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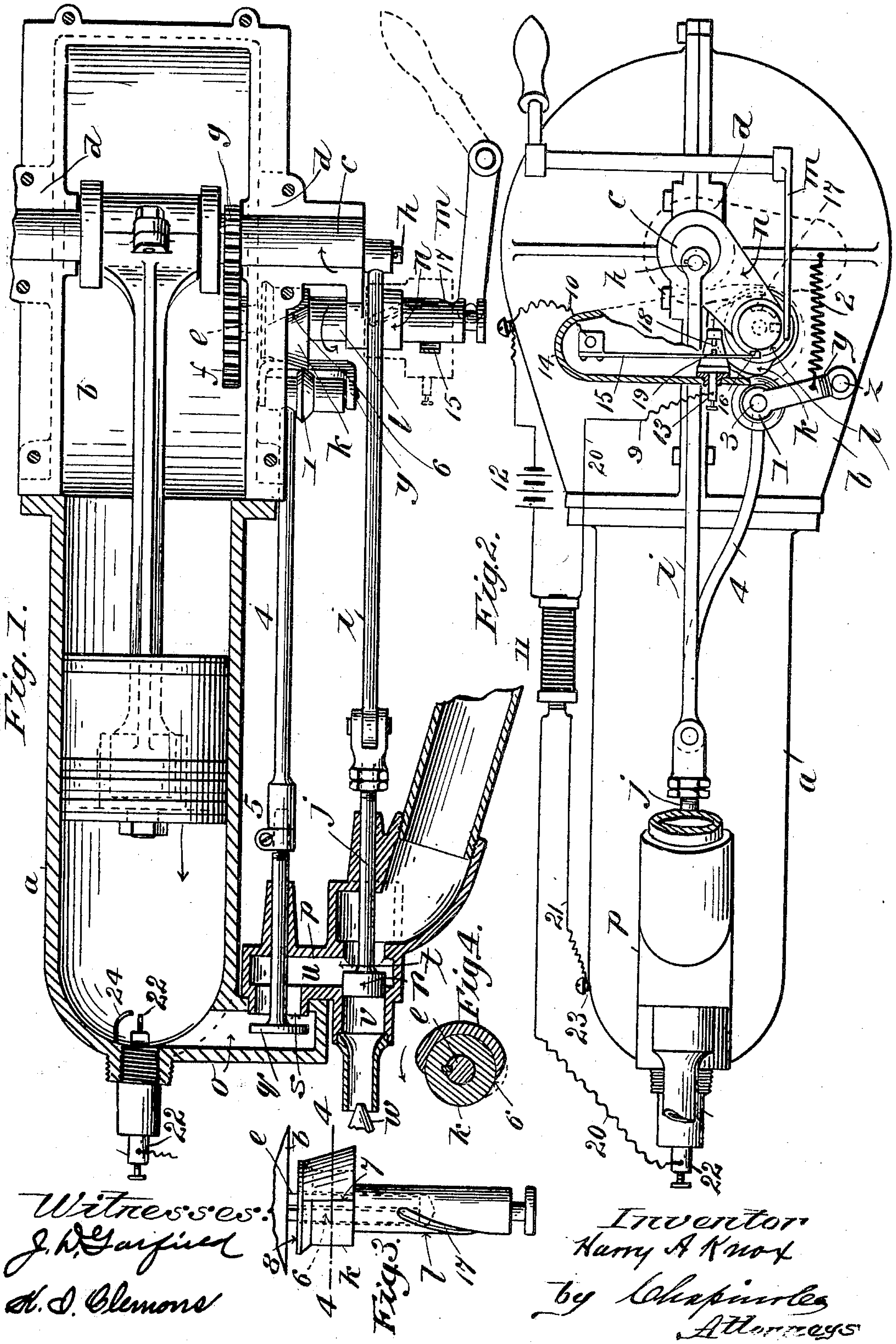
H. A. KNOX.

VALVE MECHANISM FOR EXPLOSIVE ENGINES.

(Application filed Sept. 22, 1900.)

(No Model.)



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VALVE MECHANISM FOR EXPLOSIVE-ENGINES.

SPECIFICATION forming part of Letters Patent No. 679,152, dated July 23, 1901.

Application filed September 22, 1900. Serial No. 30,817. (No model.)

To all whom it may concern:

Be it known that I, HARRY A. KNOX, a citizen of the United States of America, residing at Springfield, in the county of Hampden and State of Massachusetts, have invented new and useful Improvements in Valve Mechanism for Explosion-Engines, of which the following is a specification.

This invention relates to internal combustion or explosion engines and particularly to the valve mechanisms thereof, one object of the invention being to construct a valve mechanism adapted to the requirements of engines of the class referred to, which shall be of simple and strong construction, positive in action, and adjustable, whereby the admission of an explosive mixture to the cylinder of the motor may be regulated to the requirements of the latter.

A further object of the invention lies in the construction of the inlet and exhaust valves, whereby their action is made positive and one port controlled by one valve serves for both an inlet and an exhaust port.

A further object of the invention lies in the provision of means whereby when the valve mechanism is adjusted to vary the quantity of the explosive mixture admitted to the motor the time of ignition of the charge is automatically varied also; and the invention consists in the construction embodying the above-referred-to novel features, all as set forth fully in the following specification and pointed out particularly in the claims appended thereto.

In the drawings forming part of this specification, Figure 1 is a plan view, partly in section, of an engine of the type preferred, embodying this invention. Fig. 2 is a side elevation of Fig. 1, with parts thereof broken away. Fig. 3 is a plan view of the valve-controlling cam. Fig. 4 is a section of the latter on line 4 4, Fig. 3.

The engine shown in the drawings is a single-cylinder machine of the ordinary four-cycle type; but the valve mechanism is equally well adapted to a two-cylinder engine by only such slight changes as would come entirely within the scope of the invention.

In carrying out the invention in practice the cylinder *a* may be made as shown, having one closed end. The open end thereof has bolted thereto the casing *b*, in which, in proper bearings *d*, the crank-shaft *c* is supported and within which casing it rotates. A rotatable stud *e* is rotatably supported on the casing in proximity to the crank-shaft and parallel therewith, one end of the stud projecting through the wall of the casing and having secured thereto a gear *f*. A gear *g* on the crank-shaft *c* meshes with the gear *f*, and their respective diameters are such that the stud *e*, by reason of its connection with the crank-shaft, will be rotated once to two revolutions of the shaft. One end of the latter, outside of its bearing, is provided with a pin *h*, eccentrically located relative to said shaft, with which the connecting-rod *i* of a valve-stem *j* is pivotally connected. Said valve and its functions will be described further on. The opposite end of the crank-shaft is provided with a balance-wheel. (Not shown in the drawings.)

The above-referred-to rotatable stud *e* carries a valve-regulating cam *k*, provided with an axial extension *l*. This cam is connected with said stud by a spline-and-groove connection, as shown in Figs. 3 and 4, to the end that it may slide endwise thereon while rotating therewith. The outer end of said extension *l* of the cam is provided with an annular groove, with which, as by a pin or analogous means, connection is made with an operating-lever *m*, by means of which the said cam may be moved as described on the stud *e*. Said extension of the cam *k* has a bearing in an arm *n*, cast on or bolted to the casing, within which it both slides and rotates. The above-described means for moving the said cam endwise may be replaced by any other device, if desired, which will permit the operator to impart said movement to the cam at will.

At the closed end of the cylinder a chamber *o* is provided, which communicates with the cylinder. This chamber preferably is cast integral with the cylinder; but, if desired, it may be made separately and bolted thereto. Secured to this chamber *o* is the valve-supporting member *p*, in which are supported the valves *q* and *r* and in which are the valve-ports *s* and *t*. The port *s* leads directly into the chamber *o* from a passage *u*, which in turn leads into a transverse passage

v, through one end of which the explosive mixture is drawn and through the opposite end of which the exhaust is ejected. The valve r plays across the end of the passage u at its juncture with the passage v, placing the latter periodically in communication with each end of the passage v and closing one end thereof when the other is open. In Fig. 1 a portion of an atomizer-nozzle w is shown at the entrance of one end of said passage v, and through this nozzle the liquid or gaseous combustible is drawn, through the passages v and u and the chamber o, into the cylinder upon the suction-stroke of the piston in the latter, a suitable amount of air entering the passage v through the annular opening around the end of the nozzle w in the end of said passage v. In Fig. 1 of the drawings the piston is shown as having accomplished one-half of its return stroke after its effective forward stroke, and upon this return stroke the valve q will be open and the valve r will have closed the suction end of the passage v and left the passage u in communication with the opposite or discharge end of said passage, through which, as stated, the exhaust-gases will be expelled. The next forward stroke of the piston after the exhaust-stroke above mentioned will be the suction-stroke, and at the beginning of this stroke the valve r will move across the passage u and close the discharge end of the passage v, having free communication between the suction end of said passage with the passage u, and thence into the chamber o and cylinder, as described.

Now in order to vary the power of the motor according to the requirements of the work put upon it it is necessary to vary the amount of the explosive which may enter the cylinder to accomplish the work, and this is done by varying the time of closing the valve q during the suction-stroke of the piston. The time of the valve r (which is connected directly with the crank-shaft of the engine by means of a connection between its stem j and the connecting-rod i, already referred to) never varies, and it has two movements to one of the valve q. The latter receives its movements directly from the cam k. These movements are imparted to it as follows: A swinging yoke y is hung pivotally on the engine at z, and between its arms is the roller 1, made, preferably, with a thin edge, as shown, which is held in contact with the surface of said cam by a spring 2, and the prolongation of the stem of the valve q engages the pin 3, on which said roller 1 is supported, said stem for this purpose being provided with an extension 4, which is made adjustable, as at 5, to provide means for bringing the valve to a proper seat. Said cam is formed by taking a one-half portion of a transverse section of a cylinder and, leaving one edge thereof parallel with the axis of the cylinder, the other edge is cut off at an angle thereto. The surface of the piece is then worked down to form a sharp edge on both ends thereof—that is, the straight edge and the inclined edge. In the drawings, in Fig. 1, the inclined edge of the cam is shown uppermost and is indicated by the numeral 6. In Fig. 4 the straight edge of the cam is shown and is indicated by the numeral 7. The cam, as shown by the arrows in the drawings, revolves in such direction that the roller 1 mounts the cam from the side thereof having the straight edge 7, and hence whether the cam be drawn out more or less on its support the time of the beginning of the opening of the valve q will not be affected; but as said roller runs off of said cam at the inclined or oblique edge thereof the time of the closing of the valve q will be varied according as the cam is moved outward or inward on its support. If the roller is in the position shown in Fig. 1, then it is on the longest part of the cam and the valve q will remain open until the piston has moved nearly the whole length of the cylinder on its suction-stroke, and the machine will develop under these conditions its maximum power. If the cam is moved outwardly, as above described, then a narrower part of the cam will lie under the roller 1, and the valve q will close at a proportionately shorter stroke of the piston. Thus by the manipulation of the lever which is connected to the cam the operator can vary at will the power developed by the motor.

It is obvious that if the valve q closes at half-stroke on the suction-stroke of the piston the remaining half-stroke must be made against more or less vacuum-pressure; but this is so slight as not to be taken into practical account.

It will be seen by reference to Fig. 3 that at the narrowest or inner end of the cam there is provided a narrow circular ledge or flange 8, contiguous to the said edge, extending entirely around the stud e and whose surface forms a continuation of the surface of the cam where the latter is in contact therewith; but the surface of said ledge is parallel with the axis of rotation of the cam and is concentric therewith. By moving the cam outward to the limit of its movement this ledge 8 is brought under the roller 1, and the diameter of the ledge is such that when said roller is running thereon the valve q will be continuously held in a slightly-open position. With the valve q in this position the crank-shaft may be easily revolved, and while it is in motion the lever m may be operated to throw the cam inward, which will cause the roller i to run off from said flange onto the narrowest part of the cam, whereupon regular explosion within the cylinder will take place, starting the engine under its own power. The sole object of this ledge or flange 8 is to provide means for easily starting the engine.

Without the above-described provision for holding the valve q slightly open when the crank-shaft is revolved to start the machine it would be necessary to apply force enough to the crank-shaft to effect the compression, which, as is well known, is a laborious operation.

The sparking device shown herein is one of the type common to many explosion-engines as far as the general circuit is concerned; but the make-and-break devices for this circuit and the relation of the make-and-break device to the valve-operating cam *k* form an important part of the invention. As stated, the cam revolves but once to two revolutions of the crank-shaft, and the make-and-break device is operated from the extension *l* of the cam *k*, and it is constructed and arranged as follows: The two terminals 9 10 of the primary circuit of an induction-coil 11, in which is a suitable battery 12, are carried, respectively, to a binding-post 13, supported on the casing 14, which covers the circuit-breaking device, and to the end of a spring-lever 15, supported in the upper end of said casing. Said binding-post is insulated from the casing and said lever is in electrical connection therewith. The free end of said spring-lever 15 is turned in at an angle and forms thus a short finger 16, which is in contact normally with the long extension *l* of the cam *k*, which, together with the whole machine, is in the aforesaid electrical circuit, as is usual in this class of motors. In said extension *l* is cut the spiral groove 17, into which the finger 16 drops as the cam revolves. On the binding-post 13 is provided a contact-point 18, and on said lever 15 is a second contact-point 19, the distance between said points being less than the depth of the groove 17. Hence whenever the finger 16 drops into said groove the said two contact-points come together, completing the circuit, which sets up a current in the secondary circuit of the induction-coil, which comprises the wires 20 21, one of which, 20, is connected with the insulated binding-post 22 in the rear end of the cylinder and which extends into the latter, as shown in Fig. 1, the other wire 21 being connected with the cylinder, as at 23, Fig. 2, a small wire finger 24 being inserted in the wall of the cylinder within the latter and having its end turned down into proximity to the end of the binding-post 22. When the finger 16 drops into the groove 17, and thus completes the circuit, as described above, the primary circuit of the induction-coil 11 is energized, and as said finger moving out of the groove 17 breaks the contact the secondary circuit of the induction-coil becomes in turn energized, causing the current to bridge the gap between the ends of the two fingers in the rear end of the cylinder, thus producing a spark by which the charge of explosive can be fired.

When the engine is to develop its maximum power, the suction-stroke of the piston will take in a volume of explosive mixture nearly equal to the cubic contents of the cylinder, and on the compression-stroke of the piston the firing of this charge will take place just prior to the completion of said compression-stroke—that is to say, the finger 16 will drop into the groove 17 of the cam extension *l* just before the end of the compression-stroke is reached by the piston.

When the piston is drawing in a smaller quantity of explosive, it is desirable that the time of the firing of the charge should be delayed in proportion to the diminution of the latter. If the explosion of the charge should invariably take place when the piston arrives at a certain point in the cylinder, then said groove 17 would be laid out parallel with the axis of the cam extension; but as it should be delayed, as above specified, according to the quantity of explosive mixture in the cylinder said groove has been laid out on said cam extension on a spiral course, the pitch of which is such as to produce the firing of the charge at the proper time when the cam is drawn out on its stud to reduce the quantity of material to be admitted to the cylinder, as described.

While it is desirable to explode the full charge of explosive before the complete compression thereof, it is impossible to do this with a light charge in the cylinder, for the reason that when running under a light charge the engine does not acquire sufficient momentum from one stroke to complete the compression of the following stroke if added to that compression resistance there is the further resistance to be overcome consequent upon an explosion prior to the full completion of the compression-stroke. When the engine is running under a minimum charge of explosive, the time of sparking will be delayed until the full compression-stroke has been completed or even a little later, if desired. If this provision were not made, then an explosion occurring before the completion of the compression-stroke would overcome the momentum of the piston and the latter would be driven back without having completed its cycle.

The above-described valve mechanism is of extreme simplicity, is practically noiseless, has a wide and rapid range of adjustment, and permits suitable variation in the time of sparking relative to the power to be developed. Furthermore, all springs are eliminated from the valves proper. It is to be noted also that the same valve *q* serves both as an inlet and exhaust valve and that when said valve closes it is always against an inwardly-moving current. Hence the operation thereof is noiseless.

Having thus described my invention, what I claim, and desire to secure by Letters Patent of the United States, is—

1. In an internal-combustion engine, a cylinder, a single puppet-valve serving both as an inlet and an exhaust valve for the cylinder, adjustable valve-operating devices for imparting movements to said valve, and means for adjusting said devices during the operation of the machine, whereby said valve

may be opened more or less, substantially as described.

2. In an internal-combustion engine, a cylinder, a piston therein, a single valve-port and valve therefor, serving as an inlet and exhaust port for the cylinder, an inlet-passage for an explosive charge, a passage for exhaust-gases, both in communication with said valve-port, and a second valve arranged to alternately open and close said communication between each of these passages and the valve-port, at the proper times, and means for actuating said valves, substantially as described.

3. In an internal-combustion engine, a cylinder, a piston therein, a single valve-port serving both as an inlet and an exhaust port for the cylinder, a valve for said port, and means for operating said valve, whereby the time of its closing may be varied, relative to the position of the piston in said cylinder, without varying the time of its opening, combined with a sparking device constructed and arranged to be operated by the valve-operating means, whereby the time of ignition of the explosive charge may be changed simultaneously with the change of time of said valve, substantially as described.

4. In an internal-combustion engine, a cylinder, a piston therein, a single valve-port and valve therefor serving as an inlet and exhaust port for the cylinder, an inlet-passage for an explosive charge, a passage for exhaust-gases, both in communication with said valve-port, and a second valve arranged to alternately open and close said communication between each of these passages and the valve-port at the proper times, means for actuating said valves, and means for changing the time of closing of said first-named valve, while the movements of the second valve remain uniform, substantially as described.

5. In an internal-combustion engine, a cylinder, a piston therefor, a valve-port serving both as an inlet and exhaust port, and a valve therefor; an inlet-passage for explosive mixture, and a passage for the exhaust-gases, both in communication with said valve-port; a crank-shaft, a second valve operated by the latter, arranged to alternately close said inlet-passage and said exhaust-passage; a rotating cam having one edge thereof lying diagonal to its axis of rotation, means of connection between said cam and said first-named valve whereby the latter is opened and closed, and means for moving said cam lengthwise of its axis, to vary the time of closing of said valve, substantially as described.

6. In an internal-combustion engine, an adjustable puppet-valve for controlling the admission of explosive mixture, and serving also as an exhaust-valve, a tapered cam for actuating said puppet-valve, an annular flange on said cam, whereby said valve may be held continuously open, and means for moving the cam endwise during the operation of the machine, to variably operate said valve, substantially as described.

7. In an internal-combustion engine, a cylinder and piston, a crank-shaft connected with the latter, a rotatable tapering cam supported near the crank-shaft parallel therewith, and rotated thereby at a different speed from said shaft, a valve-port in said cylinder serving both as an inlet and an exhaust port, a valve for said port operatively connected with said cam, means for moving said cam to bring different portions of its bearing-surface into operative relation with said valve, combined with a sparking device and means operated by the cam, whereby the time of sparking is governed by changes made in the position of said cam to vary the time of the valve, substantially as described.

8. In an internal-combustion engine, a cylinder, a piston therein, a single valve-port serving both as an inlet and an exhaust port for the cylinder, a valve for said port, and means for operating said valve, combined with an inlet-passage and an exhaust-passage, both in communication with said valve-port, a second valve adapted to close said passages in succession, and means for actuating said last-named valve, substantially as described.

9. The combination in an internal-combustion engine, of a cylinder having a piston therein, a single valve-port for said cylinder, serving both as an inlet and an exhaust port; a passage leading to said port, a valve for the latter and a valve for said passage; positive means for actuating the valve in said passage in unison with the piston, and means for variably operating the valve for said port relative to the position of the piston.

10. The combination in an internal-combustion engine, of a cylinder having a piston therein, a single valve-port for said cylinder, serving both as an inlet and an exhaust port; a passage leading to said port, a valve for the latter and a valve for said passage; positive means for actuating the valve in said passage in unison with the piston, and adjustable means for actuating the valve for said port, consisting of a slidable cam having one edge inclined to its axis, and means of connection between the cam and said valve, substantially as shown.

11. The combination in an internal-combustion engine, of a cylinder having a piston therein, a single valve-port for said cylinder, serving both as an inlet and an exhaust port; a passage leading to said port, a valve for the latter and a valve for said passage; positive means for actuating the valve in said passage in unison with the piston, combined with a sparking device, and operative connections between the latter and the means for actuating the valve for said port, whereby the regulation of said valve will coincidently effect the adjustment of said sparking device.

12. In an internal-combustion engine, a cylinder, a single puppet-valve serving both as

an inlet and an exhaust valve for said cylinder, a tapered cam for imparting movement to said valve, an annular flange on said cam, means of connection between the valve and the cam, and means for adjusting the latter during the operation of the machine, whereby the valve may be operated either by said cam or said annular flange, substantially as described.

13. In an internal-combustion engine, a variable cut-off puppet-valve for controlling the admission of explosive mixture to the engine and for controlling the eduction of exhaust-gases therefrom, electric igniting devices, and means for operating said cut-off valve during the operation of the machine, and for simultaneously varying the time of operation of said igniting devices, substantially as described.

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