(No Model.) 2 Sheets—Sheet 1.

W. DONALDSON.

GAS MOTOR.

No. 577,160. Patented Feb. 16, 1897.

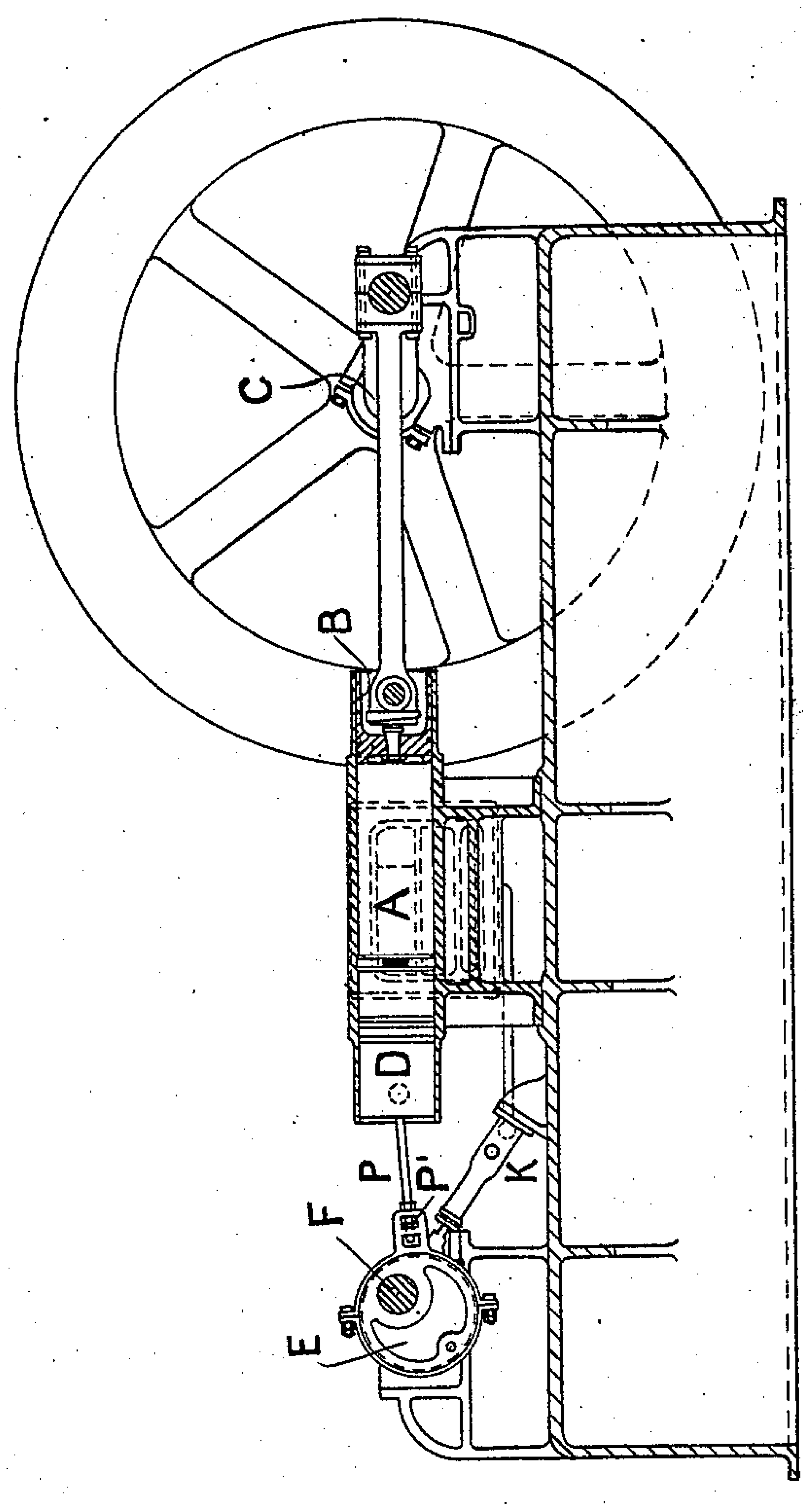

FIG. 1

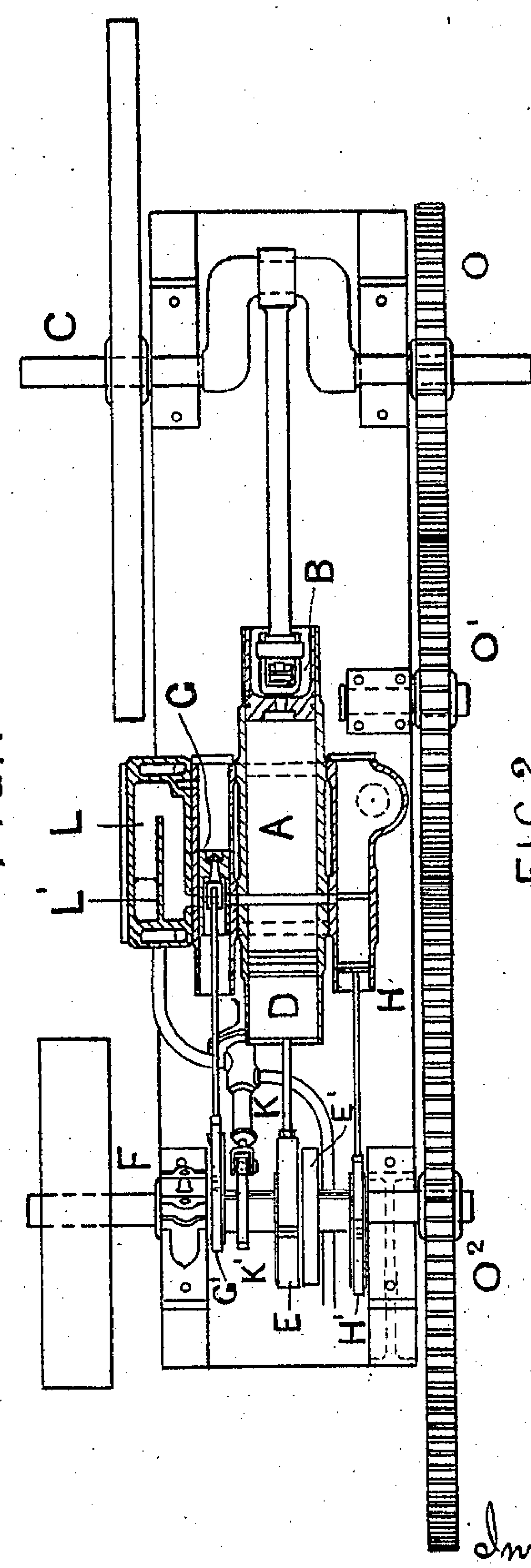

FIG. 2.

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(No Model.)

2 Sheets—Sheet 2.

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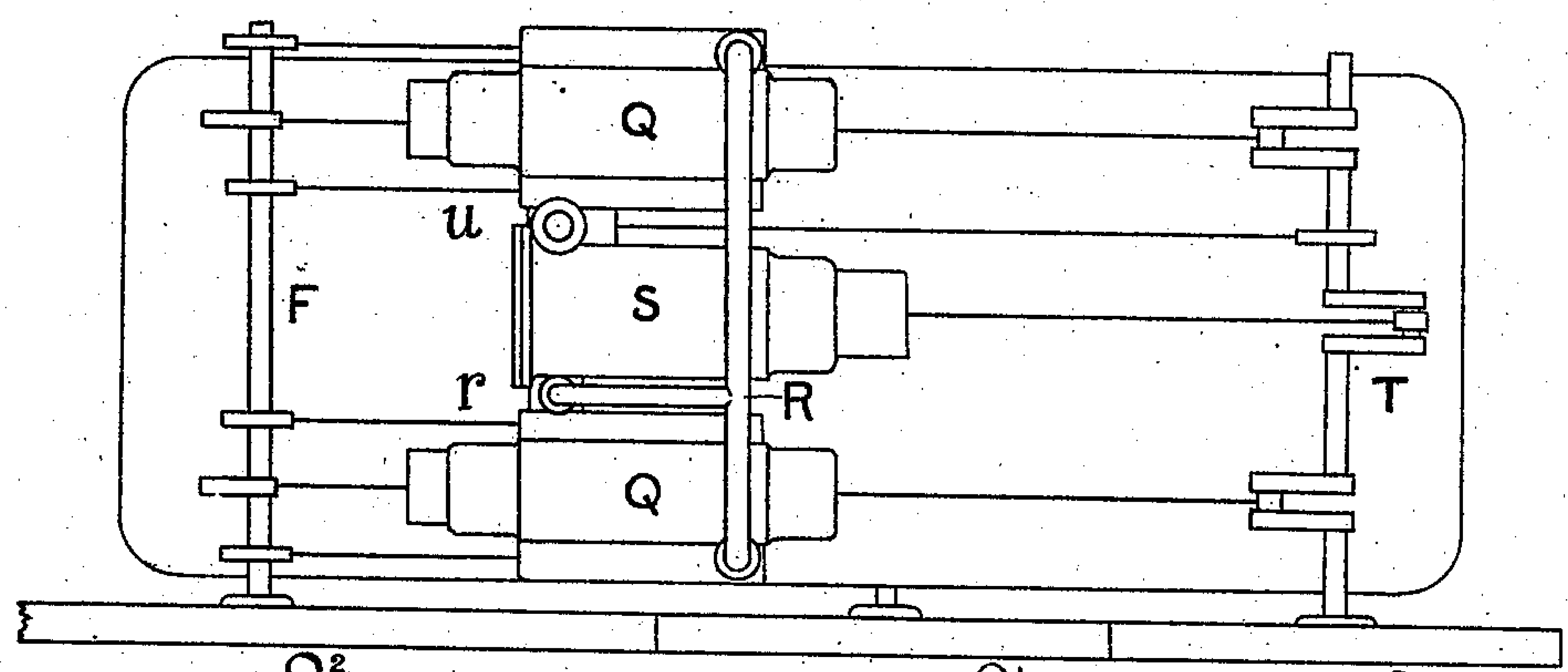
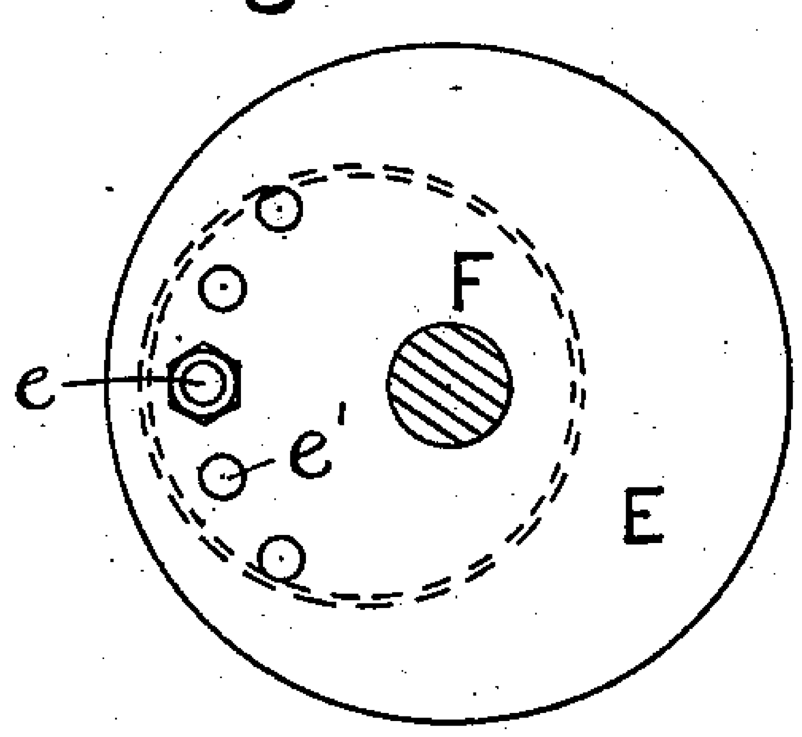


FIG.3



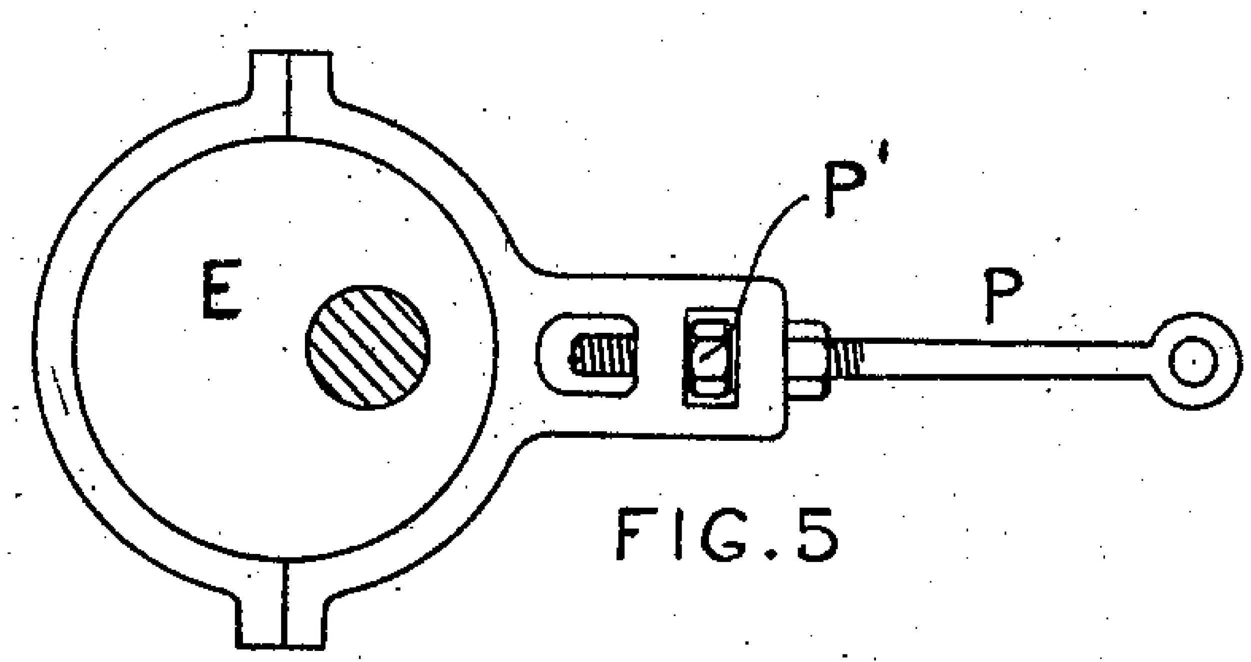


FIG.5

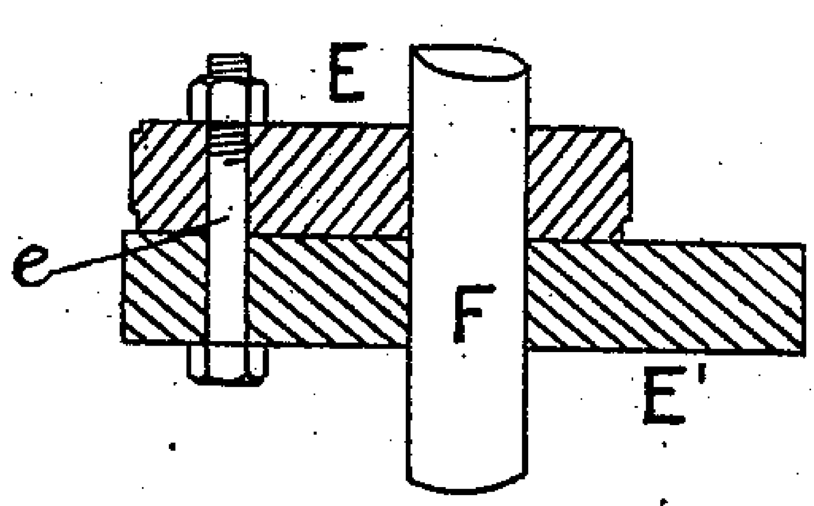


FIG.4

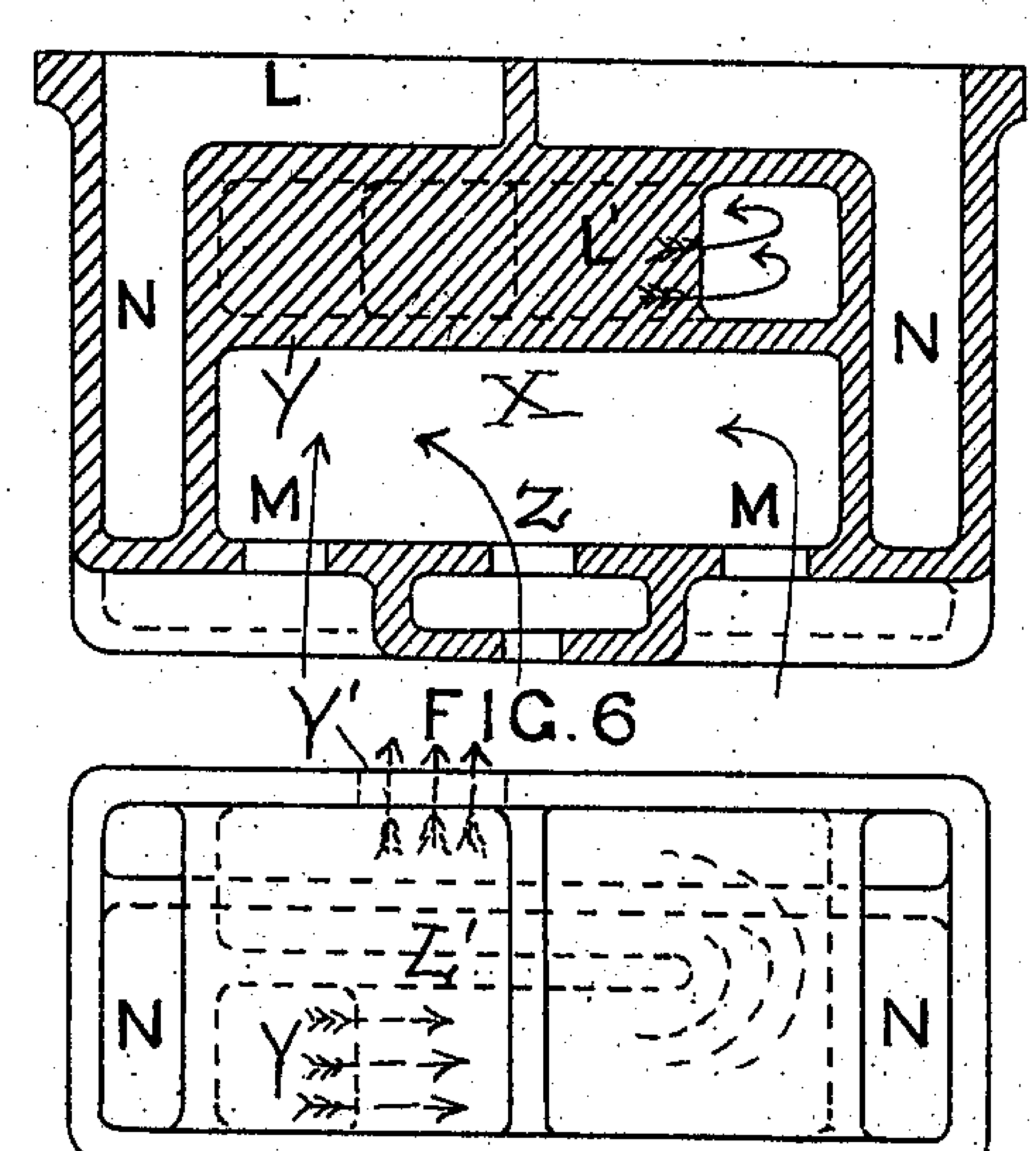


FIG.6

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UNITED STATES PATENT OFFICE.

WILLIAM DONALDSON, OF LONDON, ENGLAND.

GAS-MOTOR.

SPECIFICATION forming part of Letters Patent No. 577,160, dated February 16, 1897.

Application filed October 11, 1895. Serial No. 565,387. (No model.) Patented in England April 4, 1895, No. 6,972.

To all whom it may concern:

Be it known that I, WILLIAM DONALDSON, a subject of the Queen of Great Britain and Ireland, residing at London, England, have invented Improvements in Gas-Motors, (for which a patent has been granted in England, No. 6,972, dated April 4, 1895,) of which the following is a specification.

This invention relates to motors operating by the explosion of combustible gas, and has for its object the provision of means in such engines or motors working on what is known as the "Otto cycle" (that is, working in the following cycle of operations: first, suction of inflammable charge; second, compression of the same; third, explosion and operative stroke, and, fourth, exhaust of burned products) by which it shall be easy to vary at and after construction the volume of residual burned gases left in the cylinder after the termination of the exhaust-stroke from a minimum represented by the unavoidable volume of short port-hole passages to any desired amount; further, to insure, in the case of a single-cylinder engine, that the ratio of expansion after explosion shall, if desired, exceed the ratio of compression before ignition, and to vary both ratios, and to thus allow of the regulation of the work done in any of the cylinders of a compounded engine.

The means I employ to effect my purpose are as follows:

Figure 1 is a vertical section through the cylinder of my gas-motor. Fig. 2 is a sectional plan of the same. Fig. 3 is a diagrammatic view of the said motor with compounded cylinders. Fig. 4 is a detached elevation and section of the adjustable eccentric driving the regulating-piston. Fig. 5 is a detached detail of the adjustable connecting-rods of same eccentric. Fig. 6 is a sectional elevation and plan of the mixing-chamber for the explosive charge.

A is the usual open cylinder of a gas-engine in which the Otto cycle of operation takes place. B is the usual operative trunk-piston, connected in known manner by connecting-rod and crank to a crank-shaft C, carrying a fly-wheel. The back of the operative cylinder A is also made open and is closed by an auxiliary regulating-piston D, receiving a reciprocating motion, making half the number of strokes in a given time as compared with that of the operative piston, from an eccentric-tumbler E or equivalent crank on a counter-shaft F at the rear of the motor-cylinder. The said counter-shaft F is driven from the main crank-shaft C conveniently by a train of cogged wheels O O′ O^2 or by any equivalent connection or gearing, such as will not allow of slip, so that the counter-shaft F revolves at half the speed of the main crank-shaft C. This relative arrangement of the operative piston B, making two strokes to one of the regulating-piston D, is all important, as it enables me to regulate the residual burned-gas products left in the cylinder at the termination of the exhaust-stroke without sensibly altering the volume of the fresh charge of air and gas admitted in the following return stroke of the piston B, and also to cause the ratio of compression to be less than the ratio of expansion, which could not have been effected had the reciprocations of the regulating-piston D been equal in number in a given time to those of the piston B.

The length of the stroke of the regulating-piston D is so adjusted as compared with that of the operative piston B that when the angular position of the eccentric E on the counter-shaft F coincides with or is opposite to the crank on the main crank-shaft C the exhaust products are entirely discharged from the cylinder, while, owing to the half-speed of revolution of the shaft F as compared with the crank-shaft C, the regulating-piston D does not again meet the reëntering piston B on its next compression-stroke and in this way by receding provides the space required for the compressed charges.

By giving the eccentric-tumbler E angular advance on the shaft F as compared with the position of the crank on the crank-shaft C, I can vary at any time during the lifetime of the engine the ratios of compression and of expansion, and at the same time leave any desired volume of exhaust products behind in the cylinder at the termination of the exhaust-stroke. To conveniently effect this, the eccentric-tumbler E is not keyed to its shaft, but is secured by a carrying pin or bolt *e*, Fig. 4, to a disk E′, keyed to the shaft, such disk being provided with a series of holes *e*′, by which the angular position of the eccentric-tumbler E may be adjusted on the shaft F as desired at any time. If, also, it is desired to alter the ratios of compression and of expansion, as above, by altering the angular position of the eccentric E on the shaft F, I can still effect the entire discharge of the exhaust products from the cylinder by throwing forward the piston B by lengthening the eccentric-connecting rod or by adding a false inner end to the piston D or B.

The eccentric-rod P is provided with an adjustable sliding joint P′, Fig. 5, by which the length of said rod may be adjusted at any time for this purpose.

The explosive-charge admission-valve G and exhaust-valve H may be of any known or convenient type, but are shown as piston-valves operated by eccentric-tumblers G′ H′ from the shaft F, and the gas-admission valve K may be operated conveniently by a cam K′ on the shaft F.

In order to effect the thorough mixture of the gas and air for the explosive charge before ignition, they pass through a mixing-chamber L, the gas entering by the orifice Z from the gas-valve K, operated mechanically at the required time by the cam. The gas and air mix in the lower compartment X and proceed by an orifice Y to an upper compartment. The upper compartment is provided with a baffle-plate L′, Fig. 6, around which the gases travel to insure thorough mixing of the gas and air before issue by the port Y′ to the cylinder as it passes through the chamber L, which is conveniently kept cool by a water-jacket N in communication with the usual water-jacket of the operative cylinder A.

For the greatest economy in working expansively I combine two high-pressure explosive cylinders (exploding, as in the Otto cycle, alternately in every other outward stroke) with a single-acting low-pressure cylinder receiving the exhaust in each outward stroke of the low-pressure piston from either high-pressure cylinder alternately, thus making a working stroke in the low-pressure cylinder on each outward stroke and exhausting on each inward stroke of the piston. This is shown diagrammatically in Fig. 3, where Q Q are the two single-acting high-pressure exploding-cylinders of the construction hereinabove described, each exploding in every other stroke and alternately to one another. Their exhaust-exits are connected by a breeches-pipe R to the supply-port *r* of the low-pressure cylinder S. The expanded gases are finally discharged from the cylinder S by the exhaust-port U, controlled by a valve operated in the usual way from the rotating crank-shaft T.

The pistons of the three cylinders Q Q and S are connected in the usual manner by connecting-rods to a single three-throw shaft T, in which the cranks of the high-pressure cylinders Q Q are at the same angular position on the shaft, and the crank of the low-pressure cylinder S is opposite to these.

The exhaust-valve of cylinder S is operated in the usual way from the main crank-shaft T. In this arrangement one gas-admission valve, air-and-gas-mixing chamber, and supply will suffice for both the high-pressure cylinders Q Q, the admission gas-valve being operated to lift every revolution of the main crank-shaft T in place of every alternate revolution of the main crank-shaft, as in the case of a single-cylinder engine, as hereinabove described.

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

1. In an explosive-gas motor, in combination, an open explosive gas-cylinder, two revolving shafts, situated one at either end of said cylinder at right angles to and in the plane of the axis of said cylinder, bearings adapted to support said shafts on surface of bed-plate, two single-acting pistons one operative and one regulating in said cylinder, a crank and connecting-rod connections between operative piston and main shaft; eccentric connections between the regulating-piston and counter-shaft, and gearing between said shafts adapted to revolve counter-shaft at half the revolutions of main shaft to effect the variable regulation of the volume of burned products undischarged on exhaust and the ratios of compression and expansion.

2. In an explosive-gas motor, a regulating-piston in main cylinder at rear of operative piston, an adjustable lengthening-piece adapted thereto, and means for reciprocation of said regulating-piston from counter-shaft revolving at half-speed of main crank-shaft.

3. In an explosive-gas motor, a regulating-piston in main cylinder at rear of operative piston, a connecting-rod adjustable as to length, connecting same to eccentric on counter-shaft revolving at half-speed of main crank-shaft.

4. In an explosive-gas motor, a regulating-piston in main cylinder at rear of operative piston, and adjustable means for reciprocating same at various angular positions to main crank-piston, consisting of a loose eccentric-tumbler on counter-shaft, a keyed disk on said counter-shaft and a steady-bolt fitting a series of holes in said disk to effect adjustment of eccentric to fixed disk.

5. In an explosive-gas motor, two explosion-cylinders, each having a trunk-piston, and an auxiliary piston, and means to reciprocate the latter with half as many reciprocations in a given time as the trunk-piston, in combination with a single-acting expansion-cylinder, and connections from the exhaust-port of each explosion-cylinder to the supply-port of the expansion-cylinder.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

WILLIAM DONALDSON.

Witnesses:
CHARLES H. CARTER,
RICHARD A. HOFFMANN.