O. KRAUS.

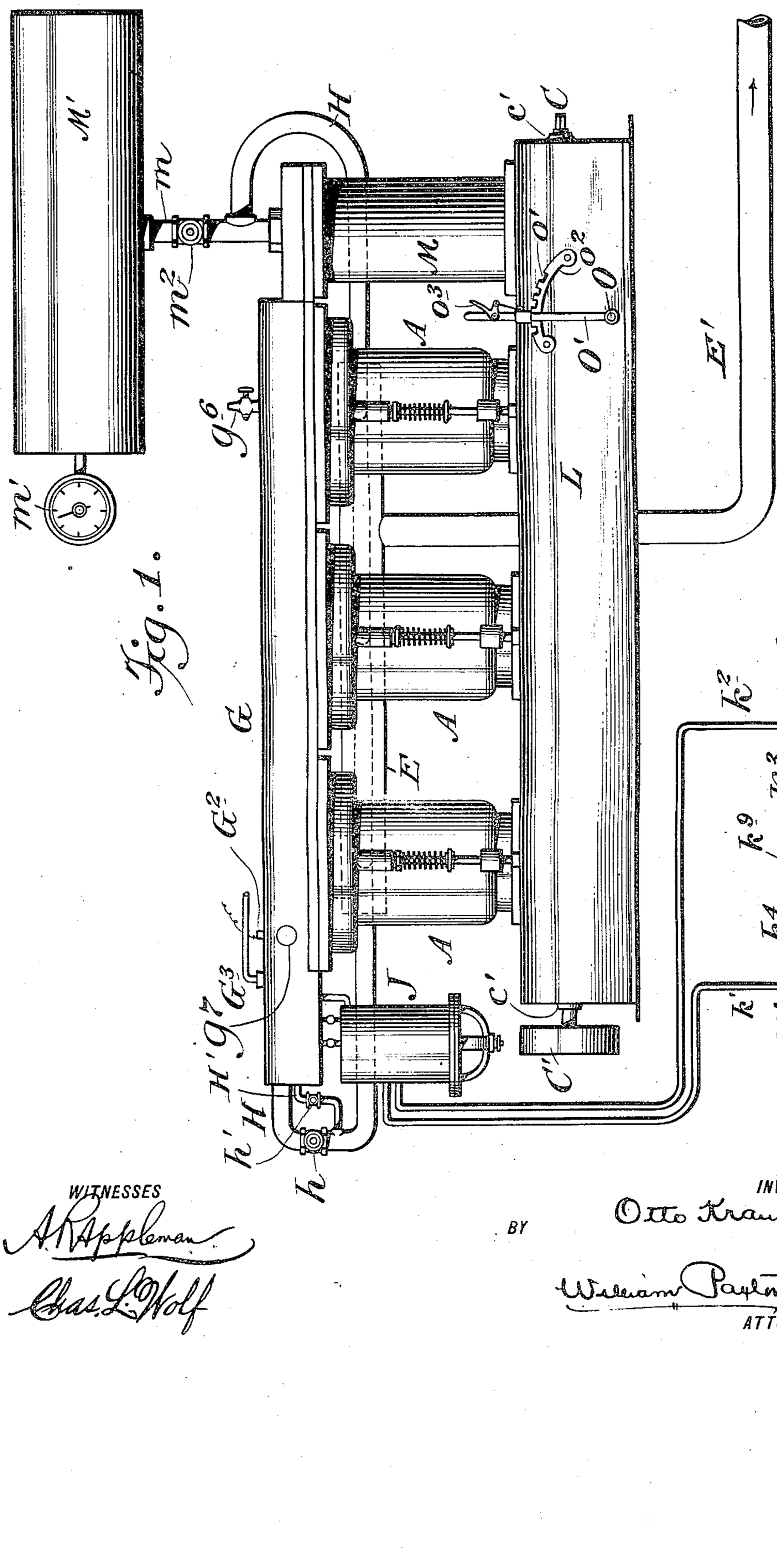
INTERNAL COMBUSTION ENGINE.

APPLICATION FILED NOV. 16, 1904.

980,801.

Patented Jan. 3, 1911.

3 SHEETS—SHEET 1.



WITNESSES

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3 SHEETS—SHEET 2.

Fig. 5.

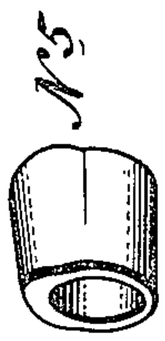
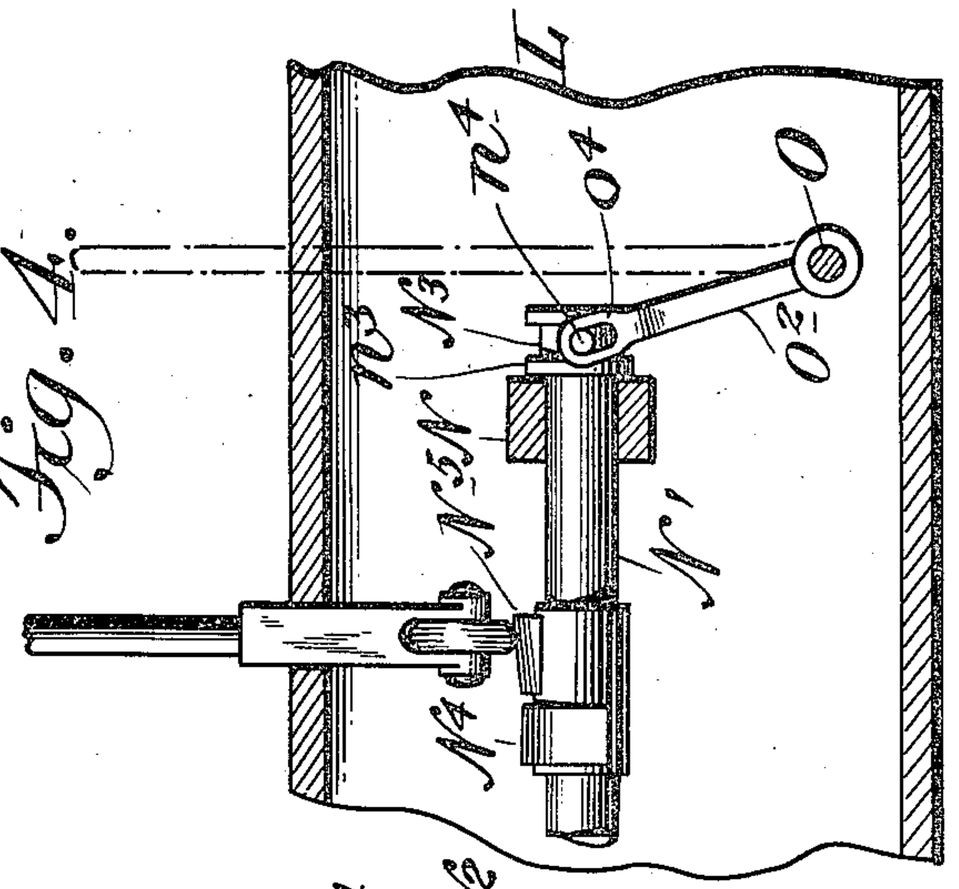


Fig. 4.



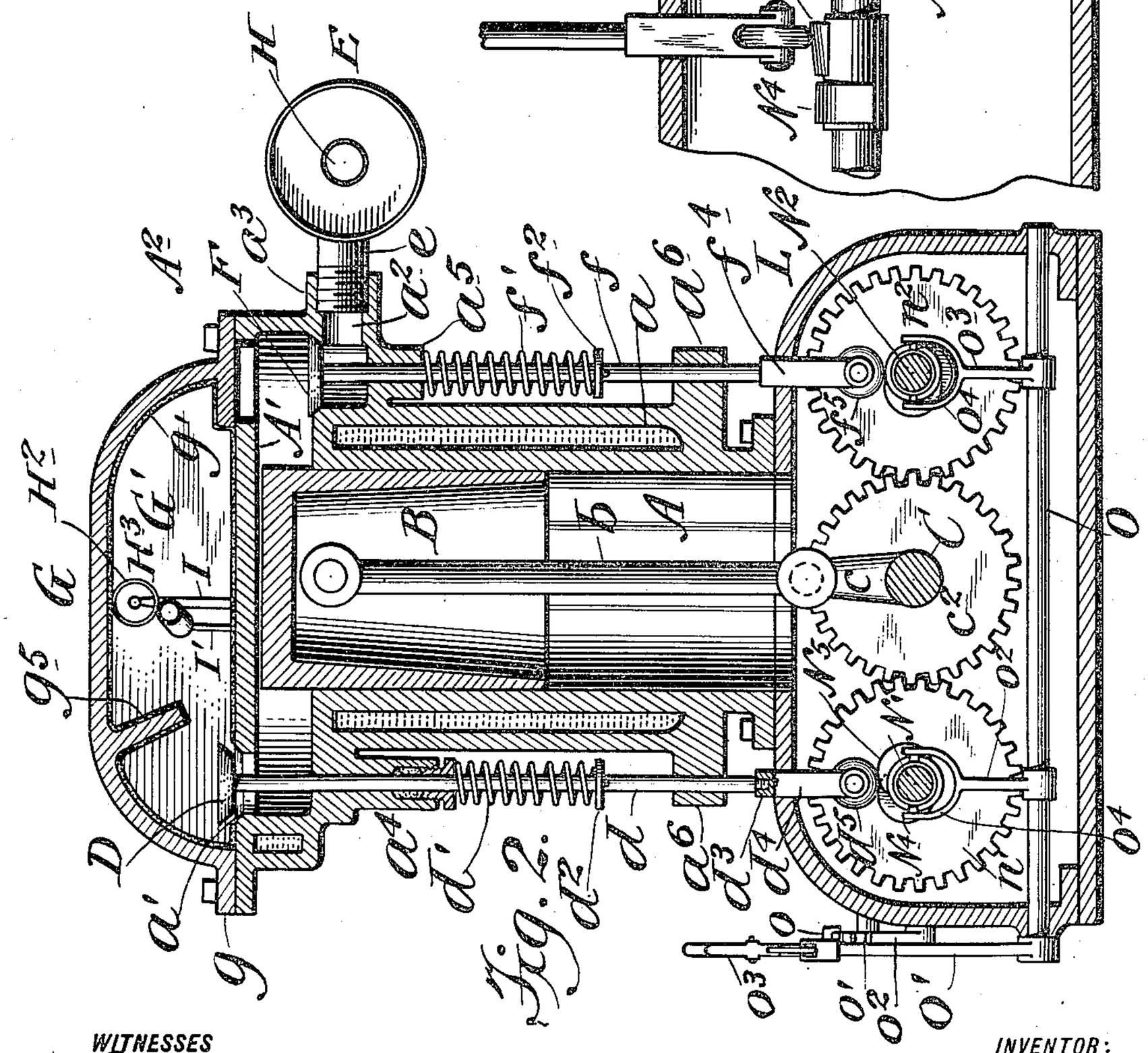


Fig. 2.

WITNESSES

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3 SHEETS—SHEET 3.

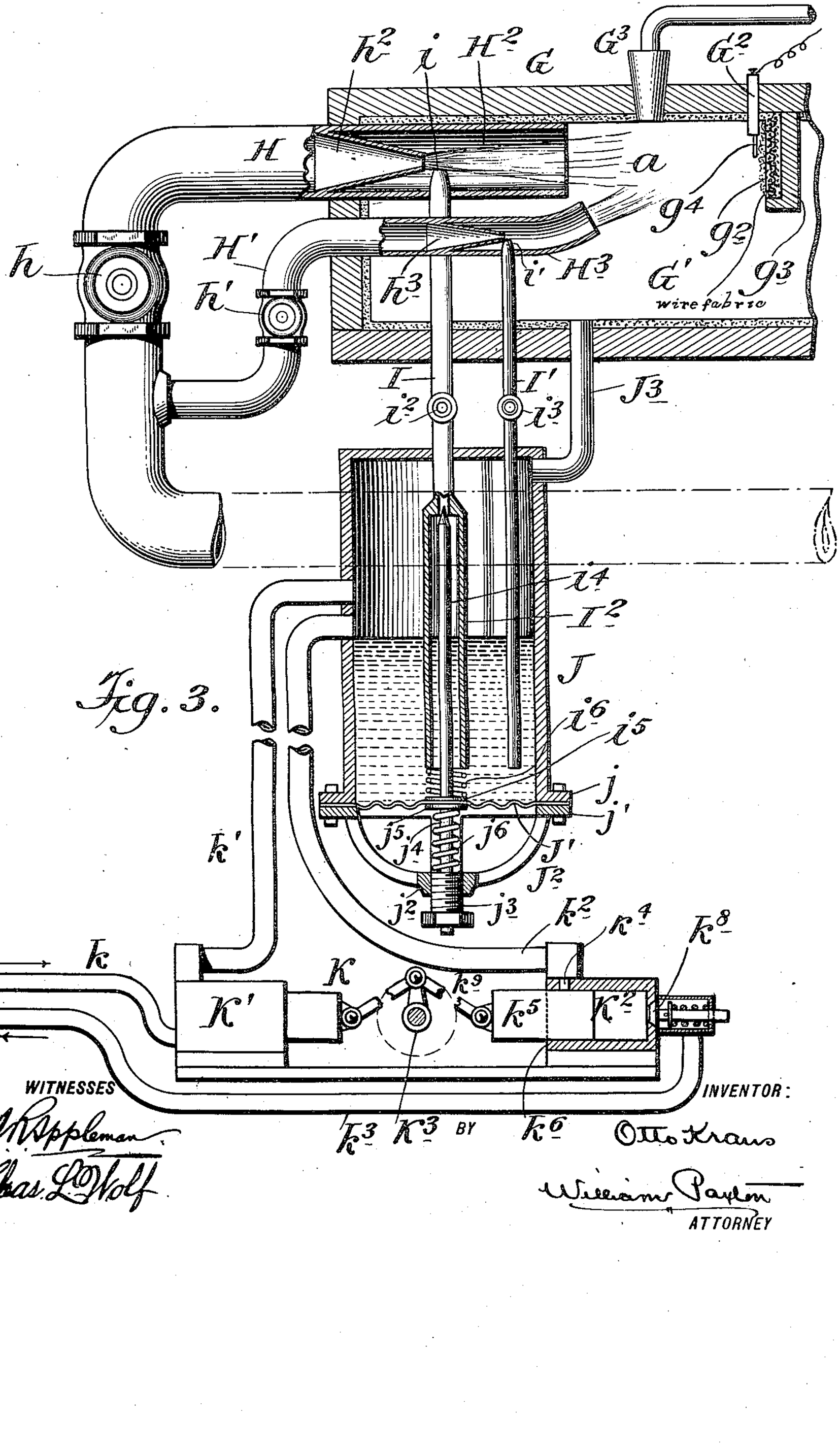

Fig. 3.

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UNITED STATES PATENT OFFICE.

OTTO KRAUS, OF NEW YORK, N. Y., ASSIGNOR TO KRAUS ENGINE COMPANY, A CORPORATION OF NEW YORK.

INTERNAL-COMBUSTION ENGINE.

980,801. Specification of Letters Patent. **Patented Jan. 3, 1911.**

Application filed November 16, 1904. Serial No. 232,925.

To all whom it may concern:

Be it known that I, OTTO KRAUS, a citizen of the United States, and resident of Manhattan borough, city of New York, and State of New York, have invented certain new and useful Improvements in Internal-Combustion Engines, of which the following is a specification.

The present invention comprehends a novel apparatus for utilizing fuel in internal combustion engines, whereby in addition to obviating the objectionable explosions characteristic of engines of the class mentioned, an even and uniform pressure can be exerted on the piston or similar movable element, the pressure controlled, the engine worked within a wide range of adjustability, and in general, results obtained equal to those of the best types of steam engines.

An important consideration connected with the novel apparatus, is the availability of heavy oil, for instance "fuel oil", or kerosene, for conversion in the generation of the motive fluid, thus attaining in comparison with other types of internal combustion engines, greater economy of operation as well as rendering the apparatus more safe owing to the minimum of danger from accidental explosions. While heavy oils will preferably be employed for the purpose stated, other combustible fuels such as gasolene, naphtha, alcohol, etc., or even combustible gas, can be used with highly satisfactory results.

The main feature of the invention involves the practically continuous combustion of the fuel in the presence of air at a high pressure say at about from 60 lbs. to 200 lbs. per square inch, according to the number of piston surfaces operated on by the motive fluid during one revolution of the engine. That is to say, if the engine is composed of three cylinders, the pressure would be considerably less than in a six cylinder type as in the latter, the cut-off could occur earlier without interrupting the continuous flow of the motive fluid to the engine. If the cut-off occurs early it is plain that the pressure may be higher as there will be more opportunity for the fluid to expand to atmospheric pressure at the opening of the exhaust valve. It will be appreciated that under such conditions, a perfect combustion can be attained by properly regulating the combustion flame which should burn at an intense heat without carbonization. Such a high degree of combustion cannot readily be accomplished in engines of the explosive type, as the combustion occurs at intervals, necessitating intermittent ignitions of the explosive mixture, besides being attended with the liability of the mixture varying in proportion, resulting in a more or less imperfect combustion producing smoke and odor, as well as entailing loss of power.

The high pressure motive fluid which is developed in practicing my invention is not only serviceable in connection with engines embodying reciprocating pistons, but can also be advantageously used in connection with other types of engines including those of the turbine principle. Moreover, the intensely hot gases generated can be rendered sensible of a spray of water or other suitable liquid in proper proportions, and the heat convert such water into steam which will combine with the gases of combustion to constitute a motive fluid possessing a lower temperature and therefore less liable to injuriously affect the engine parts, than the gases that have not been deprived of heat in the conversion of water into steam.

The combustion of the mixture of fuel and air develops a supply of motive fluid considerably greater in volume than that of the mixture, and as such combustion is practically continuously maintained, the supply of motive fluid thus produced can be most favorably employed in an engine wherein the pressure of the fluid is utilized in a constant manner, as for instance in an engine comprising a plurality of consecutively acting pistons either single or double acting, where the pressure is exerted in closely consecutive order on the pressure faces presented by said pistons.

There are other important features connected with the invention, which, besides those alluded to, are clearly explained in the subsequent detailed description.

In the accompanying drawings forming part of this specification—Figure 1, is a diagrammatic view of one form of apparatus for carrying my invention into effect. Fig. 2, is a vertical sectional view through one of the working cylinders, the generator, crank-casing and immediately related parts. the section being in a plane at right angles to Fig. 1. Fig. 3, is a partial vertical sectional

detail view disclosing a portion of the generator and certain immediately related parts, together with the fuel-regulator and pump coöperating with the latter. Fig. 4, is an enlarged sectional detail view of the crank-casing, and illustrating more particularly features connected with the valve-gear, the section being in a plane at the lower left-hand side of Fig. 2, and looking toward the right. Fig. 5, is a perspective view of one of the cams employed in connection with the valve-gear.

Similar reference characters are employed to designate corresponding parts in the several figures where they occur.

In Fig. 1, A, A, A, refer to a plurality of engine-cylinders (three being shown) each of which contains a single acting trunk piston B, illustrated in Fig. 2, the connecting rod *b*, of which piston is pivotally connected at its lower end, to one of the cranks *c*, of the crank shaft C, common to the piston rods of the other cylinders, the cranks being disposed at equi-distant angles so that the strokes of the consecutively acting pistons will lap and thus insure a uniform rotation of the crank-shaft. It will be noted that the piston is conditioned to move in close proximity to the cylinder head A′, so as to effect the expulsion of the gases to the highest possible extent. Each cylinder will preferably have jacketed spaces *a*, for the reception of a fluid capable of reducing the temperature of the cylinder-body and that of the locale of the admission and exhaust valves, acquired during the working of the engine. As many means for supplying the cooling fluid to and circulating it through the spaces *a*, are well known, special illustration and description thereof are not deemed necessary. The head A′, of the cylinder contains to one side an opening *a′*, at the upper end of which the head is beveled to afford a suitable seating for the admission valve D. At the opposite side of the cylinder, is a passage and an opening, the latter forming a seat for a tapering exhaust valve F, said opening communicating with a passage a^2, extending through a laterally projecting nipple a^3, threaded for connection with the branch *e*, of the trunk E. At appropriate points, the cylinder has an upper depending stuffing box a^4, and upper depending boss a^5, for the passage of the valve rods *d*, *f*, respectively. These valve-rods are guided at their lower portions by playing through offsets a^6, on the cylinder, and are yieldingly depressed through the medium of expanding springs *d′*, *f′*, surrounding the rods and interposed between the stuffing box and boss, and stops d^2, f^2, on the rods.

A motive fluid generator G of the extended character indicated in Fig. 1, comprises a bottom and transversely arched top conjointly forming a generating chamber G′, said generator being provided with side flanges *g*, admitting of its being bolted in position on the cylinder heads, the generator bottom being removed at points coincident with the cylinder-heads to secure lightness and economy of metal, as well as permit the admission valves to control communication between the chamber G′, and the respective cylinders without requiring the disturbance of said valves and their connections, whenever the generator is to be removed. The surfaces of the generating chamber are faced with a material *g′*, which is a non-conductor of heat and capable of resisting the destructive action of flame. A lining of an asbestos or an equivalent composition may be employed.

Extending longitudinally a short distance within the generating chamber at one end thereof, are burners H^2, H^3, adapted to be supplied by pipes H, H′, respectively, which pipes communicate with each other external to the generator and are independently controlled by hand-operable valves *h*, *h′*. The pipe H and its burner are of greater diameter than the pipe H′, and its burner, the main length of the pipe H, being in communication with a suitable supply of compressed air, say at about 200 lbs. to the square inch. The means disclosed for providing such supply of compressed air will presently be fully described.

At points well within the burners H^2, H^3, are tapering nozzles h^2, h^3, arranged so that their contracted apertures will discharge in the direction of the burner-mouths. Vertical tubes I, I′, have their upper portions extending gas-tight through the generator bottom and within the throats of the burners H^2, H^3, in which latter, the reduced extremities *i*, *i′*, of the tubes are located in such juxtaposition to the nozzle-discharges, that liquid issuing from said extremities will be subject to jets of air discharged from the nozzles in planes at right angles to the tube discharges, with the result that the liquid will be thoroughly atomized and discharged with force from the burner-mouths. It will be observed that the tube I, is larger in diameter than the tube I′, so that the tubes will deliver liquid to the respective burners H^2, H^3, proportionate with the capacities of the latter.

The tubes I, I′, are provided with hand controlling valves i^2, i^3, below which the tubes depend through the closed top of the casing of a fuel-regulator J, down to a plane contiguous to the bottom of said casing. The major portion of the tube I, within the casing is of enlarged diameter as indicated by I^2, in Fig. 3. The tube-opening at the upper end of the portion I^2, constitutes a seat for the tapered extremity of a vertically extended needle-valve i^4, rigidly provided at its lower end with a disk i^5, resting centrally

on a diaphragm J′, marginally bolted between the base flange *j*, of the casing, and the complementary flange *j′*, of a depending spider-frame J², presenting a lower internally threaded bearing *j²*.

A nut *j³*, is thread-engaged within the bearing *j²*, and has a lower angular head to facilitate its adjustment. A stem *j⁴*, having its lower portion guided in the nut, carries at its upper end a disk *j⁵*, bearing against the underside of the diaphragm, at a point vertically corresponding with the position of the disk *i⁵*. A coiled expanding spring *j⁶*, is interposed between the nut and the disk *j⁵*, while between the disk *i⁵*, and the lower end of the tube I², is a shorter expanding spring *i⁶*, of weaker force, the spring *j⁶*, tending to hold the diaphragm in a normal position, while the weaker spring *i⁶*, act to hold the needle valve slightly open but act to further open said valve proportionate with a depressed movement of the diaphragm. Manifestly, the nut can be adjusted to either increase or diminish the force of the spring *j⁶*, and thereby vary the degree of pressure required to depress the diaphragm.

Coöperating with the fuel-regulator J, are pumping provision K, comprising a supply pump K′ designed to receive liquid-fuel through a pipe *k*, leading from any suitable source of supply, and deliver said fuel through a pipe *k′*, into the upper part of the receptacle. It will be understood that this pump is capacitated to supply the liquid-fuel to said receptacle somewhat in excess of the amount ordinarily required to maintain the fuel level indicated. The overflow pump K² is in communication with the regulator interior, above the normal plane of the liquid therein, by means of a pipe *k²*, which when the liquid rises above said plane, becomes an overflow for the excess liquid and permits the latter to flow to the pump and be forced back to the source of fuel-supply, through a pipe *k³*.

The overflow pump is shown as comprising a cylinder having an opening *k⁴*, through which the pipe *k²*, communicates, said opening being adapted to be opened when the plunger *k⁵*, having a gas-tight fit within the cylinder, approaches the limit of its movement in the direction of the cylinder end *k⁶*. By this arrangement, when the pump is not engaged in withdrawing excess oil from the regulator, the pressure conditions in the upper part of the regulator, in the pipe *k²*, and the interior of the pump will by reason of the presence of the elastic motive fluid in all three parts be substantially equal as long as the opening *k⁴*, remains open, as the slight variation within the cylinder caused by the concluding movement of the plunger after the uncovering of the opening *k⁴*, will be inappreciable in so far as the pressure condition within the regulator is concerned. The movement of the plunger in the opposite direction will close and maintain closed the opening *k⁴*. The further movement of the plunger will simply have the effect of compressing the confined body of the elastic fluid within the pump cylinder, the normally closed eduction-valve *k⁸*, of the pop-type, having its spring adjusted to resist any unseating tendency of the fluid under its maximum compression or during any period when the pump cylinder is, through the opening *k⁴*, in communication with the upper part of the regulator. The maximum compression of the elastic fluid within the pump cylinder is permitted by affording a certain amount of clearance. The return movement of the plunger *k⁵*, toward the cylinder end *k⁶*, will permit the confined fluid to expand so that when the opening *k⁴*, is again opened, the pressure within the cylinder will be brought into equilibrium with that in said pipe and the regulator. It will therefore be seen that the operation of the pump will not result in any material loss of the working fluid. When, excess oil is flowing from the regulator, a quantity of said oil will by reason of the ample proportions of the pipe K² and opening K⁴ enter the cylinder when said opening is opened, and upon the subsequent closing of said opening, the compression of the liquid will by reason of the inelasticity of the latter effect the opening of the pop-valve *k⁸*, and discharge of the liquid and possibly some of the gas through the pipe *k³*. The pump and regulator will not therefore seriously modify their respective operations. The customary check valve serving with the supply pump, opposes back pressure through the pipe *k′*.

The pump-plungers are actuated through their rods and pitman connections with the crank *k⁹*, of a shaft K³ receiving motion from the engine or other power source.

The flanged lower ends of the cylinders A, are bolted upon the extended crank casing L, the top of which contains openings admitting of the connection of the piston-rods with the crank shaft, and for accommodating the swinging movements of said rods. The crank shaft is revolubly supported in bearings *c′*, *c′*, in the casing-ends and an externally projecting portion of the shaft has keyed thereon a pulley C′, from which the motion of the engine can be transmitted.

On the casing L, near one end thereof, is an air compressor M, embodying the customary check-valves and indicated as being single acting but it may be double acting if desired. It will be understood, that although not shown, the compressor piston will be actuated through a connection with the crank-shaft to induct and compress air, and deliver it under the required tension through a pipe *m*, to a reservoir M′, prefer-

ably provided with a pressure gage m'. Communication through the pipe m, is controlled by a hand-operated valve m^2, between which and the compressor, the pipe H, connects with the pipe m. As illustrated in Figs. 1 and 2, the major portion of the pipe H, is jacketed within the trunk E, so that the exhaust from the cylinders A, can be utilized for heating the compressed air on its way to the generator, the exhaust gases subsequently flowing through a pipe E', to any suitable point of discharge.

Recurring to Fig. 3, it will be noted that the position of the burner H^2, is such that it will project its atomized oil against a facing g^2, of absorbent asbestos or similar material capable of great durability under the action of heat, said facing material being combined with wire netting suitably "grounded", the asbestos and the netting being supported in the recessed side of the plate g^3, rigidly depending from the generator top, and having such of its surfaces as might otherwise be exposed, protected by a covering of heat resisting material.

Mounted in the generator top, is a spark-plug G^2, the electrode g^4, of which is within the upper part of the generating chamber and adjacent to the wire-netting to produce a high tension or jump spark for initially igniting any liquid fuel associated with said asbestos. It will also be observed that while the burner H^3, occupies a plane below that of the burner H^2, the end of said burner H^3, is slightly bent upward to insure its discharge being directed against the asbestos, which under such conditions, need only depend within the generating chamber to a limited extent and therefore, will not be liable to obstruct or impede the free development of the motive fluid therein.

It will be desirable to screen the wire netting with the asbestos to protect such netting from the intense heat to which it would otherwise be exposed. With the netting shielded as explained, said netting will still be in sufficient proximity to the plug-electrode to coöperate with the same through the saturated asbestos, to produce the required spark.

Revolubly mounted and capable of longitudinal movement in bearings N, within the crank casing, are shafts N', N^2, at each side of and counter to the driving shaft, the counter-shafts having keyed thereon, gear wheels n', n^2, respectively meshing with a similar wheel c^2, secured on the crank shaft, the gear face of said latter wheel being sufficiently broad to permit the shafts N', N^2, to undergo longitudinal movement and still preserve the engagement of their gear wheels with the wheel c^2.

Supported oscillatively in bearings in the sides of the crank casing near the base thereof, are the end portions of a rod O, extending transversely within the lower part of the crank-chamber, and which projects beyond the casing at one side for the attachment of a hand-lever O', carrying a sliding bolt o, adapted to engage within one of a plurality of notches o', in a curved segment o^2, secured on the contiguous casing-side. The bell-crank handle o^3, connected to operate the bolt, is pivoted on the lever so that a single hand of the attendant can be employed for manipulating both the handle and the lever, to engage or disengage the bolt and for swinging the lever, as generally familiar in other applications of this device.

On that end of each shaft N', N^2, which is nearest the rod O, and which projects beyond the contiguous bearing N, is a collar N^3, capable of being held stationary while its shaft revolves but which when longitudinally shifted, is adapted to impart a corresponding movement to its shaft. This result can be attained by revolubly confining the collar between inner and outer flanges n^3, rigidly on the shaft, the former of which is designed to contact with the bearing and limit the longitudinal movement of the shaft in one direction. Lateral trunnions n^4, projecting from the sleeve, engage within the slots o^4, of the forked members of one of the arms O^2, O^3, secured at their lower ends to the rod O.

Located on each of the shafts N', N^2, to partake of the revolving movement thereof, are relatively inner and outer cams N^4, N^5, the inner cam N^4, being disposed transversely, while the outer cam N^5, on the shaft N', tapers transversely in both directions, and also tapers longitudinally in the direction of the cam N^4. The said cam N^5, also contracts in width toward the cam N^4, so that not only will the pronounced character of the cam vary at different points longitudinally along the same, but the operative face of the cam varies in width at different points along the cam.

The lower ends of the valve-rods d and f, have threaded stems, one d^3, of which is shown in Fig. 2, such stems each engaging a yoke d^4, f^4, snugly guided in suitable openings in the top of the crank-casing. The yokes have journaled in their lower portions, rollers d^5, f^5, respectively, which are adapted to coact with the cams N^4, N^5, on the shafts N', N^2, to secure the requisite lifting movements of the rods counter to their springs d', f'. Longitudinal changes in position of the cam N^5, on the shaft N' with respect to the roller d^5, manifestly varies the periods at which the admission valve is opened and also the length of time in which said valve is kept open. Bringing the cams N^4, into operative position with regard to the rollers will cause the reversal of the operation of the engine. The adjustment of the cams, relative to the rollers can be effected by unbolt-

ing and swinging the lever O′, to the desired extent, which will turn the rod O, and throw its arms O², O³, to longitudinally shift both shafts N′, N². Then by locking the lever O′, the cams will be positively held in their adjusted planes of rotation. It should be understood that the shafts N′, N², are further equipped with similar arrangements of appropriately located cams coacting with rollers carried by the valve rods of the other cylinders, such additional cams being conditioned with respect to those first mentioned and with regard to each other so that the cams N⁵, of the several admission valves will operate to effect the successive movements of the said valves of all cylinders. It will therefore be appreciated that the speed of the engine can be regulated by varying the periods and lengths of time of the closing movements of the admission valves, and that the direction of rotation can be reversed.

Assume that at the period of starting the engine, the valves *h*, *h′*, of the air-pipes are closed and the valve *m²*, is open. The crank-shaft will preliminarily be rotated by some auxiliary force, which, where the size of the engine admits, can be power manually exerted through the medium of a crank applied to the squared end of the shaft. The compressor will thus be actuated until the pressure of the air, as read off the pressure gage of the reservoir M′, will warrant the opening of the valve *h′*, whereupon the air will be discharged within the generator. The valve *i³*, of the oil-tube I′, being open, the effect of the air passing through the burner H³, will be, notwithstanding the moderate pressure of the air, to suck-up liquid-fuel in said tube, which fuel emerging at the tube extremity, will be thoroughly atomized and the resulting mixture of air and fuel, projected against the asbestos *g²*, in the upper part of the chamber, so that a percentage of the liquid-fuel will become associated with the asbestos and can be ignited by the plug-spark. The ignition thus established will be communicated to the mixture continuously issuing at the mouth of the smaller burner H³, with the result that said mixture owing to the compressed air, will burn with an intensely hot flame representing thorough combustion and production of intense heat within the generating chamber. At this stage and with the air-pressure continuing to increase, the valve *i²*, of the larger fuel-tube I, and the valve *h*, of the pipe H, are both opened so that the larger jet of mixture issuing at the mouth of the burner H², will be ignited by the flame of the smaller burner H³, and undergo combustion in a manner and under conditions similar to those previously described, the valve of the air-pipe H′, being now closed to extinguish the flame at the smaller burner when the air has attained the desired working pressure, the volume of gases resulting from the combustion at the burner H², will alone be ample for operating the several pistons. The heat produced expands the gases of combustion within the generator to an extent that will through the operation of the engine, so drive the air-compressor, that the latter will within a short period effect the increase of the air pressure within the reservoir to the desired working pressure, predetermined by the proportions of the engine construction. The current for the spark-plug can for economical reasons be turned off, after the ignition of the small burner has been established. The engine is not dependent upon accurate time ignitions, for after combustion has been inaugurated, no other ignition devices are employed.

The smaller burner and its appurtenances are generally furnished for engines of large capacity, where it is desirable to more positively provide for the ignition of the larger burner. The smaller burner can be kept burning during a brief stoppage or very slow running of the engine, and will thus provide for the ready re-ignition of the larger burner, besides conducing to economy through its obviating the necessity for heating up the generator, in again starting the engine or increasing the speed. In lieu of igniting the oil-saturated asbestos *g²*, by an electric-spark, such ignition can be accomplished by a flame introduced through an opening in the generator-wall contiguous to such asbestos, and which opening is normally hermetically closed by a plug *g⁷*. The character of the gases of combustion issuing from an opened cock *g⁶*, on the generator, will, when desired indicate the combustion conditions within the chamber G′. By closing the valve *m²*, at the proper time, a volume of compressed air will be confined within the reservoir M′, sufficient to serve for restarting purposes, in which event the turning of the crank-shaft by auxiliary force, is not required.

The motive-fluid constituted by the gases of combustion will be admitted at the proper time to the several cylinders, and acting on their pistons which each acquire an impulse on each revolution of the crank-shaft, will effect the power-strokes of the pistons to uniformly rotate said shaft, the gases being expelled through the exhaust openings on the return movements of the pistons, the cam control of the admission and exhaust valves, permitting these operations. There should be no lapse of time or at least so little, between the closing and opening of the admission valves of the successive cylinders, that the draft upon the generator will not be seriously interfered with, and thus preventing the extinguishment of the flame. Consequently during the normal working of the engine, the pressure conditions within the

generator are never in excess of that of the compressed air, for otherwise the generator pressure would not permit the air and oil to emit from the burner and therefore, the flame would cease. Manifestly, the speed of the engine will be dependent upon the periods and lengths of time the admission valves are opened, or by the throttling of the current of air supplied to the generating chamber.

A pipe J^3, connecting the generator and regulator, is adapted to communicate the pressure conditions within the former to the space within the regulator, above the liquid-fuel therein. Consequently, either a rise or fall of the pressure within the generator will operate the diaphragm to cause a proportionate further opening or closing of the needle-valve. The quantity of liquid-fuel flowing past the needle-valve will therefore be automatically regulated and the supply of fuel proportional with the volume of air, controlled by the pressure within the generator which in turn is governed by the pressure of the air supplied to the burners. Therefore, as the increasing density of the air as it rises in pressure, will furnish a greater proportion of oxygen for burning a larger amount of oil to develop a greater heat, the oil-feed is automatically governed to graduate the quantity of oil supplied.

With a view of preventing the burner flame from injuring the adjacent admission valve and its seat, I locate in the upper part of the generating chamber between the burners and said valve, a depending section g^5, faced with refractory material and inclined to form an efficient guard for the purpose mentioned.

The intensely hot gases developed within the generating chamber can as previously stated, be rendered sensible of a spray of water or other suitable liquid introduced in proper proportions within the chamber G′, preferably in proximity to the burner H^2, whereby such water will be converted into steam which combining with the gases of combustion, will result in a motive fluid possessing a lower temperature than that of the gases alone, and therefore, less liable to be injurious to the engine parts, than said gases independently might be.

G^3, designates a spray-nozzle in the generator-top and adapted to appropriately deliver the water or other liquid within the generator, in the manner stated. When water or other liquid is used as set forth, provision for cooling the engine cylinders, may be dispensed with. The water can be in a heated condition when admitted to the generating chamber, to require less heat for its vaporization. Water supplied from the cooling-spaces of the cylinders, can be utilized for this purpose.

The constant employment of the motive fluid, characteristic of an engine embodying a plurality of consecutively acting pressure surfaces, will tend to such proportionate withdrawals from the supply of motive-fluid, as will contribute to maintain the continuous combustion of the mixture and consequent development of the motive fluid during the operation of the engine. The direct feed of the oil to the burner without previous vaporization, avoids carbonization in any portion that the oil flows through, as the oil is atomized and coming in contact with an intensely hot flame is completely consumed immediately at the burner.

I do not desire to be understood as limiting myself to the particular features and arrangements of parts embodied in the apparatus disclosed herein, but reserve the right to all modifications within the scope of my invention.

Having now described my invention, what I claim as new and desire to secure by Letters Patent, is—

1. In a device of the class described, an engine comprising a plurality of vertically arranged working cylinders and a reciprocating piston within each cylinder; a separate inlet port leading to each of said cylinders; a separate puppet valve for controlling the flow of motor fluid to each of said cylinders; a generator of motive fluid extending longitudinally of said cylinders and supported at the head ends thereof and with which generator each of the said inlet ports communicates; means for operating said valves in succession; a conduit through which combustible fluid may be supplied to said generator; a conduit through which air may be supplied to said generator, and an igniting device for igniting the combustible mixture within said generator.

2. In an apparatus of the character described, the combination with an engine having a plurality of vertically arranged cylinders and pistons in said cylinders so connected as to operate successively, of a generator extending longitudinally of said cylinders and supported thereby and having independent communications with each of the cylinders, valves opening into said generator for controlling said communications, and means for operating said valves to open and close communication between the generator and the cylinders in succession, means for delivering combustible fluid to the generator, means for supplying air under pressure thereto, and means within the generator for igniting the combustible fluid to develop motor fluid therein, whereby the withdrawal of motive fluid from the generator will be substantially continuous and the motive fluid will enter the cylinders without substantial loss of heat.

3. In an apparatus of the character described, the combination with an engine hav-

ing a plurality of vertically arranged cylinders, and pistons in said cylinders so connected as to operate successively, separate inlet ports leading to said cylinders and separate valves controlling said inlet ports, of a generator extending longitudinally of said cylinders and supported upon the heads thereof above the inlet ports and with which said inlet ports communicate, means for operating said valves to open and close communication between the generator and the cylinders in succession, means for delivering combustible fluid to the generator, means for supplying air under pressure thereto, and means within the generator for igniting the combustible fluid to develop motive fluid therein, whereby the withdrawal of motive fluid from the generator will be substantially continuous and the motive fluid will enter the cylinders without substantial loss of heat.

4. In an internal combustion engine, the combination with power means adapted to be constantly actuated, of a generator in operative relation with respect to said means, means for supplying compressed air to said generator a regulator with means for delivering liquid fuel to said generator pumping means for supplying liquid fuel to the regulator, and an overflow device for the regulator comprising a discharge valve adapted to be opened only by a pressure in excess of that in the regulator.

5. In an internal combustion engine, the combination with power-means adapted to be constantly actuated, of a generator in operative relation with respect to said means, means for supplying compressed air to the generator, a regulator with means for delivering liquid fuel to said generator, and pumping means for supplying liquid-fuel to the regulator, an exhaust side of said pumping means having an overflow communication with the regulator and provided with an adjustable discharge valve, the over-flow communication adapted to be closed when the pump piston on said exhaust side is moved in one direction.

6. In a device of the class described, an engine comprising a plurality of cylinders; a generator; independent supply ports leading from said generator to each of said cylinders; a valve for controlling the flow of power gases through each of said ports; means for supplying combustible fluid to said generator; a second means for supplying combustible fluid to said generator; and means dependent for its operation upon a rise of pressure in said generator for placing said second supply means in operation.

7. In a device of the class described, a generator; an engine; a conduit connecting said generator and engine; a chamber adapted to contain oil; an oil supply conduit leading from said chamber to said generator; a second oil supply conduit leading from said chamber to said generator; a valve in said second conduit; and means dependent for its operation upon a rise of pressure in said generator for opening said valve.

8. In a device of the class described, a generator; an engine comprising a plurality of working chambers; separate passages leading from said generator to each of said working chambers; a chamber adapted to contain oil; an oil supply conduit leading from said chamber to said generator; a second oil supply conduit leading from said chamber to said generator; a valve in said second conduit; a diaphragm exposed to the pressure existing within said oil chamber and operatively connected with said valve; and a passage leading from said generator to said oil chamber.

9. In a device of the class described, a closed chamber, means for supplying a combustible fluid thereto; means within said chamber for igniting the combustible fluid; a second means for supplying combustible fluid to said chamber; and means dependent for its operation upon a rise of pressure within said chamber for placing said second supply means in operation.

10. In a device of the class described, a closed chamber; a conduit for conducting compressed air thereto; an oil supply conduit leading to said air supply conduit; a second compressed air supply conduit; a second oil supply conduit leading to said second air supply conduit; a valve for controlling the flow of oil through said second oil supply conduit; means for igniting the combustible mixture within said chamber; and a diaphragm operatively connected with said valve and exposed to the pressure within said chamber, the arrangement being such that said valve will be opened as the pressure in said chamber increases.

11. In a device of the class described, a closed chamber; a plurality of means for supplying combustible fluid to said chamber; means for igniting the combustible fluid supplied to said chamber; means whereby one of said fluid supply means is placed in operation; and means dependent for its operation upon the operation of said first mentioned fluid supply means for automatically placing a second fluid supply means in operation.

12. In a device of the class described, a closed chamber; means for supplying a combustible fluid to and for igniting it within said chamber; a chamber adapted to contain oil, a conduit leading from said oil chamber to said first mentioned chamber; a conduit connecting said chambers; a pump for supplying oil to said oil chamber; an overflow conduit leading from said oil chamber; a second pump to which said overflow

conduit leads; a discharge conduit leading from said second pump; and a spring pressed valve in said last mentioned conduit.

13. In a device of the character described, an engine having a plurality of cylinders; a closed combustion chamber extending over said cylinders and fastened directly thereto, said combustion chamber having an outlet opening into each of said cylinders; a separate valve for each of said openings, said valves being located in said combustion chamber; and means for operating said valves successively.

14. In a device of the character described, an engine having a plurality of cylinders; a closed combustion chamber extending over said cylinders and provided with a plurality of outlets one of which leads to each of said cylinders; a valve for controlling each of said outlets; and means for operating said valves in timed relation with said engine, said combustion chamber serving as a housing for said valves.

15. In a device of the character described, an engine having a plurality of cylinders each of which is provided with a cylinder head; a closed combustion chamber extending over said cylinders and provided with a plurality of outlets one of which leads to each of said cylinders and said cylinder heads serving as a bottom for said combustion chamber; a valve for controlling each of said outlets; and means for successively operating said valves.

16. In a device of the character described, an engine having a plurality of cylinders each of which is provided with a cylinder head; a closed combustion chamber resting on said cylinders and said cylinder heads serving as a bottom for said chamber; a passage connecting said combustion chamber with each of said cylinders; a valve for each of said passages, said valves being located in said combustion chamber; and means for operating said valves in rotation for the purpose set forth.

17. In an internal combustion engine, a combustion chamber, an oil chamber in connection with said combustion chamber, an overflow conduit leading from said oil chamber, a pump to which said overflow conduit leads, a discharge conduit leading from said pump, and a valve in said discharge conduit adapted to open only at a pressure greater than that in the oil chamber.

Signed at New York city in the county of New York and State of New York this fifteenth day of November A. D. 1904.

OTTO KRAUS.

Witnesses:

WILLIAM PAXTON,

CHARLES L. WOLF.