No. 723,503. PATENTED MAR. 24, 1903.

E. THOMSON.

INTERNALLY FIRED ENGINE.

APPLICATION FILED FEB. 6, 1899.

NO MODEL. 2 SHEETS—SHEET 1.

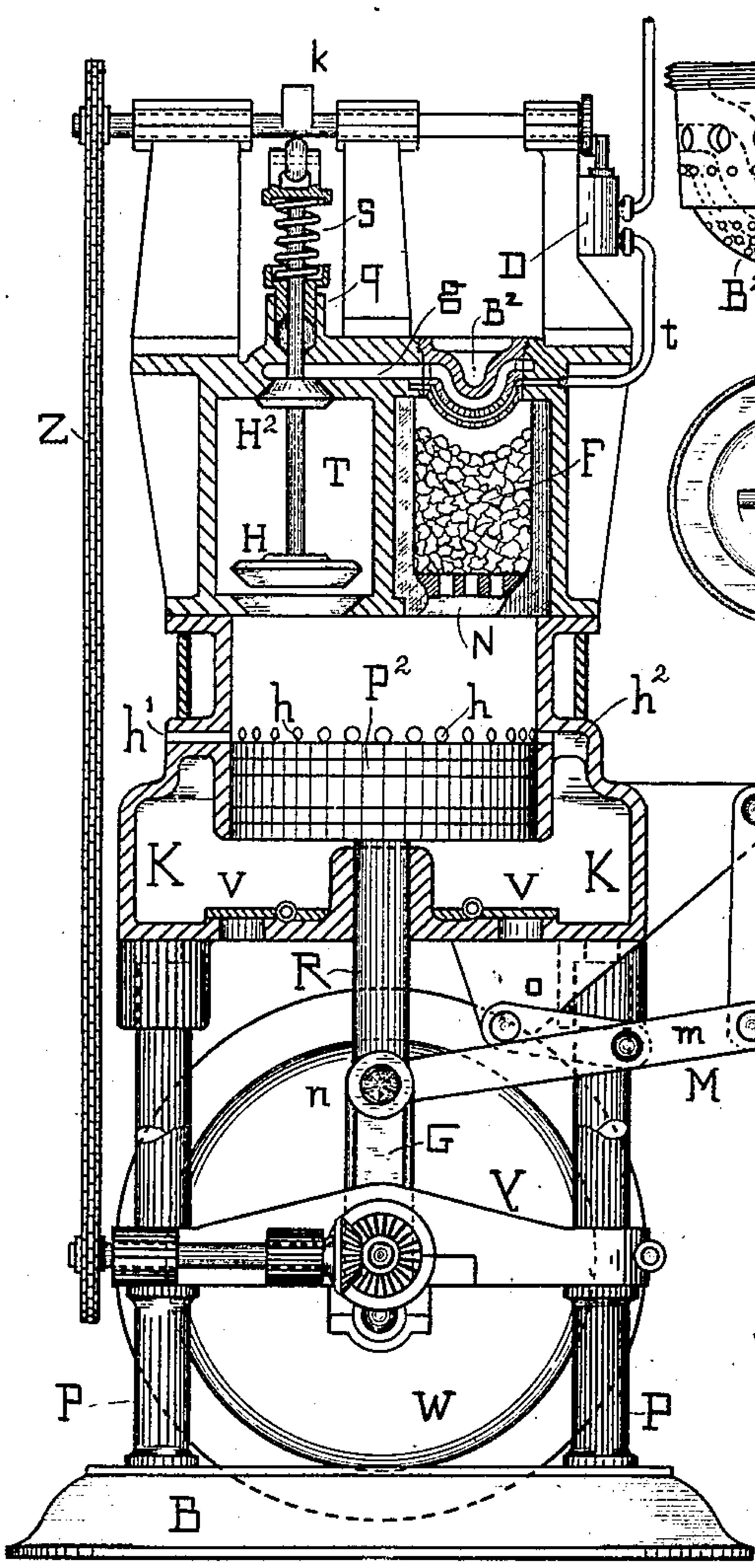

FIG. 1.

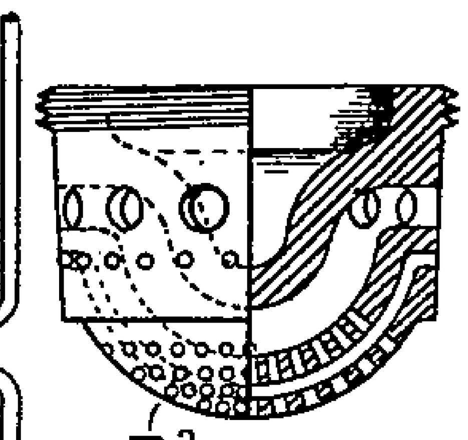

FIG. 4.

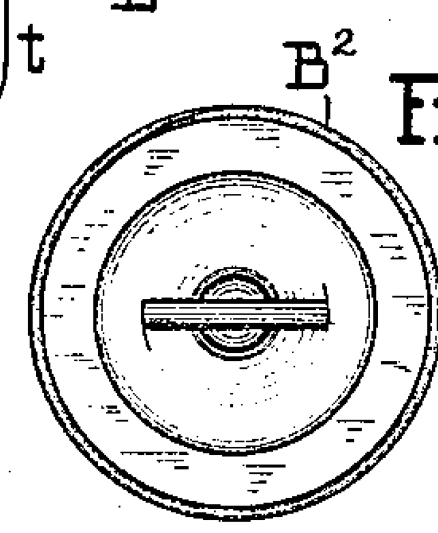

FIG. 5.

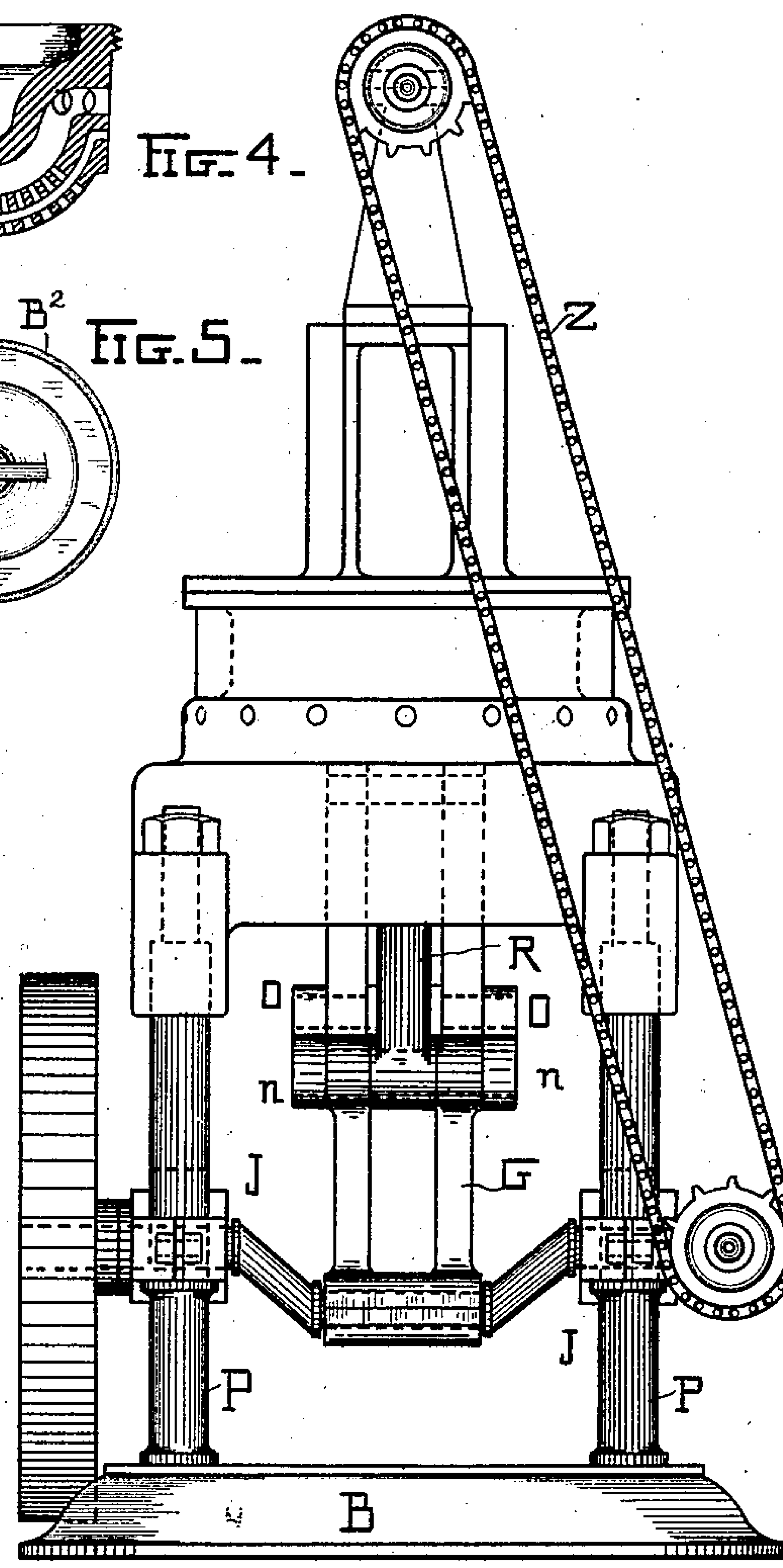

FIG. 2.

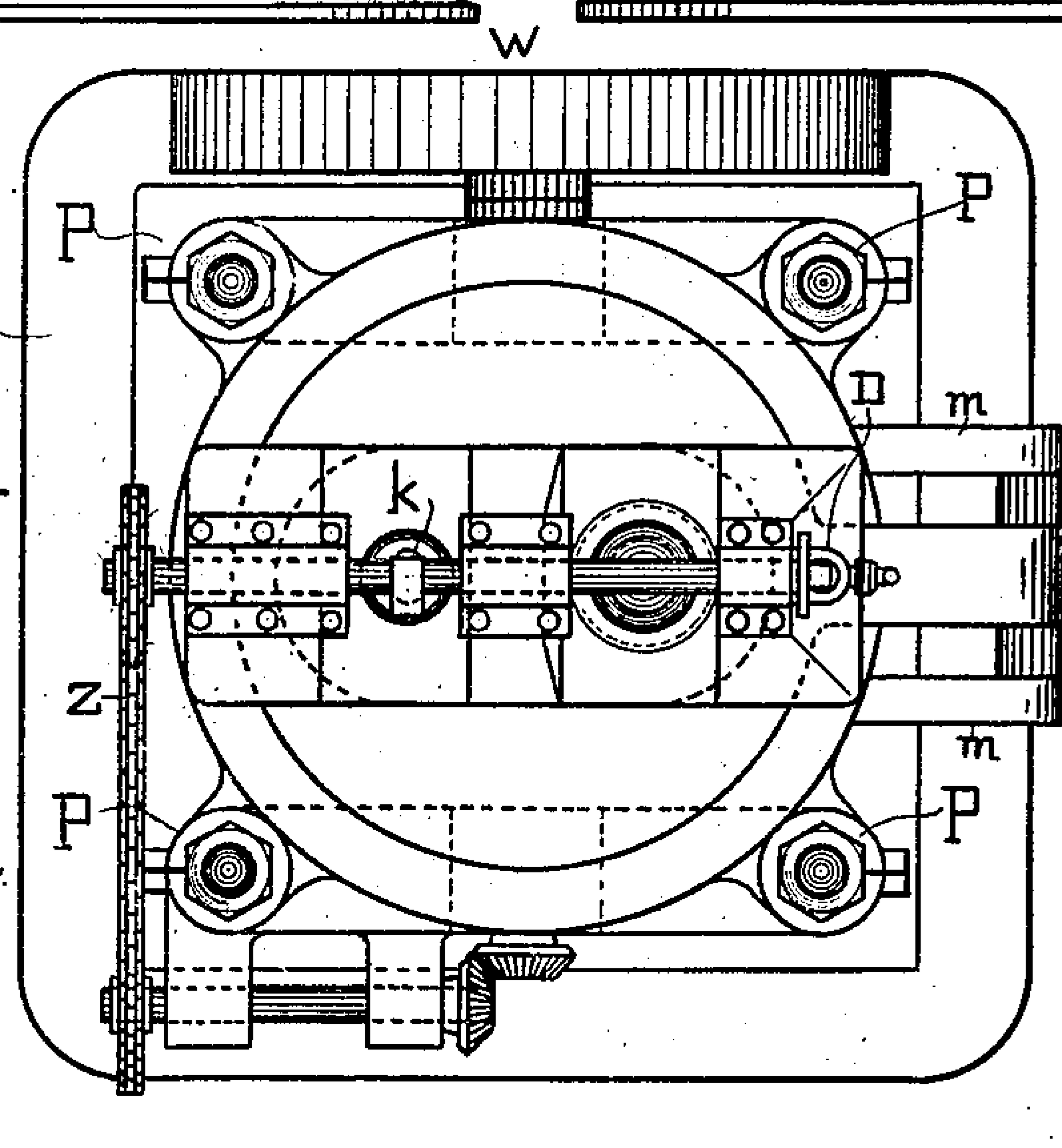

FIG. 3.

WITNESSES.

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NO MODEL. 2 SHEETS—SHEET 2.

FIG. 6.

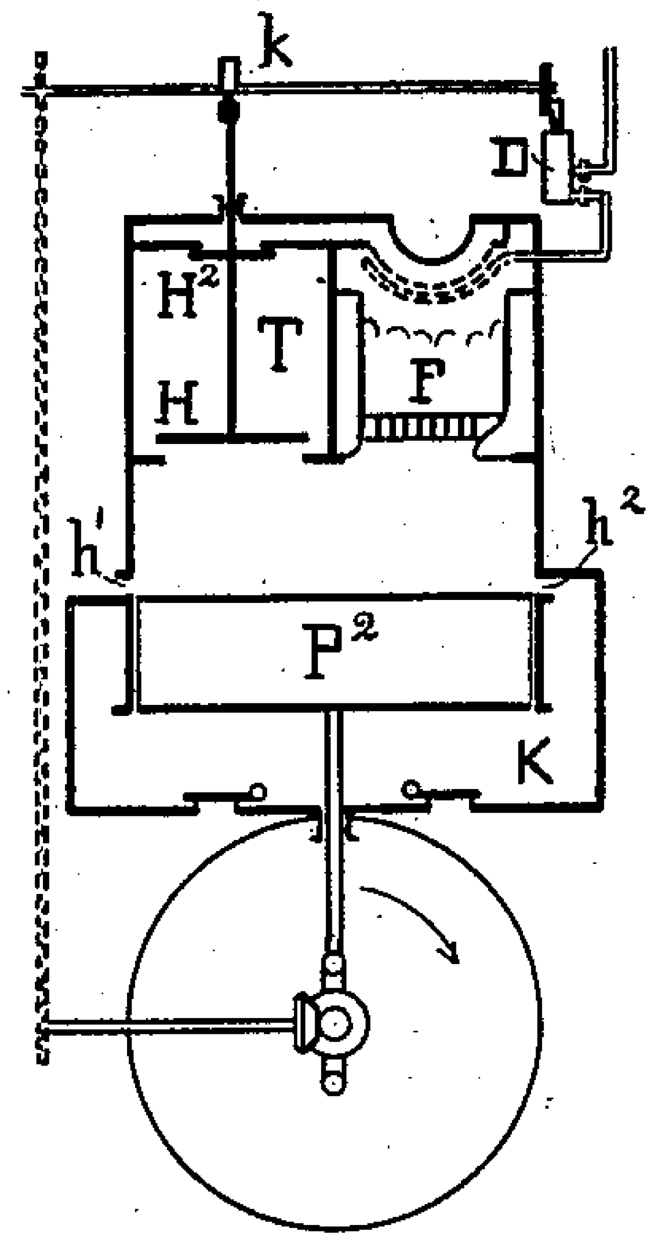


FIG. 7.

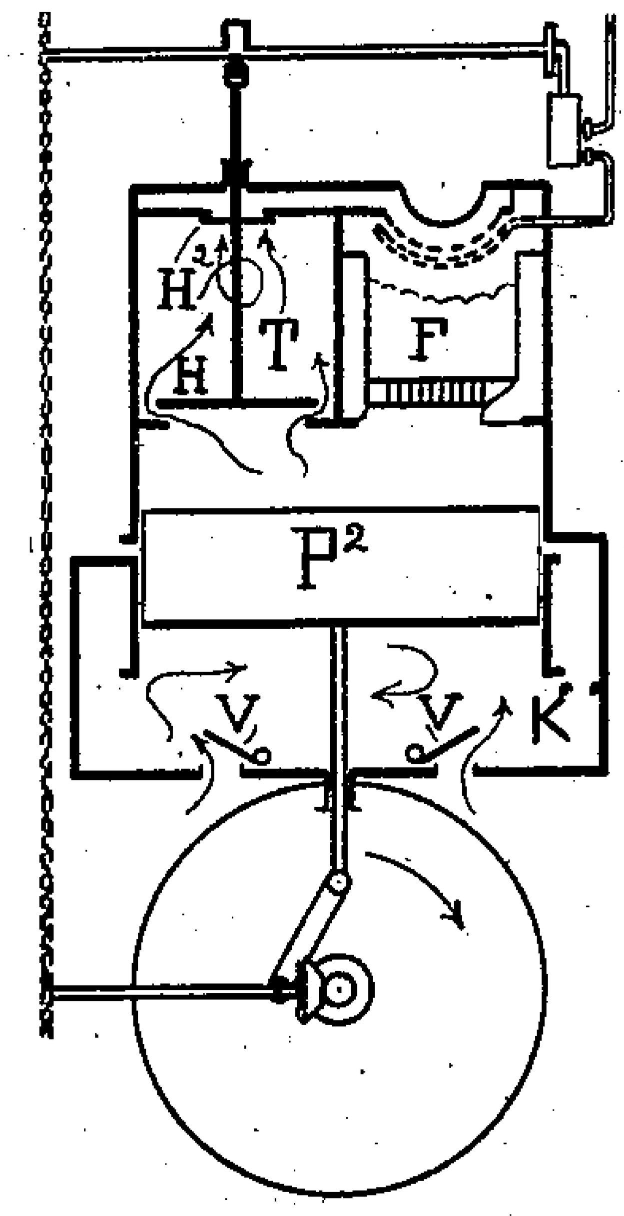


FIG. 8.

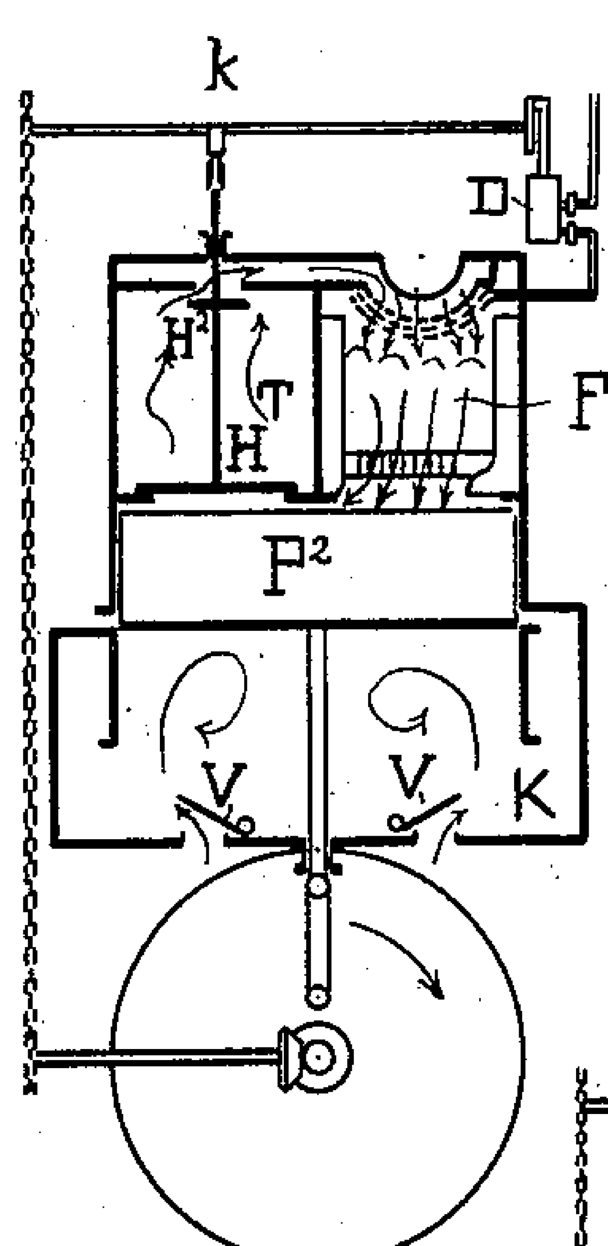


FIG. 9.

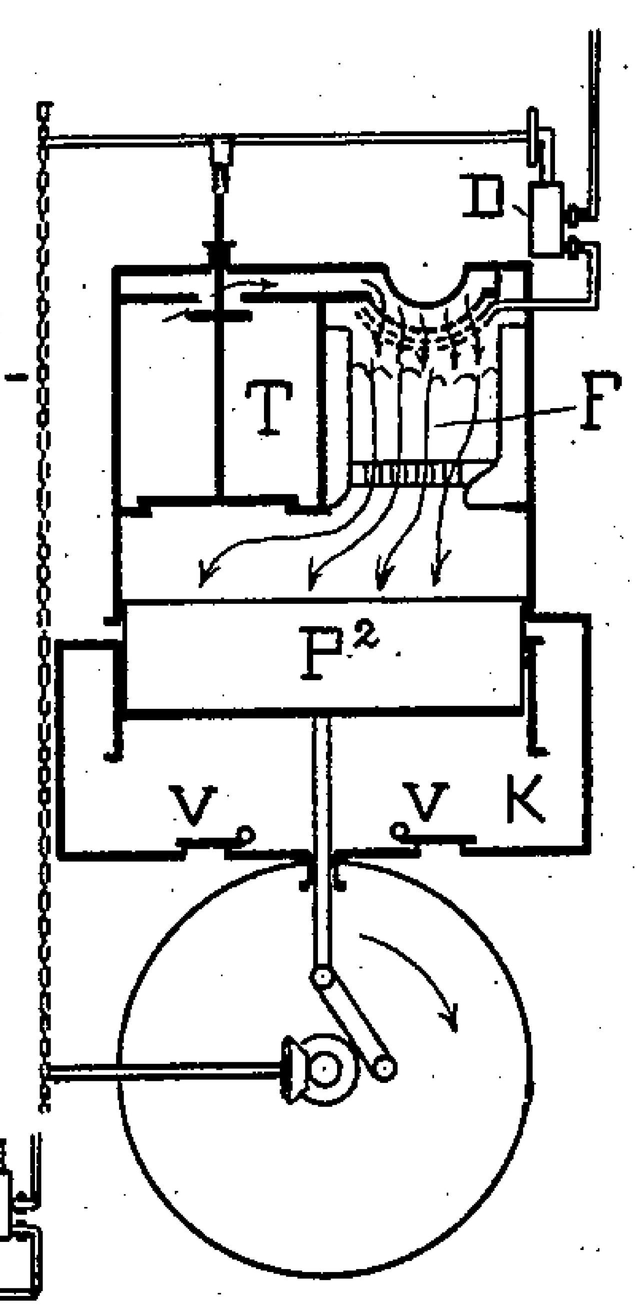
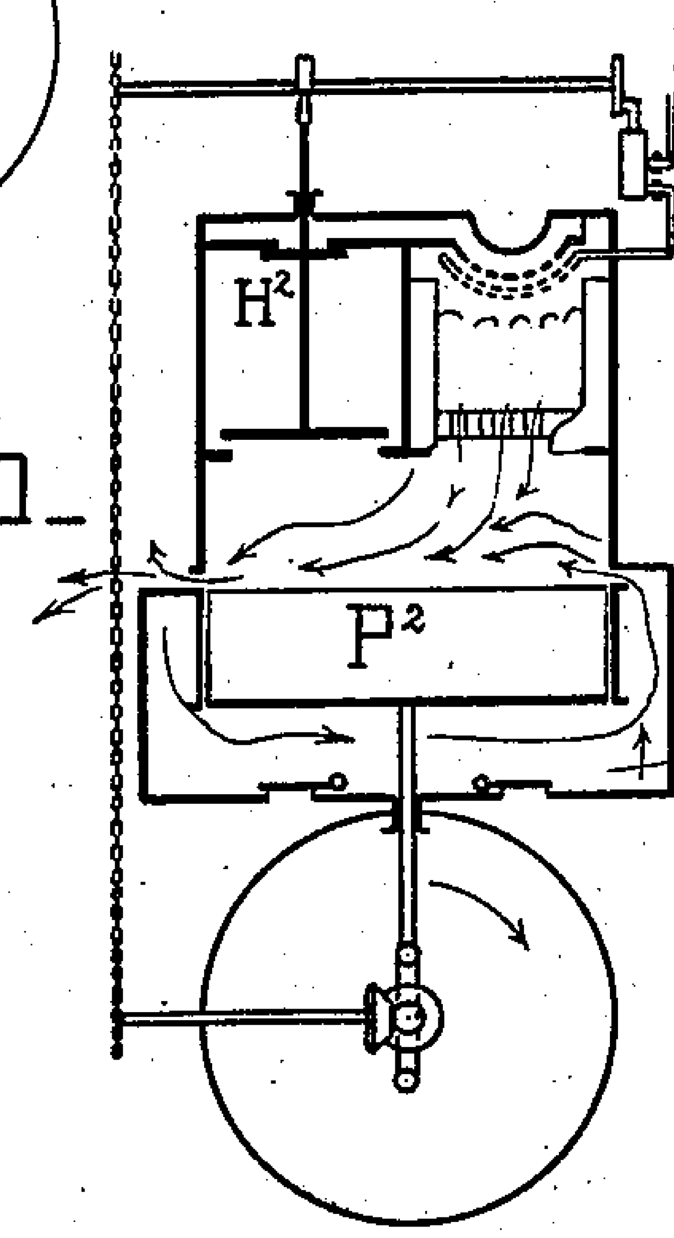


FIG. 10.



WITNESSES.

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UNITED STATES PATENT OFFICE.

ELIHU THOMSON, OF SWAMPSCOTT, MASSACHUSETTS.

INTERNALLY-FIRED ENGINE

SPECIFICATION forming part of Letters Patent No. 723,503, dated March 24, 1903.

Application filed February 6, 1899. Serial No. 704,719. (No model.)

To all whom it may concern:

Be it known that I, ELIHU THOMSON, a citizen of the United States, residing in the town of Swampscott, county of Essex, and State of Massachusetts, have invented a new and useful Improvement in Internally-Fired Engines, of which the following is a specification.

The object of my invention is to construct an engine which shall be simple and effective and which shall be capable of operating by the combustion of fuel internal to the engine. The broad principle of operation is largely the same as that of the engine of my application, Serial No. 671,963, filed February 28, 1898. The present invention differs from that of the said application in combining means for obtaining an impulse every revolution with each cylinder. It also differs in some details.

The principle of my invention is, briefly, as follows: Air is taken into the space back of the piston on the forward motion of the same, it being preferably injected from a space into which it has been previously slightly compressed. If the cylinder-space be filled with burned gas and the products of combustion, the injected air largely takes its place and expels said products of combustion through suitable openings. The air so introduced is compressed upon the return of the piston into a space adjoining the cylinder. While being thus compressed it passes a valve which has been opened and which has been kept open during the time of compression. The piston on reaching the bottom of the cylinder or on reaching the end of its inward stroke, there being but little clearance provided, has thus compressed the volume of gas which was in the cylinder into the compression-space. The valve between the compression space or chamber and the cylinder is now closed and a passage-way provided, so that on the return of the piston or during the forward stroke the air which had been compressed passes through the fire-box or fire-space into which the oil or other combustible is fed. This fire-box or fire-space is in connection directly with the cylinder-space, and the return of the compressed gases is therefore through the fire-space, whereby they are heated and expanded to a high degree. The power obtained from the engine is due to the difference of volume of the gas within the cylinder compressed at low temperature and the expansion of the same at high temperature after passing the fire-space.

My invention will be better understood by reference to the accompanying drawings.

Figure 1 is a side elevation, partly in section. Fig. 2 is an end elevation. Fig. 3 is a plan of an engine constructed in accordance with my invention. Figs. 4 and 5 show the jet or burner for mixing oil and vapor with air and burning the same. Figs. 6, 7, 8, 9, and 10 are diagrammatic views showing the sequence of actions which take place during the operation of an engine of my invention.

It is to be understood that in details of valve arrangements and valve-moving mechanism, disposition of parts, and so on it is not necessary to follow the drawings; but they may be widely modified without departing from the invention itself. Moreover, I have not shown any governing devices for controlling the speed of the engine, as these are not necessary to the operation of same under certain conditions, and governing mechanism of many types may be employed. Thus I may simply cut off the oil-supply when the speed exceeds certain limits, or I may (while cutting off the fuel or other supply) keep open the valve between the cylinder and the compression-space. As the governor forms no part of the present invention, I have not illustrated or described any methods of accomplishing the maintenance of a uniform speed.

In Figs. 1, 2, and 3, B may represent a base-plate and W a fly-wheel mounted upon the shaft of the engine, which is carried in suitable bearings, as at J J, sustained from the base. As shown, these journals are carried on a sort of yoke Y, adjoining two upright pillars, there being four pillars shown, P P P P, supporting the upper parts of the engine, which is of a vertical type, though not necessarily so. Connecting-rods are shown at G and the piston-rod at R. The piston-rod may be suitably guided, as on slides, or a parallel-motion arrangement may be employed, as is indicated in the figures at M. Though forming no essential part of my present invention, I will briefly refer to the parts of this parallel motion. A link *l* is hung from a projecting portion of the framework and pivoted to the link-pieces *m m*. The other ends of these links *m m* are pivoted to the outer end of the piston-rod, as at *n*. A third pair of links *o o* is provided, one end of each being pivoted to a link *m* and the other to a fixed portion of the frame. When the piston is in mid-position, the pivotal points of the pieces *m*, *n*, and *o* are in line, and, as shown, the pivotal points are made such that the smaller links *o o* coincide with the middle third of the long links *m m*,—*i. e*, the fixed pivot of the links *o o* will be distant from the pivots *n n* of the piston-rod one-third of the length of *m*—the length of the links *o o* being thus (between their pivotal points) equal to one-third that of the links *m m*, and the remaining third of said links *m m* is between the pivotal points of *o o* and the pivotal points of the links *l l* to *m m*. This arrangement will, if the links *l l* be of some length, give substantially a parallel movement—*i. e.*, the pivotal points *n n* on the piston-rod R will traverse nearly straight lines back and forth. Changes in proportion may, as is well understood, be made in such an arrangement and parallel action still be produced. The piston-rod R passes through an opening in what may be termed the "lower part" of the cylinder-case K K. In the head of this case are preferably arranged valves V V, which open inwardly on a slight difference of pressure existing between the exterior air and the air within the space K K. The valves close when such a pressure has been equalized. The piston P^2 is shown as down, at which position it uncovers the series of holes *h h*, part of which are the exhaust-openings from the cylinder-space and part of which form openings or passages of communication between the space K K below the piston and the space above the piston. I have illustrated by *h'* an opening which may be called an "exhaust" opening, and which may lead to any suitable exhaust-space, and by h^2 an opening which communicates between K K and the space above the piston P^2. It is preferred to make each alternate hole of the series *h h* an exhaust-opening, and the remainder will be transfer-openings, such as h^2. A large opening in the cylinder-head above is controlled by the valve H, and this opening communicates with space T, which may be called a "compression" space or chamber, since on the upward motion of the piston P^2 the greater part of the gas in the cylinder is forced into said space under increasing pressures. The valve H, operating by a stem running through a stuffing-box at *q*, is controlled by a suitable cam *k* upon a cam-shaft or by other mechanism receiving its motion directly from the motions of the engine and synchronizing therewith. This shaft in the figure is driven by a chain Z, running over suitable sprockets, the lower one moved, as is plainly evident in the figure, by the shaft of the engine and the other one mounted on the shaft bearing the cam *k*. A pump D, operated by the motions of the engine, suitably communicated, serves to supply oil to the engine, as will be described. A spring S is shown as tending to open the valve H, the cam *k* acting to close the same. The valve H is, in fact, arranged to be closed during that part of the revolution which corresponds to the downward motion of the piston P^2, and to be opened during that part of the revolution which corresponds to the upward stroke of the piston P^2. The compression-space T communicates by a passage *g* with the upper end of the fire-space and with a suitable jet or fuel and air-mixing device seated at the upper part of the fire-space shown at F. It is preferred to provide a valve H^2, which closes the passage *g* whenever the piston P^2 is on the upstroke and opens communication from the space T through *g* whenever the piston is on the downstroke.

The jet or burner B^2 (shown separately in Figs. 4 and 5 for clearness) is simply a device for causing the air compressed in T to pick up and distribute the oil discharged by pump D. To this end it is made with passages for the entrance of air from the duct *g* and passages for the entrance of oil from the pipe *t*, led from the pump D. It is also made with the openings directed toward the fire-space—*i. e.*, downwardly—the openings for air intersecting the passage for oil, so that the oil will be picked up and distributed in the fire-space. The fire space or chamber F is preferably lined with refractory material and filled with refractory material having perforations therethrough, or the fire-space is nearly filled with pieces of fire-resisting material, such as hard-baked fire-clay, supported on the lower grid N of refractory material. The object is to have the space F as thoroughly filled as possible consistent with the free combustion of the air and oil in passing therethrough.

Having described the general construction of the engine embodying my invention, I will now proceed to indicate the manner of its operation. To start the engine, the fire-plug or burner B^2 is removed, as by unscrewing it, when it has been constructed with a thread, as shown. The piston P^2 is placed in its lowest position, as shown in Fig. 1. A gas or oil blowpipe or torch has its flame now driven down through the mass of perforations or pieces of refractory material in F, so as to bring a portion of the same to a red heat. Instead of doing this the refractory material itself might be removed and heated separately in a crucible or furnace and put in place before starting. The fire-plug or burner B^2, itself made hot is now screwed into place, whereby the openings through it are made to reach the air-duct *g* and the openings from the pump D feeding oil, which oil may be any of the forms of petroleum, such as kerosene-oil, gasolene, &c. Now on giving the engine a turn the piston P^2 rises, the valve

H is opened, and the air above the piston P^2 is forced into the compression-space T, which is comparatively cool. It is to be understood that both the compression-space T and the cylinder-walls themselves may be water-jacketed or otherwise cooled for preventing too great increase of temperature. When the piston P^2 is raised to the upper limit of its stroke, nearly all the air in the cylinder will have been forced into the space T. A little of it will, however, have gone into the fire-space F; but inasmuch as its entrance into the fire-space F is attended by great expansion, due to the high temperature of the same, the amount which passes into the fire-space, is restricted. The valve H now shuts and the valve H^2 is opened. The piston begins to descend. The compressed air in T can now only get back to the cylinder by passing through the burner B^2 and the fire-space F, where it meets the fuel and is thereby burned, and the hot expanding gases are delivered from the lower part of the fire-space, as at N, back of the piston. The mean effective compression-pressure is naturally much lower than the mean effective expansion-pressure, owing to the difference of temperature, and it is to this difference of mean effective pressures that the power of the engine is due. When the piston P^2 has reached its lowest point, a rush of air takes place from the space K K through the openings h^2, while the heated or expanded gases are in large part blown out of the exhaust-openings, such as h'. The air which had accumulated in K K had been taken in on the ascent of the piston by the valves V V opening and had been slightly compressed on the descent of the piston-rod.

Of course a separate air-pump might be used instead of making the piston P^2 pump its own air, and it will be understood, further, that the various fuels and methods of supplying the same shown in my application Serial No. 671,963 referred to may be employed in the operation of the present invention.

I now briefly call attention to the diagrammatic Figs. 6, 7, 8, 9, and 10. In Fig. 6 the piston P^2 is down and the washing-out process is taking place through h^2 from K, while the ejection of the hot waste gases is occurring from h'. The valve H is just opening, as determined by the cam k on the cam-shaft, while valve H^2 is shutting. Fig. 7 shows what is occurring when the piston P^2 is rising. The air above it is being compressed into space T and the valves V V are opening and allowing the space K to fill with air on the upstroke of the piston P^2. In Fig. 8 the valve H is closed and H^2 open, so that the air which was in the cylinder above P^2 is now compressed in the space T. The cam k has closed the valve H and opened H^2. Meanwhile oil is being pumped by the pump D into the burner. On the descent of the piston, as in Fig. 9, valves V V close and what air is in K is undergoing a moderate reduction of volume. The air in T, however, is now passing through the fire, meeting the oil from pump D, and gives increased combustion, which highly heats the products of combustion. These products are expanding and exert pressure on the piston P^2 during the downstroke. On the completion of the downstroke the parts come into the same relation as in Fig. 6. Fig. 10 shows the action which at that moment occurs. This completes the cycle.

It may be stated that the valve H^2 may, indeed, be dispensed with if there is a fair amount of resistance to the passage of the gases during compression through the fire-chamber F, for in this case very little gas when the valve H is wide open will pass into T through the fire-space, and most all of it will reach the compression-space T through the large opening uncovered by the lifting of the valve H. I prefer, however, to provide the valve H^2, inasmuch as it effectively shuts off the possibility of any oil or vapor of a combustible nature reaching the compression-space T.

It will be seen that my invention produces an engine giving a power impulse every revolution and that it does not burn its combustible by explosion producing shock and that, furthermore, it is possible to obtain a very complete combustion, since the air supplied may be in excess of the combustible and since, further, all the combustible has to pass in reaching the cylinder through an intensely-heated mass of material, which destroys its power to emit odor.

What I claim as new, and desire to secure by Letters Patent of the United States, is—

1. In an engine, the combination of a piston and cylinder, means for injecting a slightly-compressed charge of air into the cylinder at or about the completion of the piston-stroke, a compression-space opening into the cylinder wherein the charge is further compressed by the movement of the piston, a fire space or chamber communicating with the compression-space and the cylinder, and means for closing the opening between the compression-space and the cylinder whereby the charge is compelled to pass through the fire-chamber and be heated on its return to the cylinder.

2. In an internally-fired engine, the combination of a cylinder, a piston, means for injecting a more or less compressed charge of air into the cylinder, a compression-space in communication with the cylinder, means for increasing the compression of the said charge, a fire-space communicating with the cylinder and the compression-space, and a valve for closing the opening between the compression-space and the cylinder so that the charge is obliged to pass through the fire-space on its return to the cylinder.

3. In an internally-fired engine, the combination of a cylinder, exhaust-ports therefor, a piston moving in said cylinder and arranged

to compress a charge of air on its inward stroke, a compression-chamber opening into the cylinder and arranged to receive the air which is compressed by the piston, a valve for closing the opening during the power-stroke of the piston, a second chamber lined with refractory material and connecting with the first, means for supplying fuel to the second chamber, and means for injecting into the cylinder under pressure a fresh charge of air to replace, in whole or in part, the spent gases.

4. In an internally-fired engine, a cylinder, a piston, a fire-chamber, a compression-chamber opening into the cylinder and also into the fire-chamber, means for supplying fuel to the fire-chamber during the power-stroke of the piston, means for cutting off communication between the compression-chamber and the cylinder except through the fire-chamber, and means for displacing the spent gases by fresh air under pressure upon the completion of the power-stroke.

5. In an internally-fired engine, the combination of a cylinder, a piston, a compression-chamber opening into the cylinder, a fire-chamber opening into the compression-chamber and also the cylinder, a valve which closes the opening between the compression-chamber and the cylinder on each power-stroke of the piston, and a second valve which opens the passage between the fire and compression chambers at or about the time the first-mentioned valve closes.

6. In an internally-fired engine, the combination of a cylinder, a piston, a compression-chamber opening into the cylinder, a fire-chamber which is permanently open to the cylinder and also opens into the compression-chamber, a double valve acting to control the action of the compression-chamber, a cam for actuating the valve, and a mechanical connection between the moving parts of the engine and the cam.

7. In an internally-fired engine, the combination of a cylinder, a piston, a chamber into which the cylinder opens and in which the air charges are initially compressed by the piston, valves in the chamber permitting air to enter but not to escape, valve-openings which are uncovered by the piston for permitting the initially-compressed charge to enter the cylinder back of the piston, a chamber in which the charge of air is further compressed, and a fire-chamber in which the charge of air mingles with the proper amount of combustible, after which it returns to the cylinder.

8. In an internally-fired engine, the combination of a cylinder, a chamber into which the cylinder opens, a set of ports or openings between the chamber and the cylinder, a second set of ports or openings connecting the cylinder with the atmosphere, the ports of one set alternating with those of the second set, and a piston for the engine, which alternately opens and closes the sets of ports or openings.

9. In an internally-fired engine, the combination of a chamber, a cylinder opening into the chamber, a piston arranged to move within the cylinder and give an initial pressure to a charge of air at the forward end of each stroke, a valve for regulating the passage of this charge into the cylinder, a chamber opening into the cylinder in which the final compression is given to the charge by the piston on its return stroke, a fire-chamber opening into the cylinder, and means for closing the direct opening between the compression-chamber and the cylinder, and permitting the charge to enter the fire-chamber on its return to the cylinder.

10. In an internally-fired engine, the combination of a cylinder, a chamber connecting with one end of the cylinder, a second chamber connected to the opposite end of the cylinder, a piston which on the forward stroke gives an initial pressure to the charge of air in the first-mentioned chamber, and on its return stroke completes the compression of said charge and discharges it into the second chamber, a means for mixing fuel with the charge after it is compressed, and a chamber containing a body of fire-resisting material for heating and expanding said charge for actuating the piston.

11. In an internally-fired engine, the combination of a cylinder, a chamber connected therewith, a port between the cylinder and the chamber, a piston which compresses a charge of air and uncovers the port on its outward stroke, and further compresses the charge of air on its inward stroke, a compression-chamber which receives the air after it is compressed for the second time, a fire-box arranged to receive the charge from the compression-chamber and deliver it to the rear of the piston, and automatic means for supplying fuel to the fire-box.

12. In the internally-fired engine, the combination of a cylinder, a chamber connected therewith, a port between the cylinder and the chamber, a piston which compresses a charge of air and uncovers the port on its outward stroke, and further compresses the charge of air on its inward stroke, a compression-chamber which receives the air after it is compressed for the second time, a valve for closing the compression-chamber to the cylinder on the power-stroke of the piston, a fire-box, a fuel-pump arranged to deliver fuel to the fire-box and a driving connection between the engine and the pump.

In witness whereof I have hereunto set my hand this 3d day of February, 1899.

ELIHU THOMSON.

Witnesses:

DUGALD MCKILLOP,

HENRY O. WESTENDARP.