cylinders a^1 and a^3 below the point of self-ignition, consequently the engine will come to rest. The last revolutions of the engine taking place without ignition, the burnt charge will be exhausted and the engine will come to rest with all the cylinders filled with an explosive mixture of air and gas.

I have found it to be perfectly feasible to retain for days an explosive mixture in the cylinders of an internal combustion engine. On the other hand in order to obtain reasonable efficiency in the engine it is essential that when running the explosive must be compressed a considerable amount before ignition takes place, and in engines as usually constructed the amount of power consumed in compressing a charge is greater than the amount of power that can be developed from the expansion of a charge ignited at atmospheric pressure. Consequently the starting of an internal combustion engine in which the compression is carried to an economical degree is usually attended with more or less difficulty. In order to overcome all difficulty in starting I increase the compression space during the first few strokes to such an extent that the degree of compression is so reduced that the power developed from the first charge, ignited at atmospheric pressure in one of the cylinders a^1 or a^3 is amply sufficient to start the engine and effect the reduced compression in the other cylinder. I prefer to so proportion the compression spaces that the power developed by the expansion of a charge ignited at this reduced compression in the other cylinder is amply sufficient to turn the engine and effect the higher normal compression of the next charge in the first cylinder; but this is not essential as the surplus energy of each succeeding charge will be stored up in the rotating parts of the engine until sufficient has been accumulated to effect the normal compression.

If the engine is at rest and the lever L^1 be sprung sidewise out of the notch in bar e^{11} and placed in such a position that it makes electrical connection with one of the studs e^1 and e^2 an electrical current will flow from battery e^9 through the frame of the engine circuit closer s^{11}, brush m^1 or m^2 and the primary of the induction coil e^5 or e^6 and this current will be rapidly broken and reëstablished by the vibrator e^7 or e^8. Consequently a spark, due to the induced current in the secondary of the induction coil, will be made to jump across the terminals of the spark plug e^3 or e^4, Fig. 6, igniting the gas in the proper cylinder to effect rotation of the crank shaft in the required direction, determined by the position of lever L^1 being in contact with stud e^1 or e^2. When lever L^1 is moved beyond the end of the notch in bar e^{11} in order to make contact with one of the studs e^1 or e^2 the enlarged end portions s^{25}, s^{26} of the cams s^{18} and s^{20} will be moved longitudinally underneath the rollers attached to the cam followers h^1 and h^5 and consequently the valves v^4 and v^7 will be kept open during the entire rotation of the cam shaft s^4, thus adding passages p^1 and p^2 to the compression spaces of the cylinders a^1 and a^3 and thereby reducing the amount of compression to the required degree for starting. When the crank shaft has rotated so far that the first ignited charge begins to exhaust through valve v^{10} the metallic surface of the circuit closer will have moved so far as to come in contact with the other brush, thereby causing the charge in the other high pressure cylinder, which has meanwhile been partially compressed, to be ignited. Thus the charges in a^1 and a^3 will be alternately electrically ignited until the engine has gained sufficient headway to enable it to effect the normal compression. When such headway has been gained the lever L^1 is to be moved away from the stud e^1 or e^2 and allowed to spring into the nearest end of the notch in the bar e^{11}, and since the primary circuits are no longer completed through the frame of the engine, the sparking at the plugs e^3 and e^4 will cease. The rollers attached to the cam followers h^1 and h^5 will be acted upon by one of the reduced portions s^{27}, s^{28} of the cams s^{18} and s^{20}, whereby the valves v^4 and v^7 will be properly seated and closed at all times except during the admission strokes of the respective pistons. Consequently the compression spaces of the cylinders a^1 and a^3 will be reduced to normal dimensions and the charges will be self-ignited by the heat of compression. If the engine is running in one direction and the lever L^1 be pushed to the other end of the notch in bar e^{11} the ignition will cease in cylinders a^1 and a^3 while the lever is passing across the notch and consequently all three cylinders will become filled with an explosive mixture of air and gas, it being remembered that the shaft and cams are thus set for running in one direction, while the engine continues by its momentum to run in the reverse direction. When lever L^1 reaches the other end of the notch the movements of the various valves are such that the contents of cylinder a^2 will be compressed into one of the cylinders a^1 or a^3 and on the ascent of the piston in a^1 or a^3 the contents of the cylinder will be ignited by the heat of compression before the piston has reached the end of its upward stroke. I prefer to so proportion the parts of the engine that the energy stored up in the rotating parts shall be entirely absorbed by the said compression of the ignited charge in cylinder a^1 or a^3 and consequently the engine will come to rest and will start to rotate in the opposite direction on account of the pressure exerted by the ignited charge in a^1 or a^3 on piston f^1 or f^3.

It will be observed that the cams s^{18} and s^{20} are set opposite to each other. That is, their corresponding working parts are 180 degrees apart, relative to the shaft s^4, so that the cylinders a^1 and a^3 alternate in their cycles of operations. As illustrated in Figs. 1, 2 and 5, the explosion has just taken place in the cylinder a^1. The cylinder a^3 is being filled with fuel drawn through the open valve v^7, while the waste gases are being expelled from the cylinder a^2 through the open valve v^{10}. Upon the next up stroke of the pistons f^1 and f^3 the former will push its waste gases into the cylinder a^2, while the latter will compress the gases in the cylinder a^3 and explode at the top of the stroke; thus the cylinders a^1 and a^3 alternately draw in, compress and explode their respective charges, and exhaust them into the cylinder a^2, which thus receives an impulse at each downward stroke, first from a^1 and then from a^3. The reversing operation by means of the lever L^1, reverses the order of alternate action of the cylinders a^1 and a^3 by reversing the leads of the respective valves. The advance of the 2-lobe exhaust cam s^{17} brings it in proper position for releasing the opening at the lower end of the stroke of the piston f^2; since, as will be seen by reference to Fig. 8, the releasing portions of the cam s^{17} are 90 degrees apart, viz., at the beginnings of the respective rises of the cams.

The diagram shown in Fig. 10 illustrates a suitable arrangement of the auxiliary circuits; and the relation of the contacts e^1 and e^2 to the lever L^1, which serves as a switch for closing the circuit between the engine frame and one or the other of those contacts which was otherwise insulated from the frame, whereas the lever L^1 being pivoted upon the frame is in electrical communication therewith, as is also the shaft s^{11}, due to being journaled in that frame. Thus the movement of the lever L^1 into contact with either the stud e^1 or the stud e^2 closes the circuit through the frame from the studs e^1 or e^2 and the circuit controller s^{11}, the circuit energizing the spark plug c^3 or e^4, according as the one or the other of the brushes m^1 or m^2 are in electric contact with the circuit controller s^{11}.

It will be understood that in moving from the contact e^1 to the contact e^2 and vice versa, the combined switch lever L^1 by moving the cam shaft s^4 longitudinally alters the position of the various cams and of the circuit closer, adjusting them into proper relation for running the engine in the forward and reverse directions, respectively.

It will be understood that the embodiment of my invention herein shown may be and should be modified in various ways to suit the different conditions under which it is to be employed.

I claim as my invention:—

1. The combination, in an internal combustion engine, of means for effecting compression to the point of self-ignition, an auxiliary space for relieving the compression below the point of self-ignition, valve mechanism, including a valve for controlling communication between the internal combustion chamber of the engine and said auxiliary space, and cams for operating said valve mechanism, provided with a portion for operating the said valve, when the compression is to be reduced below the point of self-ignition.

2. The combination, in an internal combustion engine, of means for effecting compression to the point of self-ignition, means for releasing the compression below the point of self-ignition, an electric ignition circuit for igniting the charge under the lower compression, and means combined with the compression releasing means for concurrently closing the said circuit.

3. The combination, in an internal combustion engine, of means for effecting compression to the point of self-ignition, means for releasing the compression below the point of self-ignition, an auxiliary electric circuit for igniting the charge under the reduced compression, means for switching the said circuit in and out of operation, and means for coördinating the pressure reducing means and the switching means whereby they are operated concurrently.

4. The combination, in an internal combustion engine, of a cylinder proportioned to compress the charge to the point of self-ignition, an inlet passage, an inlet valve for said passage, a cam provided with means for opening or closing the said valve during the compressing stroke of the engine, and means for shifting the cam to bring either its opening or its closing means into operation upon said valve.

5. The combination in an internal combustion engine, of compression space proportioned to compress the normal charge to the point of self-ignition, a valve, an induction port leading to an induction passage, and means for interrupting the self-ignition to stop the engine, including means for opening the said valve to extend the compression space into the said induction passage, and thereby reduce the compression below the point of self-ignition.

6. The combination in an internal combustion engine, of compression space propor-

tioned to normally compress its explosive charges to the point of self-ignition, an induction port and passage, a valve controlling the said port and normally serving as a check valve for the automatic drawing in of the charge, and means for stopping the engine by reducing the compression below the point of self-ignition, including a cam, and means under the control of the operator for establishing operative relation between the said cam and the said valve to open said valve during the compression period, and thereby extend the compression space into the induction passage.

7. The combination, in an internal combustion engine, of a cylinder proportioned to compress the charge to the point of self-ignition, an inlet passage, an inlet valve for said passage, a cam provided with different portions for controlling the valve, one portion for closing the valve during the compressing stroke of the engine to effect self-igniting compression, and the other portion for opening the valve during the said stroke for reducing the compression below self-ignition, and means for moving the said valve to bring either of the said valve operating portions into operation upon the valve.

8. The combination, in an internal combustion engine, of a cylinder proportioned to compress the charge to the point of self-ignition, an inlet passage, a valve for said passage, a controlling cam for said valve provided with different operating portions, one portion for closing the valve during the compressing stroke of the engine, to effect self-igniting compression, and the other portion for opening the valve during the said stroke to reduce the compression below the igniting point, an electric ignition circuit for igniting reduced compression charges, and means for moving the cam to bring its said different portions into operation and to concurrently open and close the said sparking circuit.

9. The combination, in an internal combustion engine, of a cylinder proportioned to compress the charge to the point of self-ignition, an inlet passage, a valve for said passage, a controlling cam for the valve provided with a portion for closing the valve during the compression stroke of the engine to effect self-igniting compression, and with another portion for opening the valve during said stroke to reduce the compression below self-ignition, an electric ignition circuit for igniting low compression charges, and means for concurrently moving the valve to its compression releasing position, and concurrently closing the said ignition circuit.

10. The combination, in an internal combustion engine, of a compression cylinder, an auxiliary pressure reducing space, a valve controlling communication between said cylinder and said space, valve mechanism, including a cam provided with a plurality of operating portions at different longitudinal positions of the cam, including a portion for opening the said valve during the compressing stroke of the engine, and means for moving the said cam longitudinally to its different operating positions.

11. The combination in an internal combustion engine arranged for compressing a charge to the point of self-ignition, valve mechanism for holding the said self-igniting compression and also for releasing the compression below the point of self-ignition, and an electric ignition circuit provided with a switch and a timing circuit breaker coöperably connected with the valve mechanism, whereby they are operated in conjunction for effecting the reversal of the engine.

12. The combination with an internal combustion engine, and means for compressing a charge to the point of self ignition of pressure releasing and restarting devices, including an auxiliary sparking circuit, a switch adapted to adjust the said circuit for forward and reverse running, respectively, and means operable with the switch in moving from one of its circuit closing positions to the other, for changing the sparking time of the circuit and relieving the compression below the point of self ignition.

13. The combination, in an internal combustion engine, provided with induction and exhaust ports of means for compressing a charge to the point of self ignition for the full speed operation of the engine, and starting and reversing devices therefor including an auxiliary ignition circuit, a switch for adjusting the circuit for forward and reverse running positions respectively of the engine, valves for closing the induction and exhaust ports of the engine, ignition devices in the circuit, and means operable with the switch in moving it from one circuit adjusting position to the other for changing the said valves and the said ignition devices to suit the forward and reverse operations of the engine.

14. The combination, in an internal combustion engine, of means for compressing a charge to the point of self ignition, including a valve for holding or relieving the pressure, a cam controlling the operation of the valve, provided with different portions for the said holding and relieving positions of the valve, means for rotating the cam, and means for making the said different portions of the cam operative upon the valve.

15. The combination, in an internal combustion engine, of means for compressing a charge to the point of self ignition, including a valve for holding or relieving the pressure, a cam for operating the valve, having different portions for determining the holding and relieving positions of the valve, an

auxiliary ignition circuit, means for adjusting the said circuit to suit the forward and reverse running of the engine, and means movable with the circuit adjusting means for moving the said cam to make its respective portions operative upon the valve to suit the desired running direction of the engine.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

WILLIAM O. BARNES.

Witnesses:
FRED B. POULIN,
H. S. QUARTY.