(No Model.) 3 Sheets—Sheet 1.

W. von OECHELHAEUSER.

METHOD OF OPERATING GAS ENGINES.

No. 440,922. Patented Nov. 18, 1890.

FIG 1.

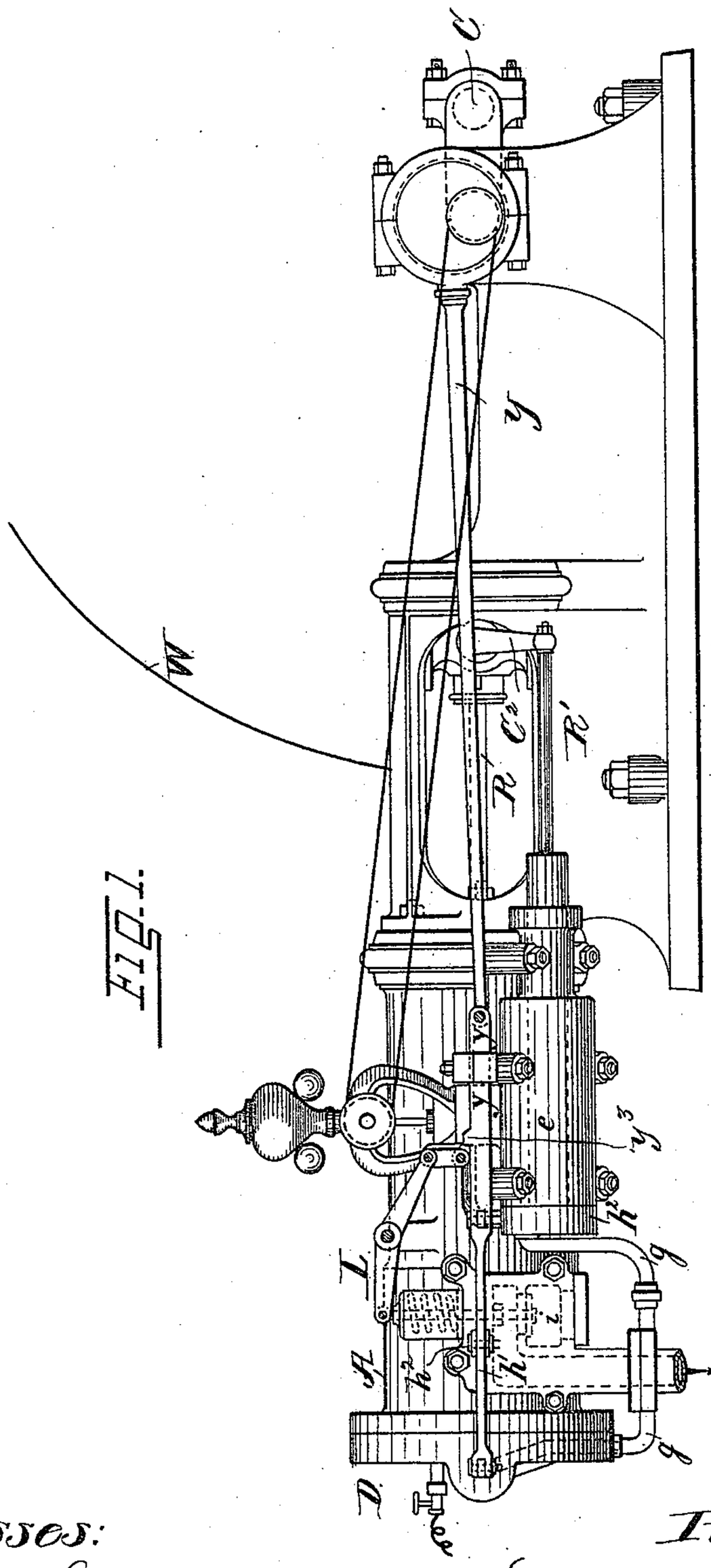

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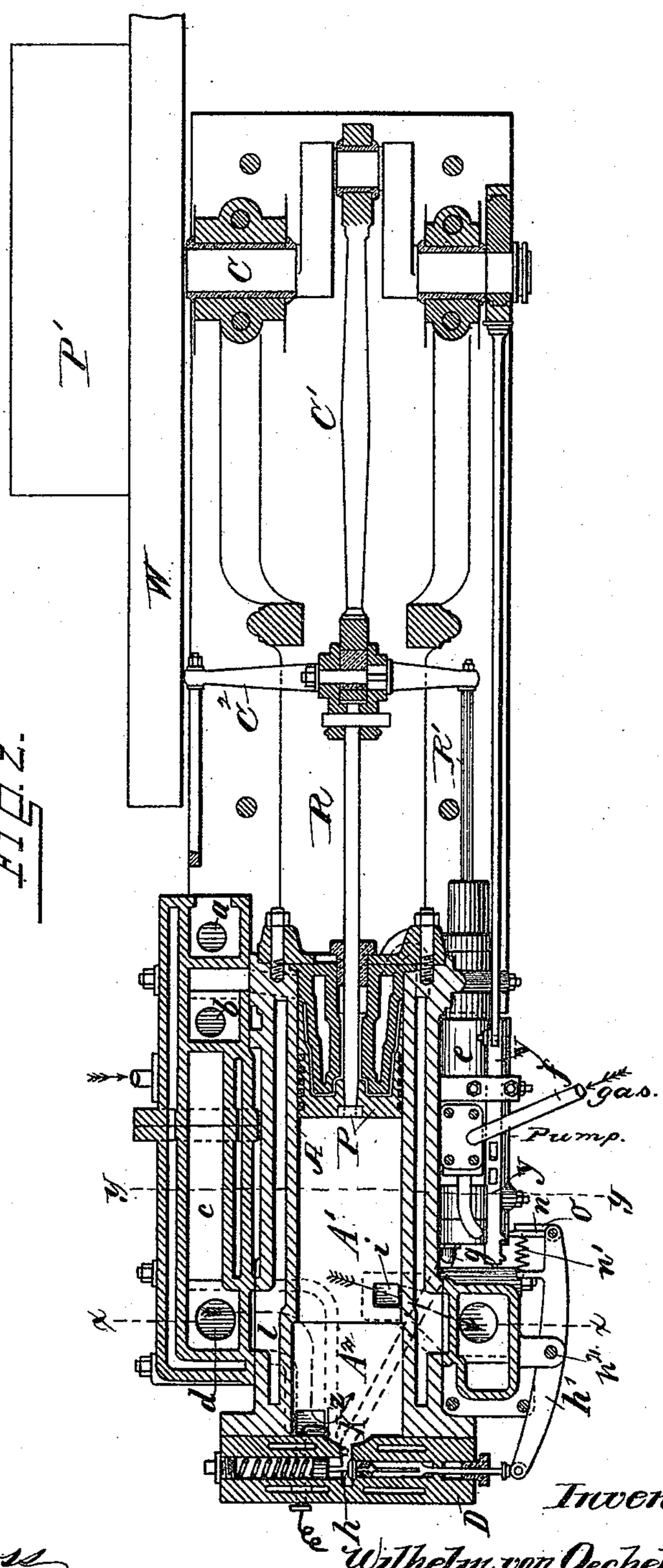
FIG. 2.



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METHOD OF OPERATING GAS ENGINES.

No. 440,922. Patented Nov. 18, 1890.

Fig. 3.

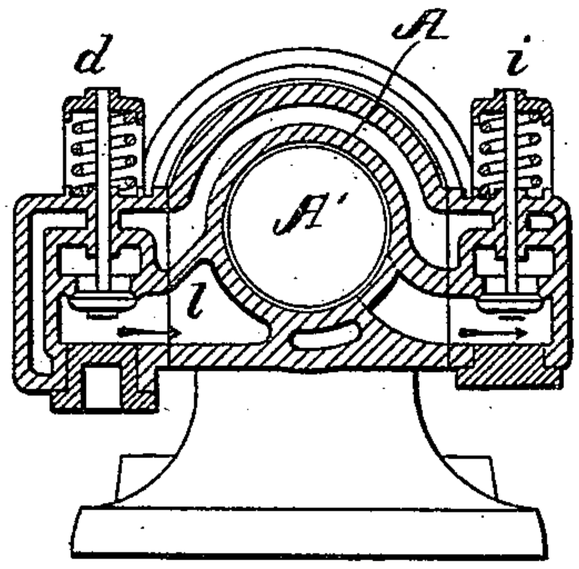


Fig. 4.

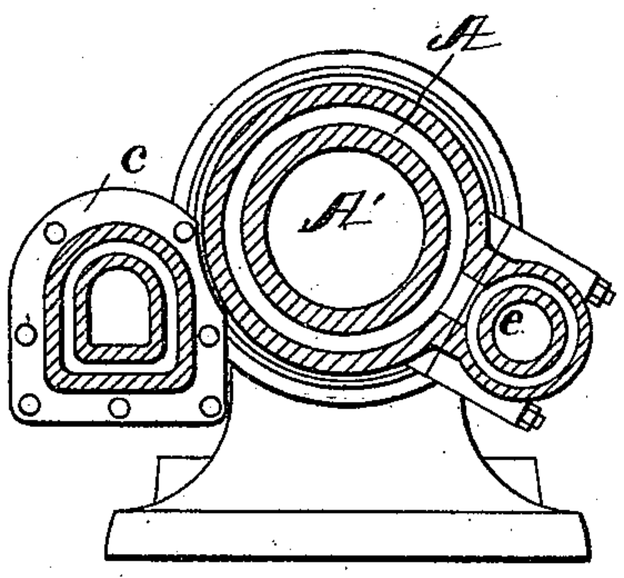


Fig. 5.

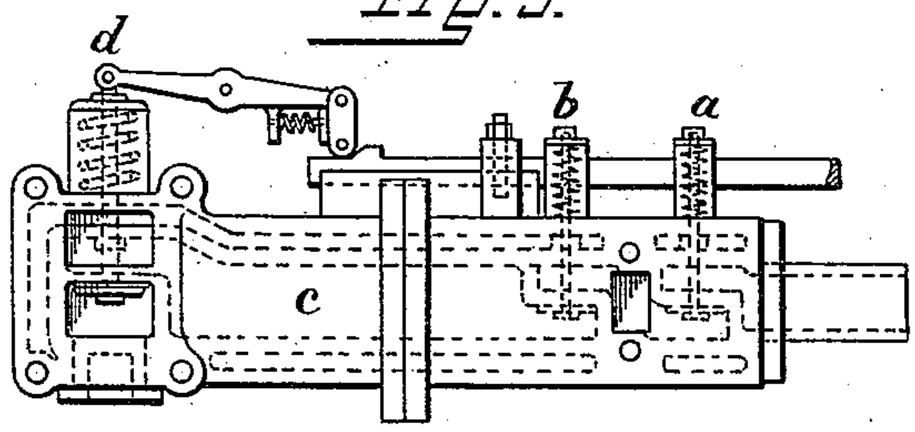


Fig. 6.

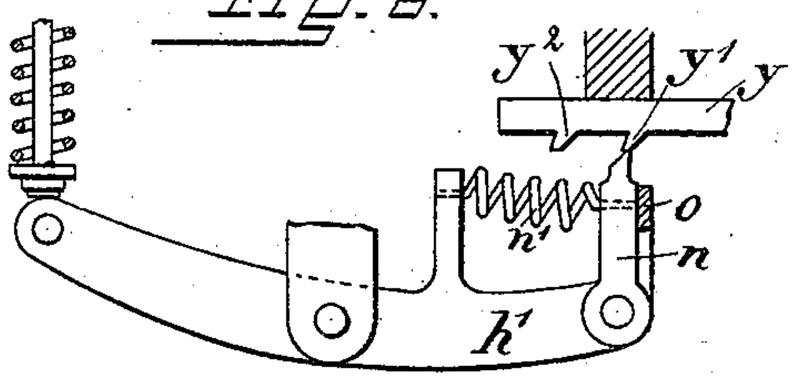
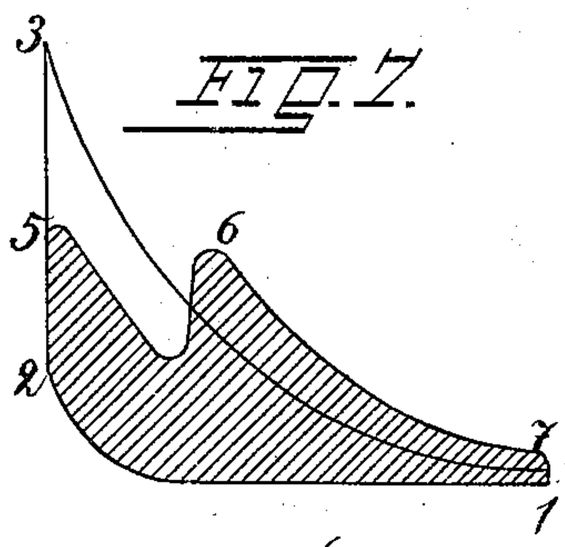


Fig. 7.



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UNITED STATES PATENT OFFICE.

WILHELM VON OECHELHAEUSER, OF DESSAU, PRUSSIA, GERMANY.

METHOD OF OPERATING GAS-ENGINES.

SPECIFICATION forming part of Letters Patent No. 440,922, dated November 18, 1890.

Application filed September 29, 1888. Serial No. 286,777. (No model.) Patented in Germany August 31, 1888, No. 47,189, and in England September 17, 1888, No. 13,425.

To all whom it may concern:

Be it known that I, WILHELM VON OECHELHAEUSER, engineer, a subject of the King of Prussia, residing at Dessau, 30 Cavalier Strasse, have invented certain new and useful Improvements in the Method of Operating Gas-Engines, (for which I have obtained Letters Patent in Germany, dated August 31, 1888, No. 47,189, and in England, dated September 17, 1888, No. 13,425;) and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same, reference being had to the accompanying drawings, and to the letters or figures of reference marked thereon, which form a part of this specification.

The invention relates to the art of operating gas-engines; and it consists in a novel method of operating such engines, substantially as hereinafter described and claimed.

The object of this invention is to increase the efficiency of gas-engines, decrease the initial or maximum pressure exerted on the piston by the explosive charge, and operate at lower temperatures and with less loss of heat and at a more uniform speed than has been the case in engines of this class of usual construction.

In the method of operating gas-engines as heretofore practiced, in order to render the power stored in a combustible, gaseous, or vaporous compound directly available, it has been the practice of introducing a previously-prepared inflammable gaseous compound into the working-cylinder of the engine or into a chamber in direct communication therewith. The inflammability of such compounds depends in such cases upon the relative proportions of combustible gas and oxygen. Thus, for instance, with ordinary illuminating-gas of about sixteen-candle power only such compounds of gas and air, irrespective of indifferent gases, are inflammable, which are composed of about one volume of gas and from four to fourteen volumes of atmospheric air, so that a compound of one volume of gas and three volumes of atmospheric air is equally as non-inflammable as a compound of one volume of gas and fifteen volumes of air. On the other hand, inasmuch as the ignition and combustion of the inflammable gas must take place with a certain rapidity, and inasmuch as the combustion of those inflammable compounds approaching the extreme proportional limits of combustible gas and air is a very slow one the said proportions of air and gas are confined within much narrower limits than said extreme limits referred to for practical purposes.

In the case of ordinary illuminating-gas of sixteen-candle power, referred to, those limits are narrowed down to one volume of gas and from five to twelve volumes of air, corresponding to a pressure of from four to seven atmospheres without previous compression of the compound. Consequently in gas-engines as heretofore operated the relative proportions of gas and air had to be confined to the latter limits, and such engines could therefore be operated only under high tensions and high temperatures, while the governing or regulating of such engines is confined to very narrow limits.

By my process it is possible to burn any desired volume of gas within the combustion-chamber of the engine, provided always that a sufficient volume of air is present to produce with the gas an inflammable compound. Thus, for instance, a charge of gas may be introduced into a charge of air in such relative proportions that when a complete admixture of the two gases is allowed to take place, a non-inflammable gas would result therefrom. It is obvious, however, that in producing means for igniting the inflammable gas as soon as it is produced by the admixture of the two gases a charge of air of sufficient volume may be introduced into the cylinder to form inflammable or explosive compounds with a plurality of charges of non-inflammable combustible gas successively introduced into the charge of air. It has also heretofore been the practice when the piston has been driven by successive charges of inflammable or explosive gas to effect the admixture of air and gas previous to its being admitted to the working-cylinder of the engine or to an explosive-chamber in direct communication therewith, while the ignition of the charge is effected after the full charge of inflammable gas has been introduced into the cylinder or into the explosive-chamber directly in communication

therewith, and the ignition follows after the inflammable or explosive charge has been introduced or has been formed.

My invention differs essentially and radically from all others heretofore practiced. First, in that I introduce into the working-cylinder of the engine a charge of air sufficient in volume to produce an inflammable or explosive compound with a plurality of charges of combustible non-inflammable gas successively introduced into the charge of air, or vice versa; second, in that I introduce successively a plurality of charges of combustible non-inflammable gas into one and the same charge of air in the working-cylinder, or vice versa, during one and the same effective stroke of the piston; third, in that I ignite the successive inflammable or explosive compounds as they are being formed, to avoid the production of a non-inflammable gas by complete admixture of too small a volume of combustible gas with too large a volume of air, or vice versa.

The advantages derived from such a method will be readily understood, and may be briefly enumerated as follows: Any desired successive small charges of combustible or non-inflammable gas may be introduced into any desired large volume of air, or, vice versa, a series of explosive compounds formed and such compounds exploded to drive the piston, while such successive charges of gas may be introduced into the charge of air an explosive or inflammable compound formed and ignited at any point of the stroke of the piston and irrespective of its speed. The control of the engine is therefore more complete than by any other method with which I am acquainted, and the combustible fuel is also more economically and advantageously utilized. Finally, a non-inflammable gas being introduced into a like gas already contained in the working-cylinder, the danger of backward explosion is effectually avoided.

Any suitably-constructed engine may be employed for carrying out my invention. Such an engine I have shown in the accompanying drawings, in which—

Figure 1 is a side elevation; Fig. 2, a horizontal transverse section; Figs. 3 and 4, vertical transverse sections taken, respectively, on or about on lines $x\,x$ and $y\,y$ of Fig. 2; Figs. 5 and 6 are detail views; and Fig. 7 is a diagram illustrative of the expansion in engines of usual construction, and in an engine operated according to my invention.

Like letters and figures of reference indicate like parts wherever such may occur.

A is the working-cylinder; A′, the piston-chamber; A^2, the gas or explosive chamber; P, the piston; R, the piston-rod; C, the crank-shaft; P′, the belt-pulley; W, the fly-wheel; C′, the connecting-rod; C^2, the cross-head to which the connecting and piston rods and the pump-rod R′ are connected, and *e* is the gas-pump.

The air is drawn into the chamber A^2 in a well-known manner through the valve *a*, Figs. 2 and 5, and is compressed within the air-chamber *c*, Figs. 2, 4, and 5, which chamber is kept cool by the circulation of a refrigerant through a suitable encompassing chamber or jacket. The air-chamber *c* is in communication with the cylinder-chamber A^2 through a valve-port or valve *d*, Figs. 2, 3, and 5, and the passage *l*, Fig. 2.

The combustible gas—such as illuminating-gas, for instance—is forced by the pump *e*, Figs. 1, 2, and 4, into and compressed within a pipe *g*, that serves as a gas-collector, said pump being connected by pipe *f*, Fig. 2, with the source of gas supplied. The suction and force valves of the pump *e* are arranged, as usual, within the head h^2 of the pump-valve.

As shown in Fig. 1, the gas duct or collector *g* communicates with a gas-passage formed in the cylinder-head D, and its eduction-port is normally closed by a cone-valve *h*, whose rod is connected with a lever *h*′, fulcrumed at h^2, Figs. 1 and 2. The lever carries a stop *o*, against which bears a tripping-plate *n*, held against the stop by a spring, as shown in Fig. 2.

The exhaust-valve *i*, Figs. 1, 2, and 3, is controlled by the actuating-rod *y*, connected by an eccentric with the crank-shaft C, which rod also controls the gas-admission valve *h*. The rod *y* has a shoulder y^3, Fig. 1, that actuates the lever L, to which the stem of the exhaust-valve *i* is connected. Said rod also has two inclined faces y' y^2, Figs. 2 and 6, that actuate the tripping-plate *n*, that is provided with a correspondingly-inclined face.

After the full charge of air necessary to the combustion of the combustible gas has been introduced into the working-cylinder before the piston commences its effective stroke, and when the working parts are about on their dead-centers, the several charges of combustible gas, approximately uniform in volume, are rapidly and successively admitted to the cylinder through the port K by the repeated and sudden opening and closing of the valve *h*, which charges of combustible gas are successively ignited. The ignition of the charges of gas may be effected in any suitable manner, as by a permanent flame or by an electric arc *z*, Fig. 2.

In the drawings I have shown a construction by which two separate charges of a combustible gas are admitted to the working-cylinder during the effective stroke of the piston and at different points of the stroke—namely, the rod *y*, provided with the inclined faces y' y^2, that actuate the admission-valve *h* twice during the effective stroke of the piston. On the return-stroke of the piston the tripping-plate *n* is forced back against the stress of its spring *n*′ to allow the actuating-faces to clear said plate without tripping or actuating the lever *h*′, as will be readily understood.

The number of charges of combustible gas to be successively introduced into the charge

of air previously admitted to the working-cylinder may be increased, if desired, by providing the rod *y* with a correspondingly-increased number of actuating-faces.

Inasmuch as there is an interval of time between the admission to the cylinder of the several charges of combustible gas, the expansive power of these charges is exerted on the piston at different points of its effective stroke, and as the quantity of gas in each charge is substantially the same the piston will be driven at a substantially uniform speed. By dividing the charge of combustible gas into two or more charges and introducing them into the working-cylinder, as described, the motion of the admission-valve *h* is so slight as compared with the motion necessary to the admission of a full charge of gas that the slide-roller at the lower end of the lever can be dispensed with. Consequently the closing of the valve is almost instantaneous under the stress of its spring or springs as soon as the valve-lever *h'* is released. Like results may also be obtained by means of slide-valves provided with one or more admission-ports. In either case the excess of pressure of the gas and the mechanism for admitting it to the working-cylinder should be so regulated or adjusted that the several charges admitted into the working-cylinder will be approximately uniform in volume.

A plurality of admission-valves may be provided and operated successively, instead of a single admission-valve, so that the several charges of combustible gas may not only be admitted to the working-cylinder at predetermined periods, but also at different points.

The admission into the working-cylinder of charges of combustible gas may be continued during the effective stroke of the piston as long as there is oxygen present in said cylinder to sustain combustion.

The distinctive feature of this invention is the successive introduction into the working-cylinder containing a single charge of air of several separate charges of a combustible gas at each effective or working stroke of the piston, so that a repeated combustion and expansion will take place during and at different points of such stroke.

The advantages of the described mode of operating gas-engines are shown in the diagram, Fig. 7, in which the line 1 2 3 4 represents the effect of a single charge of an explosive mixture and the line 1 2 5 6 7 the effect of two charges of combustible gas introduced into a single charge of air. The line 1 2 is assumed to represent the compression of the air in the air-chamber or working cylinder. This compression may, however, be dispensed with.

Whatever may be the variation in the working plane of the diagram and the economy in gas according to the number and periods of admission of the several charges of combustible gas, yet the sum of the working effect is attained by the repeated combustion at lower pressures 5 6, and at the same time at lower temperatures and less loss of heat, which is not the case in the combustion of a single charge of an explosive mixture containing the same quantity of combustible gas and resulting in the high initial pressure 3 and the corresponding high initial temperature. It follows that for a given working-power the dimensions of the cylinder and strength of the moving parts may be considerably reduced, and, as stated above, uniformity in the revolution of the crank-shaft attained by the successive application of the driving-power.

Instead of illuminating-gas, any other combustible gas or vapor may be employed.

Having described my invention, what I claim is—

1. The herein-described method of operating gas-engines, which consists in successively introducing a plurality of charges of a combustible non-inflammable gas into a charge of air contained in the working-cylinder of the engine, the charges of air being sufficient to form an inflammable or explosive compound with the successive charges of gas admitted thereto, and igniting the inflammable compounds as formed.

2. The herein-described method of operating gas-engines, which consists in successively introducing a plurality of charges of a combustible non-inflammable gas under pressure into a charge of air contained in the working-cylinder of the engine, the charge of air being sufficient to form an inflammable or explosive compound with the successive charges of gas admitted thereto, and igniting the inflammable compounds as formed.

3. The herein-described method of operating gas-engines, which consists in successively introducing during the effective stroke of the piston a plurality of charges of a combustible non-inflammable gas into a charge of air contained in the working-cylinder of the engine, the said charge of air being sufficient to form an inflammable or explosive compound with each successive charge of gas admitted thereto, and igniting the inflammable compounds as formed.

4. The herein-described method of operating gas-engines, which consists in successively introducing during the effective strokes of the piston a plurality of charges of a combustible non-inflammable gas under pressure into a charge of air contained in the working-cylinder of the engine, the charge of air being sufficient to form an inflammable or explosive compound with each successive charge of gas admitted thereto, and igniting the inflammable compounds as formed.

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

WILHELM VON OECHELHAEUSER.

Witnesses:

HERMAN MARCULL,

CARL ED. HULZ.