No. 816,215.

PATENTED MAR. 27, 1906.

L. F. BURGER.

TANDEM GAS ENGINE.

APPLICATION FILED FEB. 2, 1905.

3 SHEETS—SHEET 1.

Fig. 1.

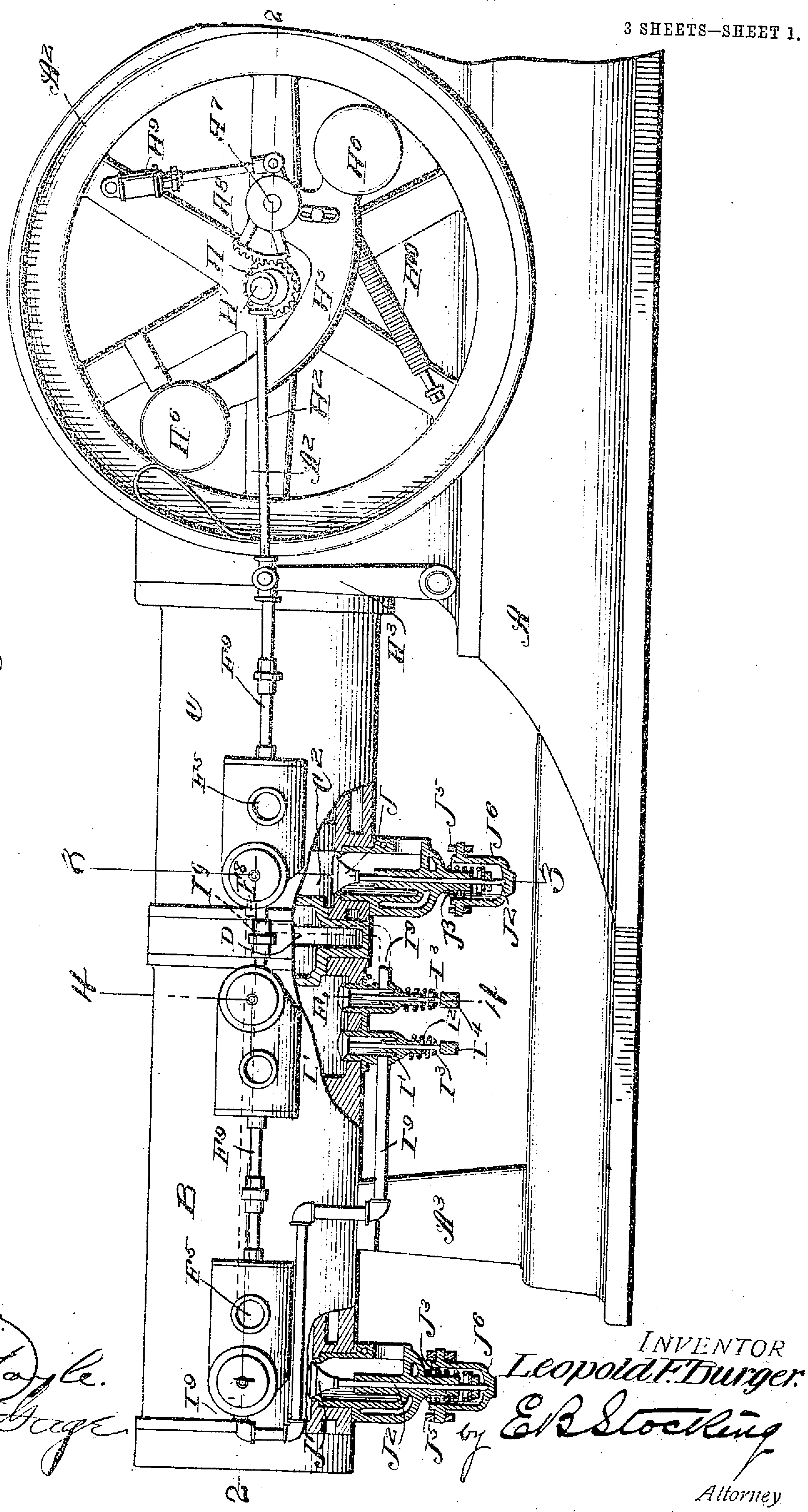

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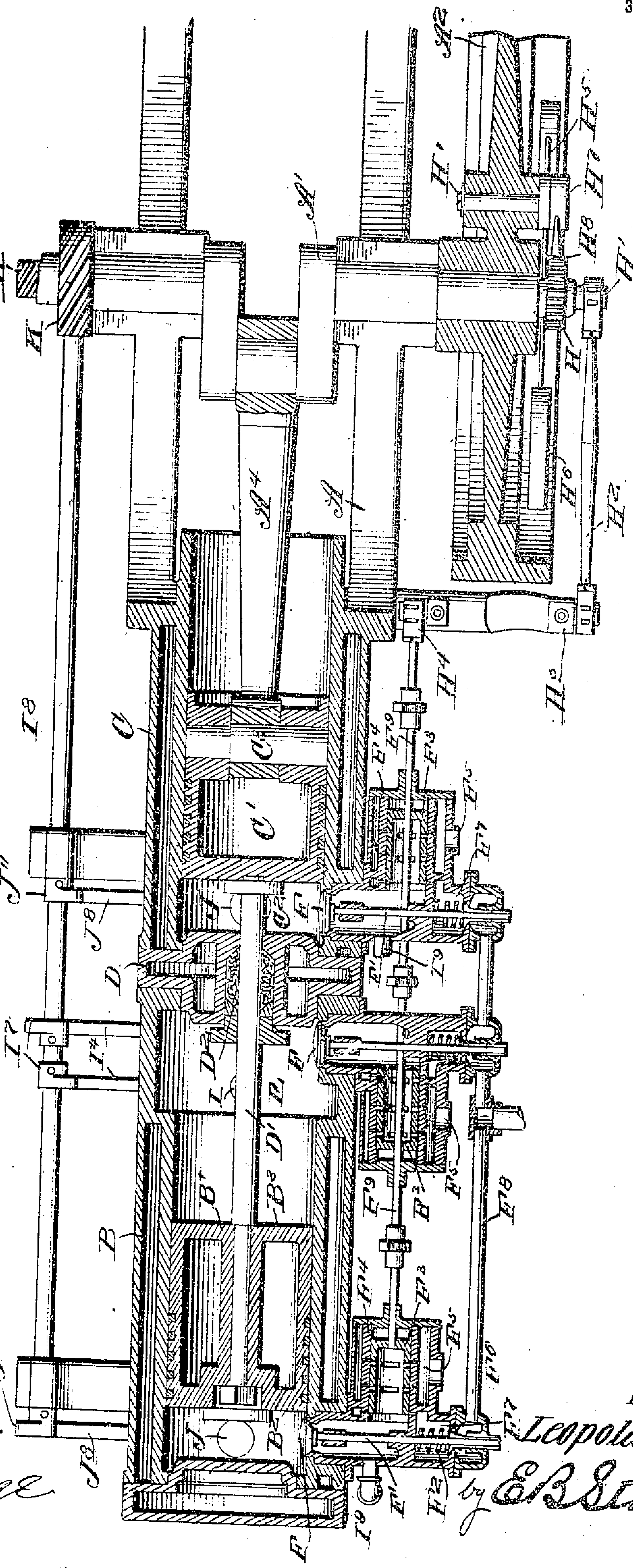
Fig. 2.



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3 SHEETS—SHEET 3.

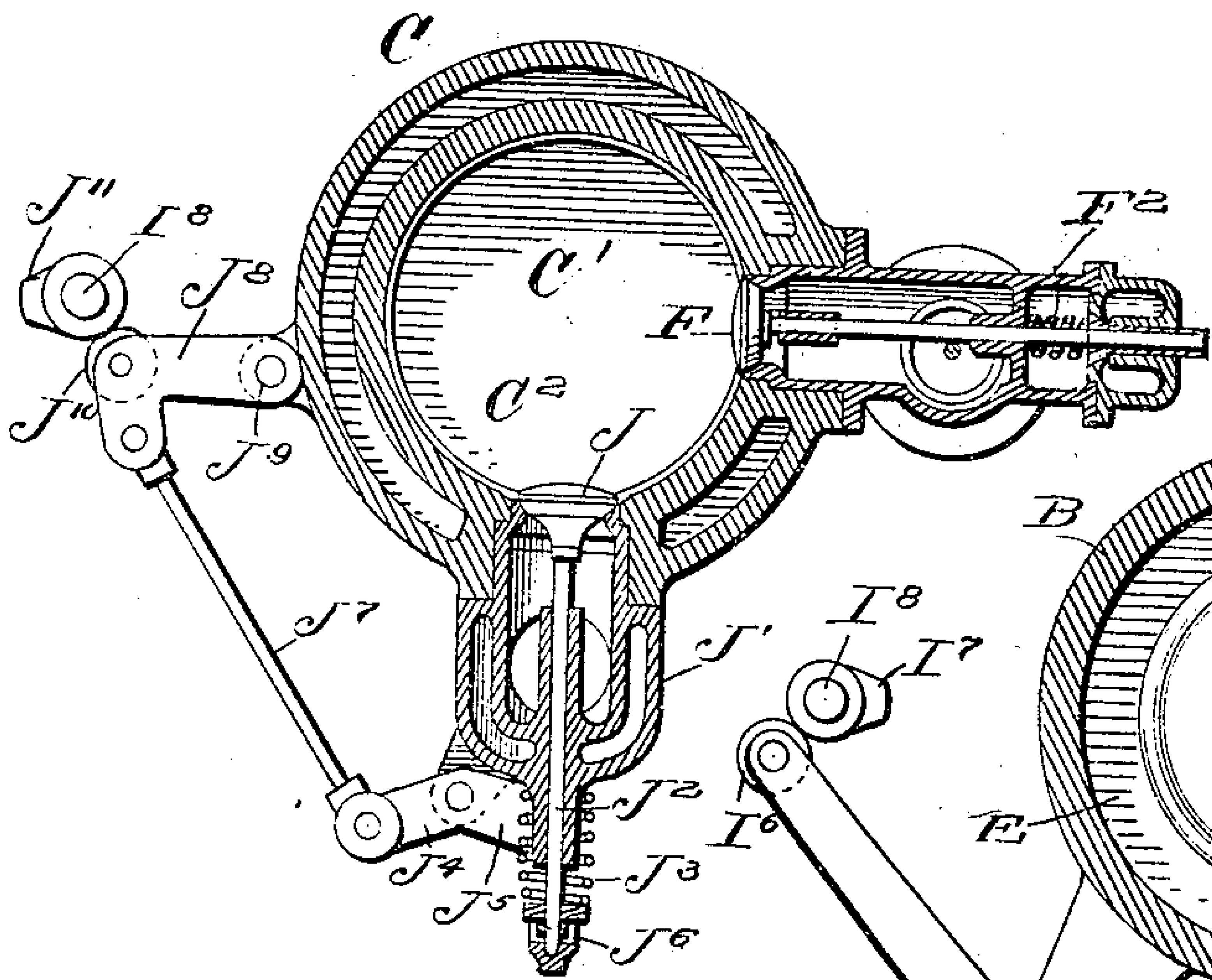


Fig. 3.

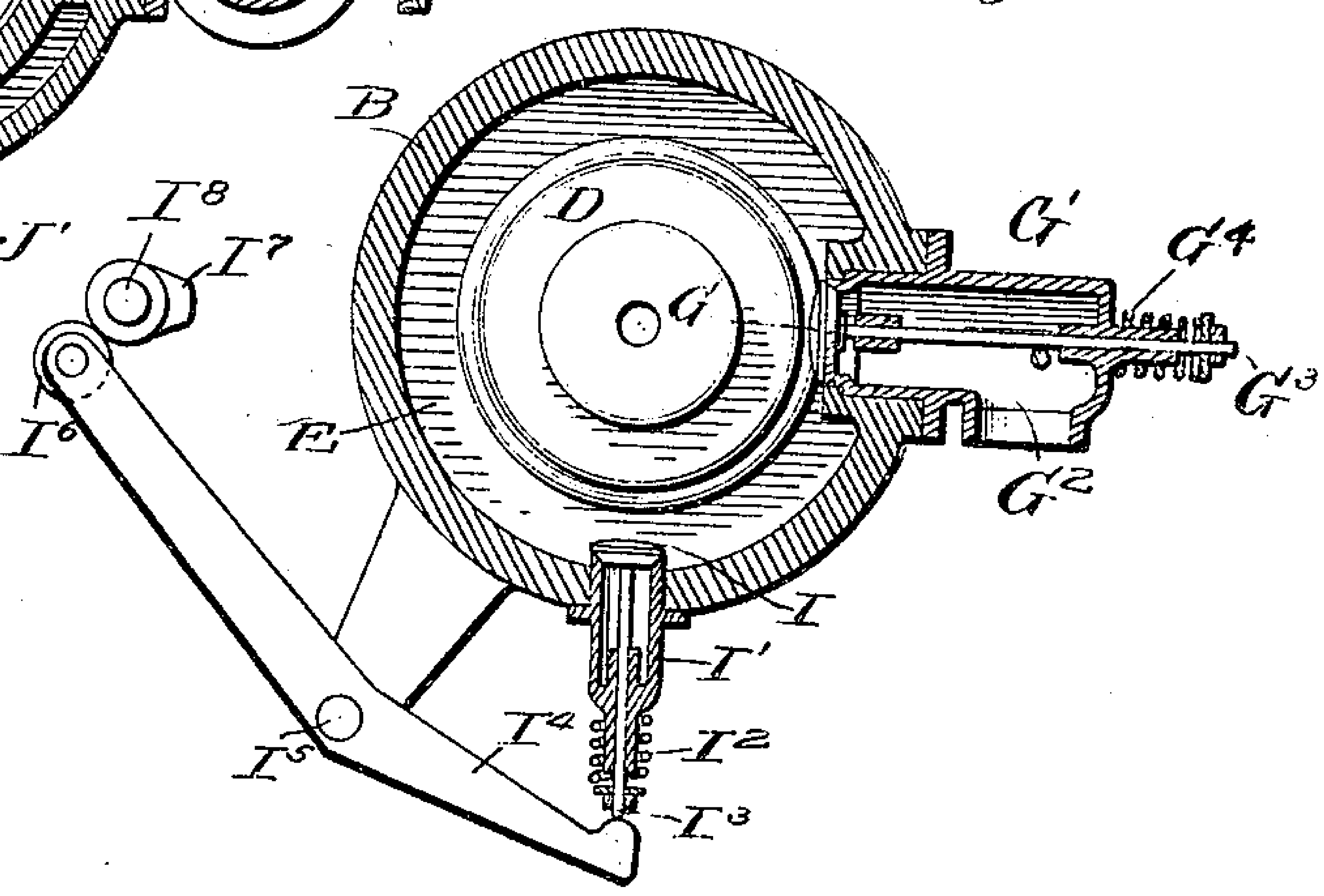


Fig. 5.

Fig. 6.

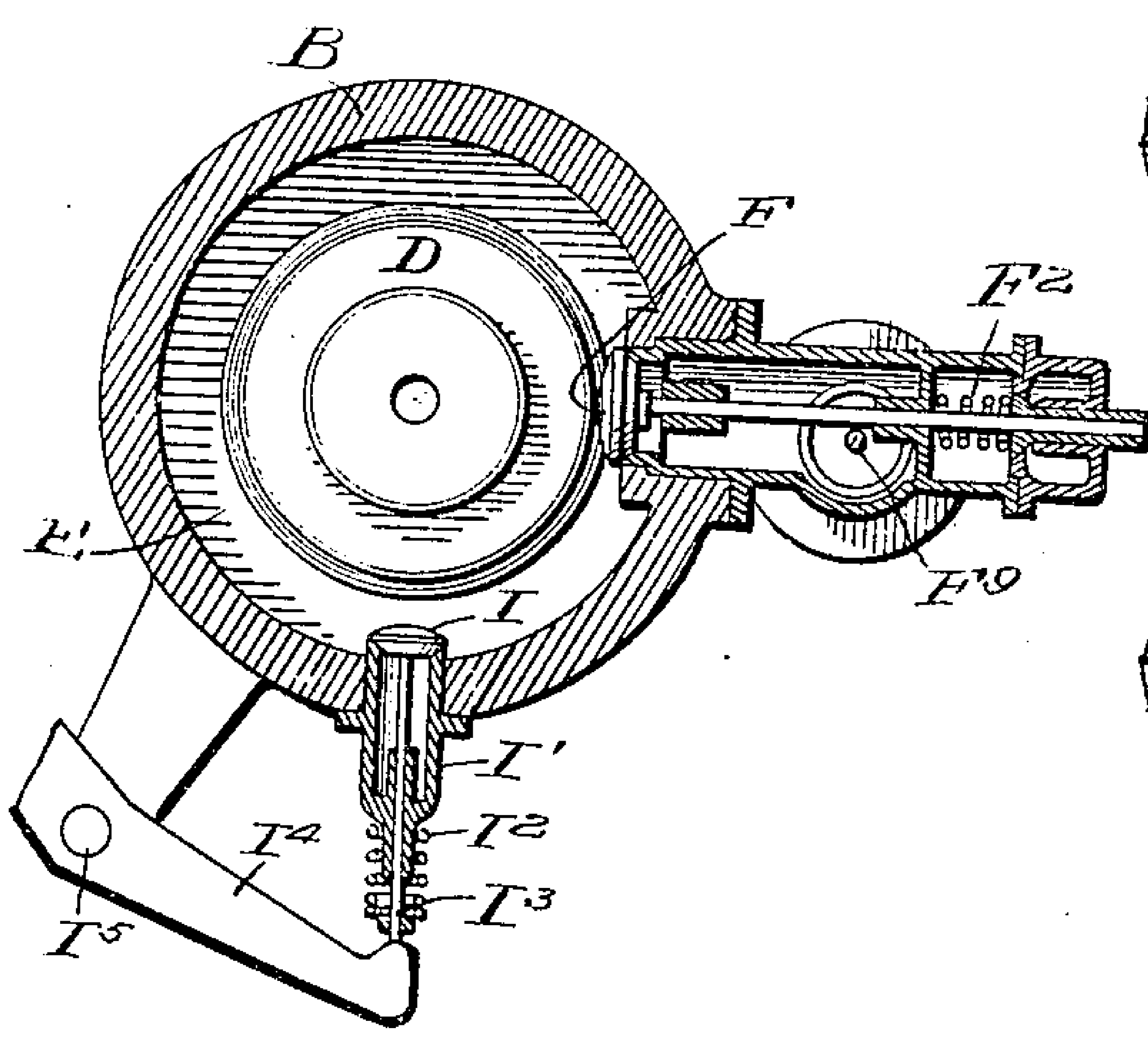
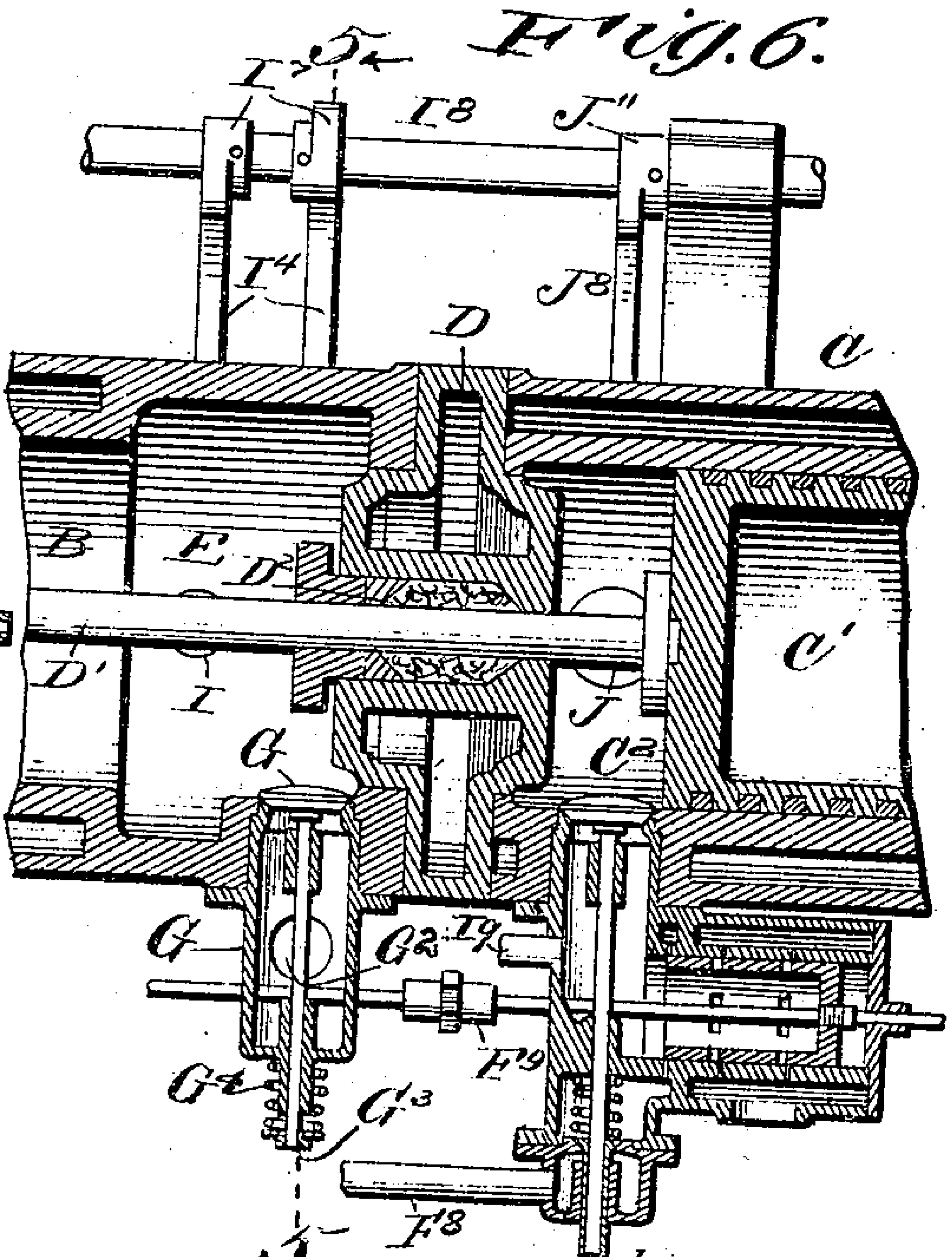


Fig. 4.



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TANDEM GAS-ENGINE.

No. 816,215. Specification of Letters Patent. Patented March 27, 1906.

Application filed February 2, 1905. Serial No. 243,826.

To all whom it may concern:

Be it known that I, LEOPOLD F. BURGER, a citizen of the United States, residing at Anderson, in the county of Madison, State of Indiana, have invented certain new and useful Improvements in Tandem Gas-Engines, of which the following is a specification, reference being had therein to the accompanying drawings.

This invention relates to a duplex tandem-engine, and particularly to an explosive-engine comprising a plurality of cylinders operating upon a four-cycle system.

The invention has for its object to provide a compression-chamber at the end of one of the cylinders, whereby the piston therein is adapted to compress the fluid within this chamber, which is subsequently alternately supplied to the explosion-chambers in addition to the suction-intake of explosive mixture drawn into the cylinder in the movement of the piston away from the intake-valve.

Another and further object of the invention is to provide a system of governing-valves for the intake into the two explosive-chambers as well as the compression-chamber, all under the direct control of a governing mechanism carried by the crank-shaft; while the exhaust from each of the explosive-cylinders and the feed from the compression-chamber to said explosive-cylinders are automatically controlled by means directly driven from said crank-shaft.

Other and further objects and advantages of the invention will be hereinafter set forth and the novel features thereof defined by the appended claims.

In the drawings, Figure 1 is a side elevation of the engine with parts in section; Fig 2, a longitudinal horizontal section thereof on the line 2 2 of Fig. 1; Fig. 3, a vertical cross-section on the line 3 3 of Fig. 1; Fig. 4, a similar view on the line 4 4; Fig. 5, a detail horizontal section of a modified application in which the governing-valve is omitted from the compression-chamber, and Fig. 6 a vertical cross-section upon the line 6 6 of Fig. 5.

Like letters of reference refer to like parts in the several figures of the drawings.

The letter A designates the engine base or foundation, which may be of any desired character or configuration and which is adapted to support at one end a crank-shaft A′, having secured thereto the usual balance or fly wheel A^2, while at the opposite end of the base the cylinders B and C are supported in tandem relation to each other. The outer cylinder may be separated by any means—for instance, a standard A^3, as shown in Fig. 1—and the cylinders are suitably water-jacketed for the purpose of cooling the same in the usual manner and are supported by a partition D, through which a piston-rod D′ extends and is connected to the pistons B′ and C′ within the cylinders B and C, respectively. A suitable packing-box D^2 is provided in the partition D, which partition preferably is of a double-wall construction, as herein shown, but it is only necessary that the same offer a proper resistance to the explosive action in the cylinder C. At one end of each of the pistons an explosion-chamber B^2 and C^2 is provided, while at the opposite end of the cylinder B a compression-chamber E is formed, and the piston B′ therein has a solid rear face B^3, which acts as a compressing-piston for the fluid within this chamber in the outward movement of the piston B′. The piston C′ is packed in the usual manner and is provided with a pivoted connection C^3 to a pitman A^4, extending from the arm of the crank-shaft A′. Each of the explosive-cylinders is supplied with a suitable intake-valve of any ordinary construction—for instance, the form of valve herein illustrated in Fig. 2, which has been found very desirable and is more specifically disclosed in my allowed application, filed December 19, 1903, Serial No. 185,880. This form of valve comprises an intake-valve F, provided at the lower end of its stem F′ with a tension-spring F^2, by which it is normally held closed, and this valve is fed by a cylindrical governing-valve F^3, having ports of greater area than the ports of the casing F^4, within which it reciprocates. This casing is surrounded for a portion of its length by an air-chamber F^5, by which air is supplied to the ports of the valve, and at one end with gas-ports F^6, communicating with the chamber F^7 at the lower portion of the intake-valve. These intake governing-valves are provided for each of the explosive-cylinders in order that the usual charge may be taken therein, and if it be desired to compress a mixed charge of air and gas within the compression-cylinder E a similar valve is provided at that point, as shown in Fig. 2, while if it be preferable to compress only a single fluid an ordinary spring-controlled intake-valve may be provided, as shown at G in Figs. 5 and 6. In this modification of the invention the casing G' of the valve G may be connected at G^2 with a source either of air or of gas, and the fluid received therethrough will be compressed and distributed, as hereinafter set forth. The valve G in this form is held normally closed by means of the spring G^4, acting upon the stem G^3 thereof, so that the charge is drawn into the compressing-cylinder in the movement of the piston away therefrom. The series of these governing-valves as used are connected to a suitable gas-supply pipe F^8, as shown in Fig. 2. When this system of governing-valves is used, they are connected together by any desired form of valve-rod, as shown at F^9, and governed by the crank-shaft through the medium of suitable governing mechanism, one form of which, particularly desirable for this purpose, is herein illustrated and comprises a pinion H, rotatably mounted upon the end of the crank-shaft beyond the balance-wheel A^2 and provided with a wrist-pin H', disposed eccentrically to the axis of the crank-shaft, from which a rod H^2 extends and is connected to the crank-arm H^3 of a rock-shaft pivotally mounted upon the base of the engine and provided at its inner end with a similar arm H^4, connected to the valve-rod F^9 to control the same. The eccentric-pin H' is usually set from ninety degrees to one hundred degrees ahead of the crank-arm, and its position relative thereto is shifted by means of the governor H^5, provided with the usual weights H^6 and pivotally mounted at H^7 upon the balance-wheel. At one side of its pivot a segmental gear H^8 is provided, which meshes with the pinion H to move the same, while the usual tension-spring H^{10} and dash-pot H^9 are provided for the purpose of governing the movement of the weighted arm. The fluid compressed within the compression-chamber E is discharged therefrom through suitable valves I, which are disposed in casings I' and normally held closed by means of a spring I^2, while the extended stem I^3 of the valve is adapted to be actuated by means of a lever I^4, Figs. 4 and 5, pivotally supported at I^5 upon a bracket and provided at its opposite end with a contact-face I^6, adapted to be engaged by a cam I^7, secured to a rotated lay-shaft I^8, so that the valve may be automatically opened at the proper period to supply the charge from the compression-chamber to the explosive-chamber after the cylinder has drawn in its ordinary charge. Two of these valves are shown in Fig. 1, one to independently control the feed to each of the explosive-cylinders, and their number may be varied as found necessary or desirable. From each of these valves a suitable feed-pipe I^9 extends to the chamber of the intake-valve F, as shown in Figs. 1 and 2.

Each of the explosive-cylinders is provided with any desired form of exhaust-valve, as shown at J, mounted in a casing J' and provided with a stem J^2, having the usual tension-spring J^3 for retaining the valve in a closed position. For the purpose of opening the valve at the proper period to relieve the exhaust from the cylinders a crank-arm J^4 is pivotally mounted upon a bracket from the casing J' and provided with bifurcated arms J^5 to embrace the lower portion of the casing, from which a shoe or stirrup J^6 is pivotally suspended, Figs. 1 and 3, and embraces the lower end of the valve-stem J^2. This crank-arm is connected at its opposite end by a pivotally-secured rod J^7, extending to a lever J^8, which is pivoted at J^9 to the casing of the cylinder and at its opposite end to the rod J^7, while upon the face thereof a friction-roller J^{10} is provided and adapted to engage a cam J^{11}, secured to the lay-shaft I^8 at suitable points relative to the disposition of the exhaust-valves in each of the cylinders. This lay-shaft may be rotated by any desired means—for instance, the worm-gearing K K', as shown in Fig. 2, whereby it is rotated in relation to the crank-shaft so as to effect one rotation during every two revolutions of the crank-shaft.

In the operation of this engine the pistons perform the usual functions of a four-cycle engine, but are so controlled as to operate in alternation—that is, while one piston is drawing in a fresh charge the other is at its explosion-stroke. Under such conditions, with the parts in the position shown in Fig. 2, the piston at the left in its movement from the intake-valve will draw in a charge of air and gas through the controlling-valve at atmospheric pressure. During this movement the face of the piston opposite the compression-chamber has effected a compression of the charge within this chamber and the automatically-controlled valve from the compression-chamber is then opened and introduces a compressed charge into the cylinder supplemental to the charge drawn therein at atmospheric pressure. In the return movement of the left piston toward the intake-valve the combined charges are compressed, constituting the second cycle, and when this piston has reached the height of its compression the ignition of the charge thus compressed occurs, driving the piston to the right, and thus compressing the charge in the chamber which has been drawn in during the second cycle of this piston movement. During the return movement of the left piston toward the intake-valve constituting the fourth cycle the exhaust-valve is opened and the explosion-chamber freed from burned gas in the usual manner. During the explosion-stroke of the left piston the right piston draws in its charge, and at the end of this suction-charge in the cylinder of the right piston the compressed charge is admitted by the automatically-controlled valves of the compression-chamber, so that it will be apparent that an impulse is received at each revolution by the alternate operation of the exhaust-valves for the respective cylinders which are controlled by the lay-shaft geared to rotate one revolution for every two of the crank-shaft. It will also be seen that the single compression-chamber supplies both of the explosion-cylinders by the alternately-operated valves disposed therein and communicating with each of said chambers, while both the explosion-cylinders and the compression-chamber are supplied with automatically and simultaneously controlled valves actuated by a governor carried upon a crank-shaft of the engine. This governor will remain in fixed position until the engine reaches the speed at which it is set, when through the connections shown the eccentric-pin will be shifted from ninety degrees to one hundered degrees ahead of the crank to possibly one hundred and fifty degrees ahead, according to the load upon the engine, and by so doing will open the ports of the controlling-valves before the suction-stroke and close these ports before the end of that stroke, thus permitting only a small amount of air and gas to be drawn into the cylinders, which effects a very light expansion relative to the power desired for the load upon the engine. In the modified form of the invention an ordinary intake-valve has been used, and in such event the compression-chamber may be fed by producer-gas or air alone. In the former case no air is admitted through the intake-valve, and as the producer-gas is of a very low British thermal unit and requires a great deal more gas than would be required when using natural or artificial gas therefore by permitting the pistons to draw in their regular charge of the mixed air and gas into the explosion-cylinders and adding thereto the gas compressed in the compression-chamber through the valve connections the volume of gas in the explosion-cylinders will be increased, and as a natural consequence will have approximately as strong an expansion as either natural or artificial gas, thus effecting a duplex engine. In the event that natural gas be used it is only necessary in most cases to admit air to the compression-chamber and draw a richer mixture of air and gas into the explosion-chambers, to which the air from the compression-chamber is added at the end of each suction-stroke of the pistons, in which event no governing-valve would be required to control the amount of air that was admitted into the compression-chamber. It will be seen that an engine constructed in accordance with this invention will produce about twice the power by using the centrally-disposed compression-chamber as when the air or gas or combined gas and air are used. This compression-chamber is particularly intended and adapted for use in connection with a plurality of cylinders operating upon a four-cycle system, whether they be disposed in tandem or otherwise, said cylinders being controlled for alternate operation, as set forth. Thus there will be an explosive impulse in one cylinder during one revolution of the crank-shaft and a similar impulse in the other cylinder during the next revolution, and as the compression-chamber acts with every revolution both of the cylinders may be conveniently charged from the single compression-chamber. This chamber is also adapted for use either with gas or air singly or gas and air combined, as hereinbefore described, and the use of the supplemental compressed charge in addition to the suction charge of the cylinder greatly increases the power of the engine and provides means by which the explosive mixture may be controlled in character and degree to effect the most efficient results.

It will be obvious that changes may be made in the details of construction and configuration without departing from the spirit of the invention as defined by the appended claims.

Having described my invention and set forth its merits, what I claim, and desire to secure by Letters Patent, is—

1. In a gas-engine, a plurality of cylinders having explosion-chambers at the same end, simultaneously-operating pistons therein, a compression-chamber disposed intermediate of said cylinders and in communication with the piston in one thereof at its end opposite the explosion-chamber, and means to convey the compressed fluid from said chamber to either of the cylinders.

2. In a gas-engine, a plurality of cylinders having explosion-chambers at the same end, simultaneously-operating pistons therein, a compression-chamber disposed intermediate of said cylinders and in communication with the piston in one thereof at its end opposite the explosion-chamber, means to convey the compressed fluid from said chamber to either of the cylinders, and governing-valves for each of the cylinders independent of the conveying means from the compression-chamber.

3. In a gas-engine, a plurality of cylinders having explosion-chambers at the same end, simultaneously-operating pistons therein, a compression-chamber disposed intermediate of said cylinders and in communication with the piston in one thereof at its end opposite the explosion-chamber, means to convey the compressed fluid from said chamber to either of the cylinders, governing-valves at the intake for each of the cylinders independent of the conveying means from the compression-

chamber, and independent discharge-valves to control the conveying means from the compression-chamber to each cylinder.

4. In a gas-engine, a plurality of cylinders, having explosion-chambers at the same end, simultaneously-operating pistons therein, a compression-chamber disposed intermediate of said cylinders and in communication with the piston in one thereof at its end opposite the explosion-chamber, means to convey the compressed fluid from said chamber to either of the cylinders, governing-valves for each of the cylinders independent of the conveying means from the compression-chamber, independent discharge-valves to control the conveying means from the compression-chamber, a crank-shaft, a governor carried thereby and connected to said governor-valves to simultaneously operate the same, and a shaft driven from the crank-shaft and provided with means for alternately operating the discharge-valves from the compression-chamber.

5. In a gas-engine, a plurality of cylinders separated by a partition, pistons in said cylinders connected by a rod extending through said partition, explosion-chambers at the same end of each of said cylinders, and an independent compression-chamber at the opposite end of one cylinder from the explosion-chamber therein and communicating with both explosion-chambers.

6. In a gas-engine, a plurality of cylinders separated by a partition, pistons in said cylinders connected by a rod extending through said partition, explosion-chambers at the same end of each of said cylinders, a compression-chamber at the opposite end of one cylinder from the explosion-chamber therein, intake-valves for all of said chambers, and discharge-valves for the compression-chamber communicating alternately with each of the explosion-chambers.

7. In a gas-engine, a plurality of cylinders separated by a partition, pistons in said cylinders connected by a rod extending through said partition, explosion-chambers at the same end of each of said cylinders, a compression-chamber at the opposite end of one cylinder from the explosion-chamber therein, intake-valves for all of said chambers, discharge-valves for the compression-chamber communicating with each of the intake-valves for the explosion-chambers, exhaust-valves for each of the explosion-chambers, and a driven shaft provided with means for alternately controlling both the discharge-valves of the compression-chambers and the exhaust-valves of the explosion-chambers.

8. In a gas-engine, a plurality of cylinders separated by a partition, pistons in said cylinders connected by a rod extending through said partition, explosion-chambers at the same end of each of said cylinders, a compression-chamber at the opposite end of one cylinder from the explosion-chamber therein, intake-valves for all of said chambers, discharge-valves for the compression-chamber communicating with each of the intake-valves for the explosion-chambers, exhaust-valves for each of the explosion-chambers, a driven shaft provided with means for alternately controlling both the discharge-valves of the compression-chambers and the exhaust-valves of the explosion-chambers, a governing-valve for each of the explosion-chambers, and a governor for simultaneously controlling said valves.

9. In a gas-engine, a plurality of cylinders separated by a partition, pistons in said cylinders connected by a rod extending through said partition, explosion-chambers at one end of said cylinders, a compression-chamber at the opposite end of one cylinder from the explosion-chamber therein, intake-valves for all of said chambers, discharge-valves for the compression-chamber communicating with each of the intake-valves for the explosion-chambers, exhaust-valves for each of the explosion-chambers, a driven shaft provided with means for alternately controlling both the discharge-valves of the compression-chambers and the exhaust-valves of the explosion-chambers, a governing-valve for each of the explosion-chambers, a governor for simultaneously controlling said valves, a governing-valve for the intake to said compression-chamber, and a gas-feed for all of said governing-valves.

10. In a gas-engine, a cylinder provided at one end with intake and exhaust valves and at the opposite end with a compression-chamber, a piston within said chamber having opposite operating-faces, a discharge-valve carried by said compression-chamber, a lever for opening said valve, a lay-shaft provided with a cam for operating said lever, a crank-shaft, and gearing from said crank-shaft to said lay-shaft for operating the same relative to the rotation of the crank-shaft.

11. In a gas-engine, a plurality of cylinders, pistons therein connected for simultaneous operation, intake-valves for said cylinders, a compression-chamber, and means constructed and arranged for admitting the compressed fluid to said cylinders after the suction charge has been received therein.

12. In a gas-engine, a plurality of cylinders, pistons therein connected for simultaneous operation, intake-valves for said cylinders, a compression-chamber, means constructed and arranged for admitting the compressed fluid to said cylinders after the suction charge has been received therein, and means for controlling the feed and exhaust to said cylinders to permit an alternate operation thereof.

13. In a gas-engine, a plurality of cylinders, pistons therein connected for simultaneous operation, intake-valves for said cylin-

ders, a compression-chamber, means constructed and arranged for admitting the compressed fluid to said cylinders after the suction charge has been received therein, a controlling-valve for each of said cylinders, an intake-valve for said chamber, and a connection from the compression-chamber to the intake-valve beyond the controlling-valve.

14. In a gas-engine, a plurality of cylinders, pistons therein connected for simultaneous operation, intake-valves for said cylinders, a compression-chamber, means for admitting the compressed fluid to said cylinders after the suction charge has been received therein, a controlling-valve for each of said cylinders, an intake-valve for said chamber, a connection from the compression-chamber to an intake-valve beyond the controlling-valve, a crank-shaft, a governor mounted thereon, and means extending from said governor for shifting the controlling-valves relative to the load upon the engine.

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

LEOPOLD F. BURGER.

Witnesses:

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