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N. A. OTTO.

GAS-MOTOR ENGINES.

No. 194,047. Patented Aug. 14, 1877.

Fig: 1.

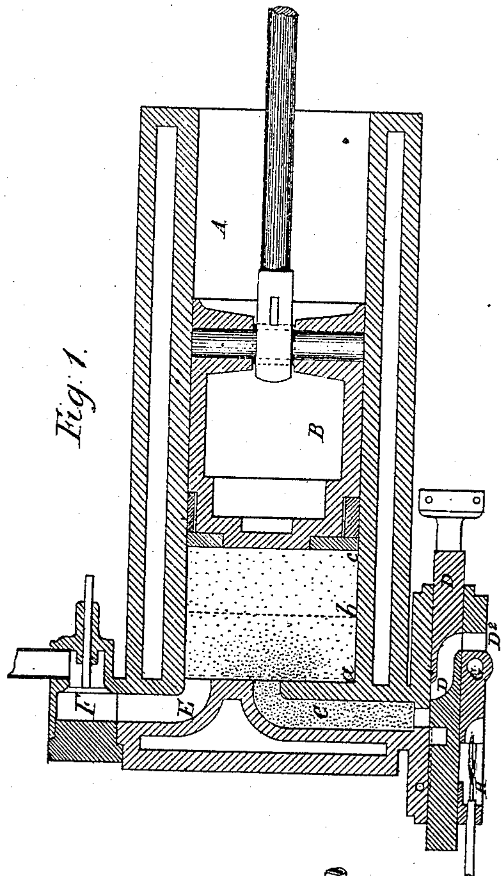
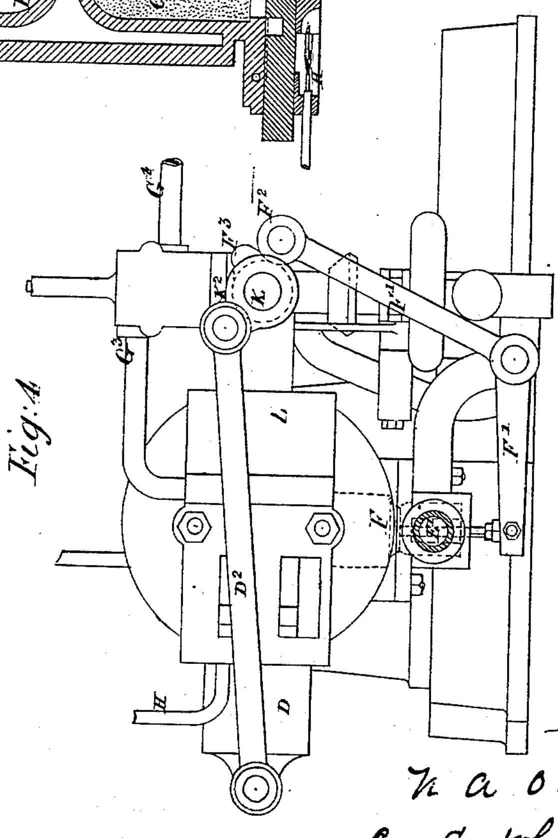


Fig: 4.



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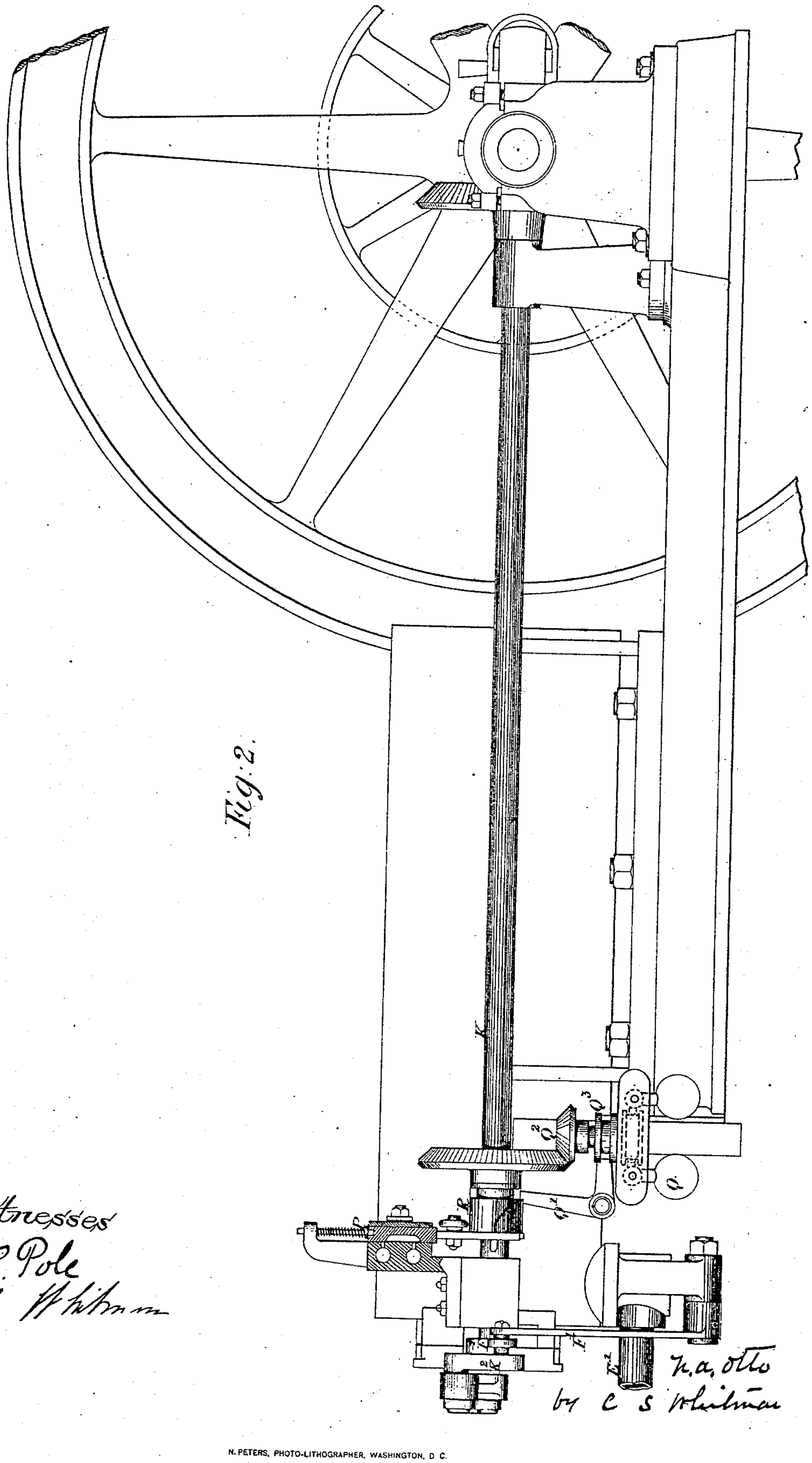

Fig: 2.

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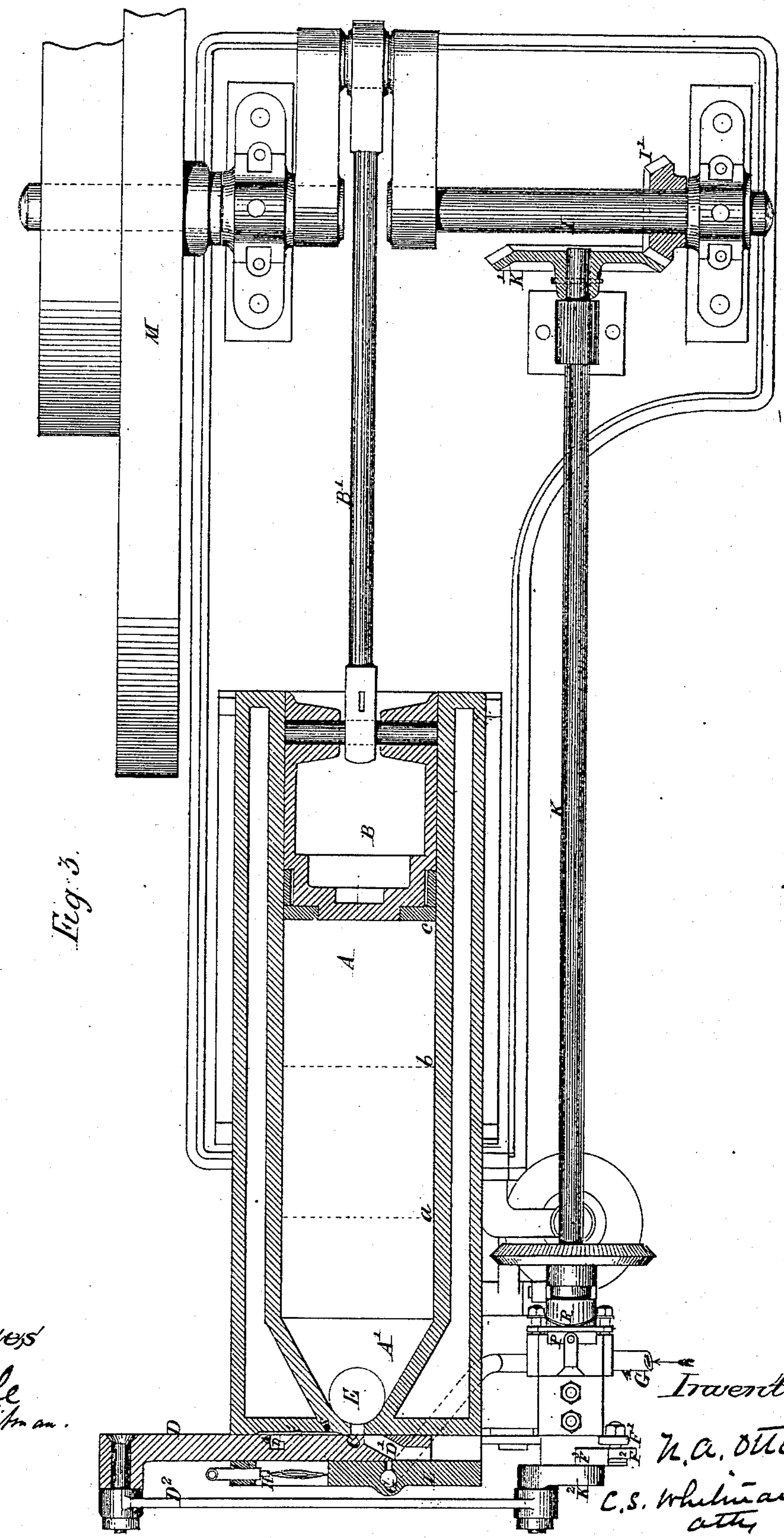

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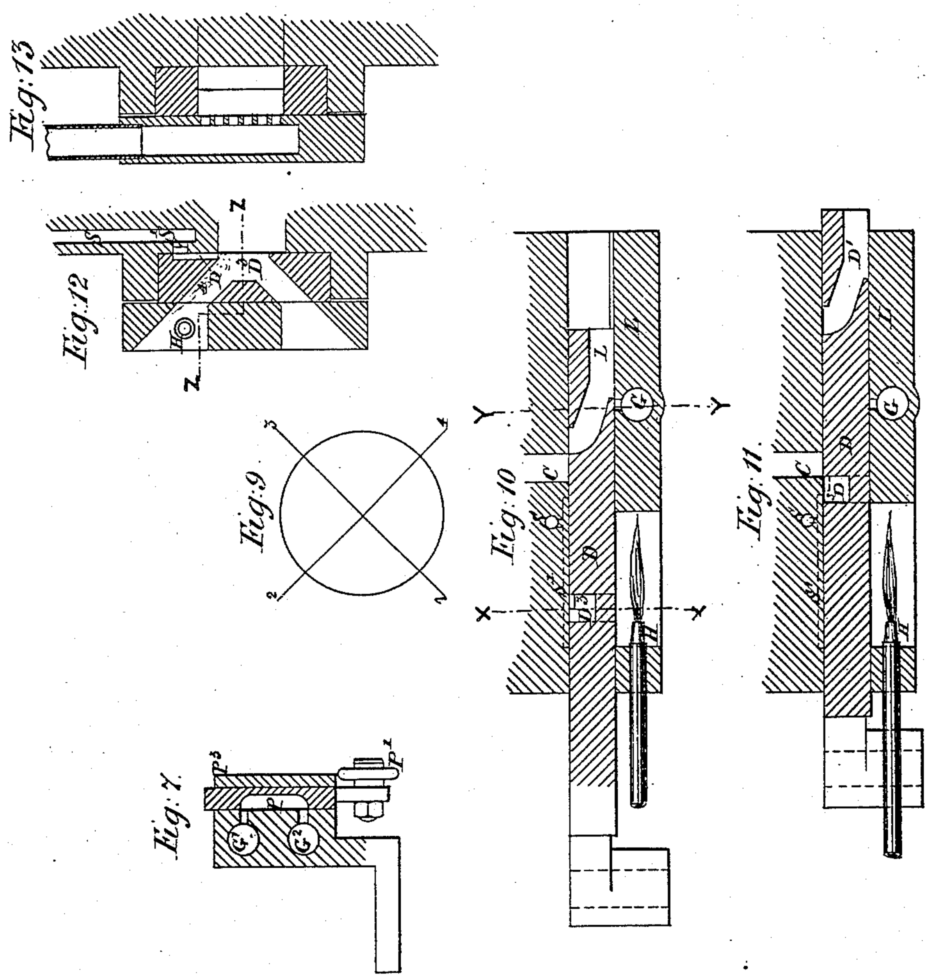

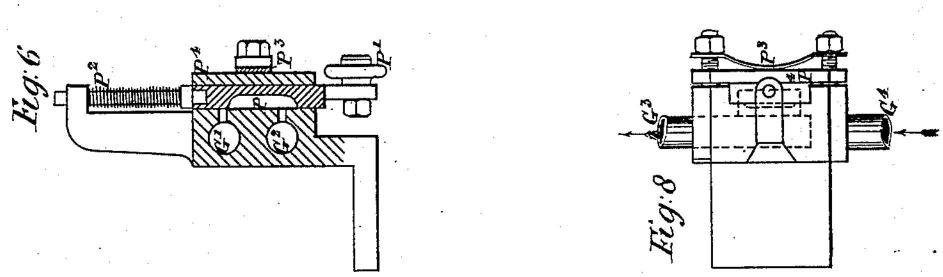

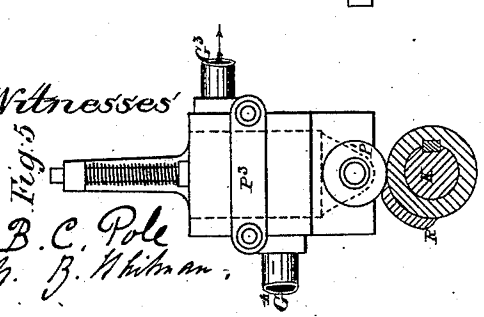

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UNITED STATES PATENT OFFICE.

NICOLAUS A. OTTO, OF DEUTZ, GERMANY.

IMPROVEMENT IN GAS-MOTOR ENGINES.

Specification forming part of Letters Patent No. **194,047**, dated August 14, 1877; application filed July 13, 1876.

To all whom it may concern:

Be it known that I, NICOLAUS AUGUST OTTO, of the Gas-Motoren Fabrik-Deutz, at Deutz, in the German Empire, have invented an Improved Gas-Motor Engine; and do hereby declare that the following description, taken in connection with the accompanying sheets of drawings, hereinafter referred to, forms a full and exact specification of the same, wherein I have set forth the nature and principles of my said improvement, by which my invention may be distinguished from others of a similar class, together with such parts as I claim and desire to secure by Letters Patent—that is to say:

In gas-motor engines as at present constructed, an explosive mixture of combustible gas and air is introduced into the engine-cylinder, where it is ignited, resulting in a sudden development of heat and expansion of the gases, a great portion of the useful effect being lost by absorption of heat, unless special provisions are made for allowing the gases to expand very rapidly.

According to my present invention an intimate mixture of combustible gas or vapor and air is introduced into the cylinder, together with a separate charge of air or other gas, that may or may not support combustion, in such a manner and in such proportions that the particles of the combustible gaseous mixture are more or less dispersed in an isolated condition in the air or other gas, so that on ignition, instead of an explosion ensuing, the flame will be communicated gradually from one combustible particle to another, thereby effecting a gradual development of heat and a corresponding gradual expansion of the gases, which will enable the motive power so produced to be utilized in the most effective manner.

In order more clearly to describe my invention, I will refer to the accompanying drawings, in which Figure 1 shows a longitudinal section of an engine-cylinder, A, having a piston, B, connected to a fly-wheel shaft, and a port or passage, C, for the admission of combustible gaseous mixture and air, controlled by the slide D, and having also a passage, E, for the emission of the products of combustion, closed by a valve, F. Assuming the piston to be at the end of its instroke, its bottom surface being represented by the dotted line *a*, while the slide D is in such a position that its passage D^1 establishes a communication between the outer air through the aperture D^2 and the port C, then, on the piston commencing its outstroke, it will draw in atmospheric air until it arrives at the point indicated by the dotted line *b*, when the slide will have been moved so as to cut off the air-supply and establish a communication between the passage G in the slide-cover, for an intimate mixture of coal-gas or petroleum vapor and air, (in such proportions that the mixture will burn of itself, but, owing to the presence of the first admitted air, will not explode,) and the port C through the passage D^1. On the continued motion of the piston, combustible gaseous mixture will consequently be drawn in until the piston has arrived at a point, *c*, when the slide will have moved into the position shown, cutting off the gas-supply, and about to establish a communication between the small gas-flame H and the charge in the cylinder, for the purpose of igniting the latter.

The combustible gaseous mixture, in entering the cylinder behind the charge of air previously admitted, will, to a certain extent, mix with the latter, the particles of the combustible mixture being close together in and near the port C, and becoming more and more dispersed in the air as they approach the piston, as indicated by the dots in the drawing, which represent the combustible particles. Thus, on the ignition of the charge in the port C, the gaseous mixture will at first burn with comparative rapidity, the flame spreading from particle to particle; but as the ignition extends toward the front end of the charge, it will proceed more and more slowly, owing to the combustible particles being farther and farther apart.

The burning particles impart their heat to the surrounding air, producing a gradually increasing pressure in the cylinder, which causes the piston to complete its outstroke. Motion being thus imparted to the fly-wheel by the piston-rod, its momentum causes the piston to perform its return stroke, whereby the products of combustion are expelled through the valve F, and, the fly-wheel also causing the piston to commence its next outstroke, a fresh charge of air and combustible mixture is drawn in, as before described.

In order to vary the power of the engine, the charge of combustible mixture (represented by the space *a* to *b*) may be varied, as may also the proportions of air and coal-gas or vapor of which it is composed, and such variation may be controlled by connecting the valve-gear with any suitable construction of governor, as will be presently described.

From the foregoing general description it will be seen that as in the improved mode of operating there is no sudden explosion of the gaseous charge, but a gradual development of heat and expansion of the gases, there will be no such losses of effect as result in gas-engines of present construction through shocks produced by the sudden development of motive power, and by the absorption of heat consequent upon the inability of the gases to expand with sufficient rapidity.

The above-described beneficial effect of the improved mode of working will be further increased by the fact that the charge of air interposed between the combustible mixture and the piston will operate as a cushion or buffer in still further reducing the suddenness of the expansive force generated as it transmits it to the piston.

Engines operating according to my invention may either be single-acting—the return stroke being effected by the momentum of the fly-wheel—or they may be double-acting, a gaseous charge being introduced at each end of the cylinder. They may also operate with the gases either at atmospheric pressure or compressed to any desired degree. In the latter case the engine may be arranged in a similar manner to that above described, the gases being compressed by any suitable known means before being introduced into the engine; but, by preference, I dispense with any such additional compressing mechanism by arranging the engine to operate in the manner I will now proceed to describe with reference to Figs. 2 to 13 of the drawings, of which—

Fig. 2 shows a side elevation; Fig. 3, a sectional plan; Fig. 4, a back-end view, and Figs. 5 to 13 details of the valve-gear.

The engine is here represented as being single-acting, the cylinder A being open to the atmosphere at its front end. At its closed back end it has a space, A′, beyond the stroke of the piston B, which space i˙, by preference, made conical at the end, as shown, tapering to the inlet-port C for combustible gas and air, and also communicating by the passage E with the escape-valve F, Fig. 3, for the products of combustion.

The piston B is connected by the rod B′ to the crank-shaft I, on which is a bevel-pinion, I′, in gear with a bevel-wheel, K^1, on a shaft, K. On the other end of this shaft is a crank, K^2, connected by a link, D^2, to the slide D, governing the admission of gas and air to the cylinder. The gearing I′ K^1 is so proportioned that the crank K^2 makes one revolution, and, consequently, the slide one to-and-fro motion, while the piston makes two double strokes.

The mode of operating with this engine is as follows: Assuming the piston to be at the end of its instroke (represented by the dotted line *a*, Fig. 3,) and about to be moved through its outstroke by the momentum of the fly-wheel M, then, the slide D (the construction of which will be presently explained) being in position to admit atmospheric air through the passage D^1 and port C, air will be drawn into the cylinder until the piston has reached the point represented by the dotted line *b*, when, the slide having established a communication with the combustible-gas supply and the cylinder, combustible gas intimately mixed with air will be drawn in until the piston has arrived at the end of its outstroke, the position shown at Fig. 3. As before explained with reference to Fig. 1, the combustible gaseous mixture, in entering, will mix to a certain extent with the air previously introduced, the particles of gaseous mixture being close together at the back end of the cylinder, and more and more separated from each other toward the front end. The slide having moved so as to close the inlet-port C, the piston is caused, by the momentum of the fly-wheel, to perform its instroke, whereby the charge of gaseous mixture and air that filled the cylinder at atmospheric pressure will be compressed into the space from the line *a* to the back end of the cylinder, the particles of gaseous mixture remaining in much the same unequally-distributed condition in the air as they did before compression. The slide now establishes a communication between the gas-flame H and the interior of the cylinder, so as to ignite the charge, resulting in a gradual development of heat and expansion of the gases, as before explained, whereby the piston will be caused to perform its outstroke, imparting fresh momentum to the fly-wheel. This momentum will again cause the piston to perform its instroke, whereby the products of combustion will be expelled through the valve F, which has been opened by the lever N, acted on by a cam, O, on the shaft K. As the piston only moves back to the line *a*, it will be seen that a certain portion of the products of combustion will remain in the cylinder, and will consequently mix to a certain extent with the air drawn in behind them at the next outstroke; but as the mixture of combustible gas and air afterward introduced will burn independently of the air or other gas surrounding its particles, it will be seen that the presence of such products of combustion in the charge will be of no consequence.

As before stated, the power of the engine may be regulated by regulating the quantity of combustible gas introduced at each charge. This is effected by the gas-slide P, controlled by the governor Q, operating on the sliding cam R as follows: Fig. 5 shows an enlarged front view of the gas-slide; Figs. 6 and 7, vertical sections, and Fig. 8 a plan, of the same. In the casing of the slide are formed two passages, G^1 and G^2, the former communicating with a pipe, G^3, leading to the gas-passage G in the slide D, and the other with the gas-supply pipe G^4. These passages have small side openings, as shown, which, when the slide is in the position shown in Fig. 7, both communicate with the cavity of the slide P, so that gas can pass from G^2 into G^1, and thence into the passage G of the slide D. When the slide is moved into the position shown in Fig. 6, this communication, and consequently the gas-supply, is cut off. The slide P rests with a small roller, P^1, upon a cam, R, which revolves with, but can slide somewhat upon, the shaft K, the raising of the slide being effected by the cam, while its downward motion is effected by the spring P^2. According as the cam is shifted relatively to the roller P^1 by the action of the governor Q and lever Q^1, (which has a fork taking into a collar on the cam, as shown,) the slide is made to establish the communication between G^1 and G^2 for a longer or a shorter period, thus allowing a greater or less quantity of the combustible gas for one charge to pass into the cylinder A independently of the action of the slide D. The gas-slide P is held against the face of the casing by a spring, P^3, pressing against a cover, P^4, on the back of the slide.

The construction and mode of operating of the engine-slide D will be understood on reference to Figs. 10 to 13, of which Figs. 10 and 11 represent two longitudinal sections of the slide and casing on line Z Z, Fig. 12, with the slide in two different positions, and Figs. 12 and 13 show transverse sections, respectively on lines X X and Y Y, Fig. 10.

From the previous description of the action of the engine, it will be seen that there are four strokes of the piston required for one complete operation—namely, an outstroke for drawing in the charge of combustible mixture and air, an instroke for compressing the gases, a second outstroke when the piston is propelled on the ignition of the gases, and a second instroke for expelling the products of combustion. The slide D consequently has to perform one to-and-fro motion while the piston is performing the above-mentioned four operations, for which purpose, as before stated, the slide-crank K^2 makes one revolution while the engine-shaft makes two. The circle at Fig. 9 represents a diagram of the path of the crank K^2, in which the part from 1 to 2 represents the motion of the slide during the time of drawing in the gaseous charge, the part from 2 to 3 the motion during the compression of the charge, 3 to 4 the motion during the working stroke, and 4 to 1 the motion during the expulsion of the products of combustion. Figs. 10 and 11 each show two positions of the slide, Fig. 10 showing, first, its position at the point 1 of the crank-path when the air-passage D^1 is just about to communicate with the port C, and, secondly, its position at point 2, the gas and air supply having just been cut off. It will be seen that in the first position the gas-passage G is also about to open; but the before-described action of the gas-slide P will prevent the admission of combustible gas until the requisite charge of air is introduced. Fig. 11 shows, first, the position of the slide at the point 3 when the flame of the gas jet H is about to be communicated to the gaseous charge by a small quantity of inflamed gas in the passage D^3, and, secondly, its position at the point 4 when the escape-valve F is about to be opened.

For effecting the ignition of the charge, a small quantity of combustible gas is made to pass down a pipe, S, into a recess, S′, in the end of the cylinder, whence it issues through a small channel, D^4, in the slide into the passage D^3. Here it is ignited by the jet H, and the flame is, by the motion of the slide, conveyed to the port C, the slide-cover L being made to close the outer opening of D^3 before its inner opening communicates with C, as shown at Fig. 11.

The gas-passage G communicates with the air-passage D^1 through a number of small openings, as shown at Fig. 13, so that the gas, in issuing in small divided jets into D^3, becomes intimately mixed with the air therein in the requisite proportions for producing the combustible mixture before described.

The opening of the escape-valve F at the commencement of the second instroke of the piston (point 4 at Fig. 9) is effected by the bell-crank lever F^1, connected at one end to the stem of the valve, and having at the other end a roller, F^2, which is acted upon by the cam F^3 on the shaft K. E′ is the pipe for conducting away the products of combustion.

The governor Q is driven by bevel-gearing from the shaft K, its arms being made to move a sliding collar, Q^3, up or down, thus imparting motion through the lever Q^1 to the cam R, as before described.

The cylinder A is, by preference, provided with a jacket, as shown.

As before stated, the engine may be arranged double-acting by providing the requisite valve-gear for each end of the cylinder. It may also be arranged in a vertical or inclined position, instead of horizontal; and if single-acting, or if great regularity of motion be required, two or more engines may be connected to one and the same crank-shaft.

Having thus described the nature of my invention, and in what manner the same is to be performed, I wish it to be understood that I do not claim generally the separate introduction of combustible gas and air into the cylinder of a gas-engine, as I am aware that is to a certain extent described in the English Patents No. 1,655 of 1857, and 335 of 1860; but,

I claim—

1. A gas-motor engine wherein an intimate mixture of combustible gas or vapor and air is introduced into the cylinder, separate from a charge of air or other incombustible gas, in such manner and in such proportions that the particles of combustible mixture will be close together at the point of ignition, but will be more and more dispersed in the charge of air forward of that point, whereby the development of heat and the expansion or increase of pressure produced by the combustion are rendered gradual, substantially as herein described.

2. A gas-motor engine wherein an intimate mixture of combustible gas or vapor and air is introduced into the cylinder separate from and subsequent to a charge of air, such introduction being effected through an aperture or apertures in the end surface of the cylinder, in order to cause the charge of air to move forward in the cylinder as the combustible mixture is introduced, substantially as and for the purposes set forth.

3. A gas-motor engine wherein, by one outstroke of the piston, separate charges of combustible gaseous mixture and of air are drawn into the cylinder, which charges are compressed by the instroke and then ignited, so as to propel the piston, which, by its return stroke, expels the products of combustion, substantially as herein described with reference to Figs. 2 to 13 of the drawings.

4. In gas-motor engines wherein charges of combustible gas and air are introduced separately into the cylinder, regulating the power of the engine by controlling the gas-supply by means of a valve operated by a governor, substantially as herein described.

5. In gas-motor engines, the shaft K, driven from the engine-shaft, with crank K^2, imparting motion to the slide D, cam R, for regulating the gas-supply, and cam F^3, for opening the escape-valve F, substantially as herein described.

6. In gas-motor engines, the combination of the cylinder A, piston B, engine-shaft I, counter-shaft K, crank K^2, slide D, gas-slide P, cam R, escape-valve F, lever F^1, and cam F^3, all arranged and operating substantially as and for the purposes herein described.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses this 1st day of June, 1876.

NICOLAUS AUGUST OTTO.

Witnesses:

FRIEDRICH ALBERT SPIECKER,
GUSTAV KLEINJING.