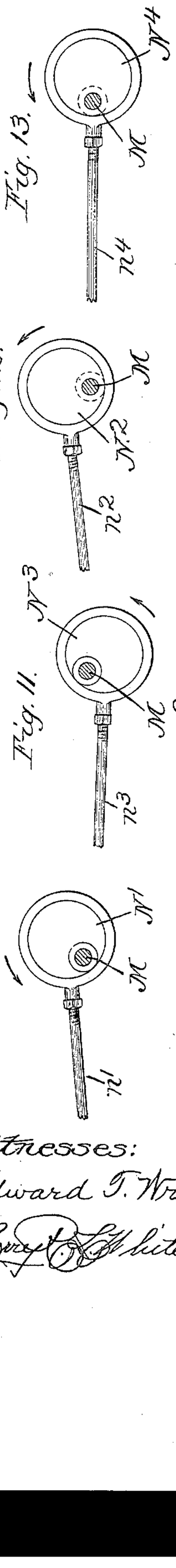
No. 659,911. Patented Oct. 16, 1900.

DE LONSON E. BARNARD.

GAS ENGINE.

(Application filed June 11, 1898.)

(No Model.) 4 Sheets—Sheet 1.



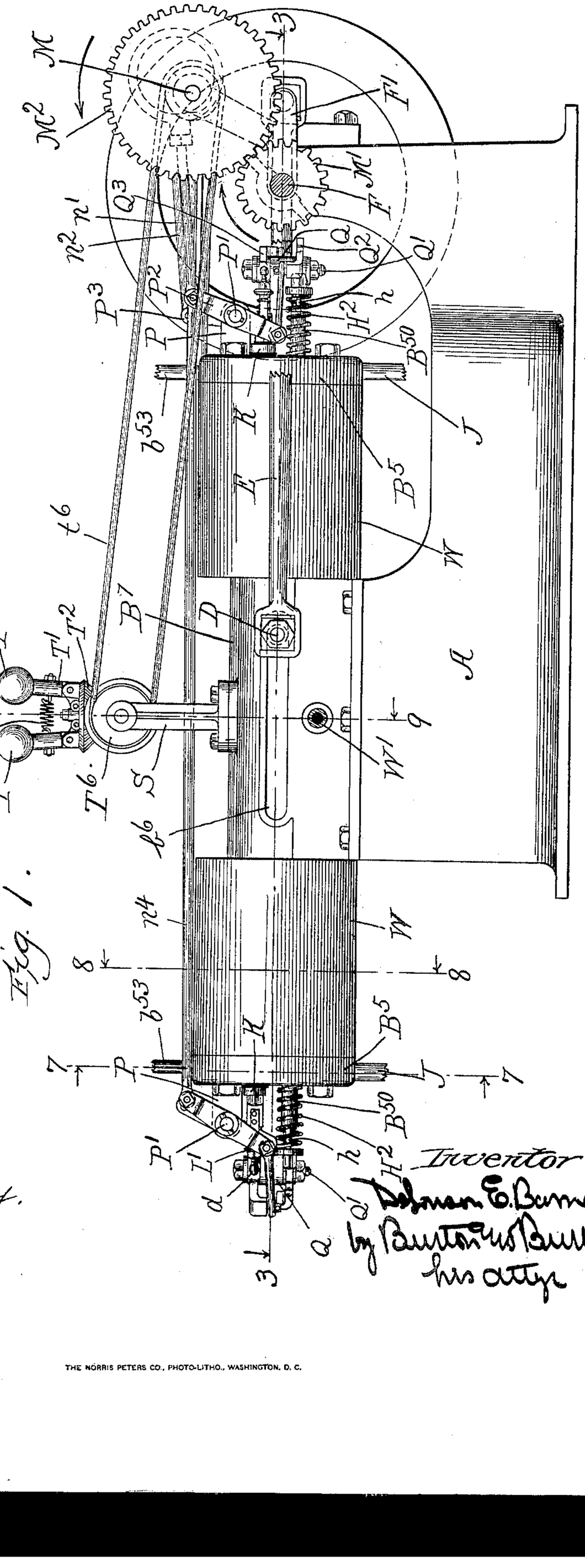


Fig. 1.

Witnesses:
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Howard C. White

Inventor:
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by Burton & Burton
his attys

THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

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(No Model.) 4 Sheets—Sheet 2.

Fig. 2.

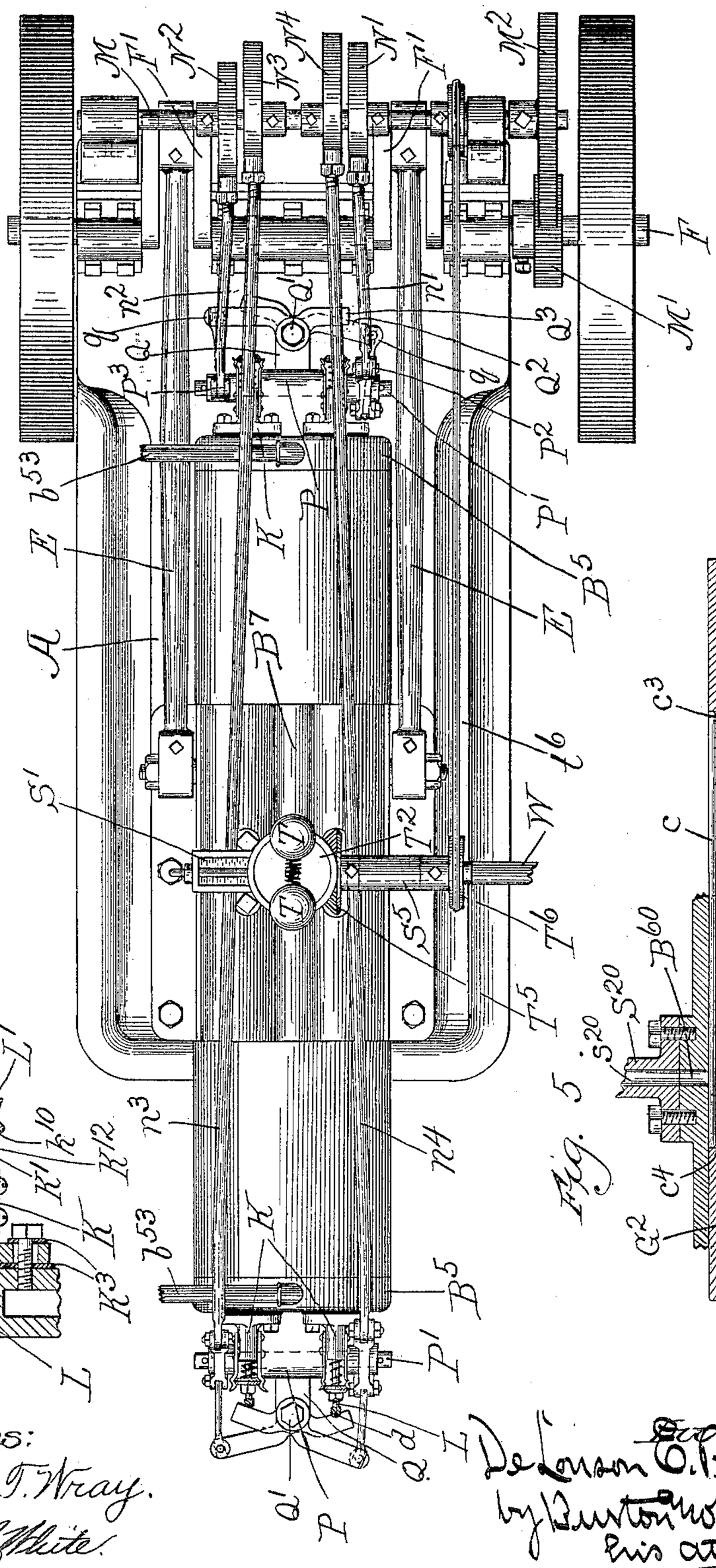


Fig. 6.

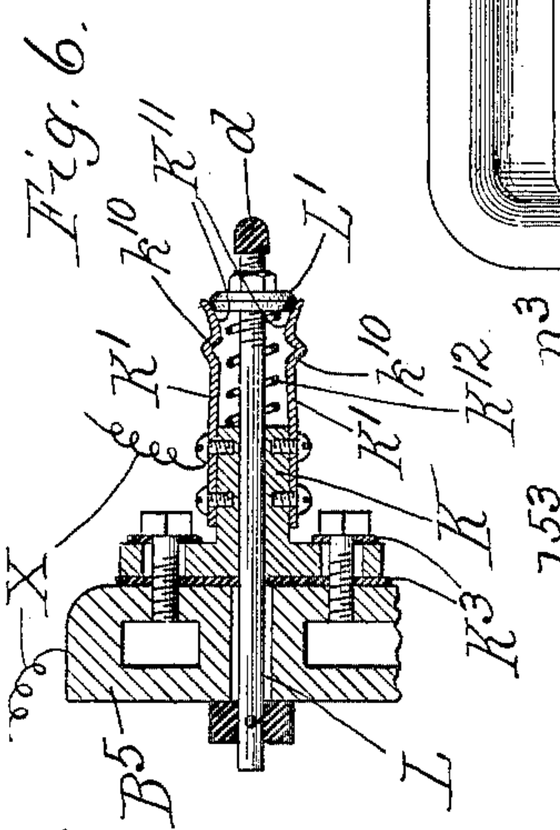
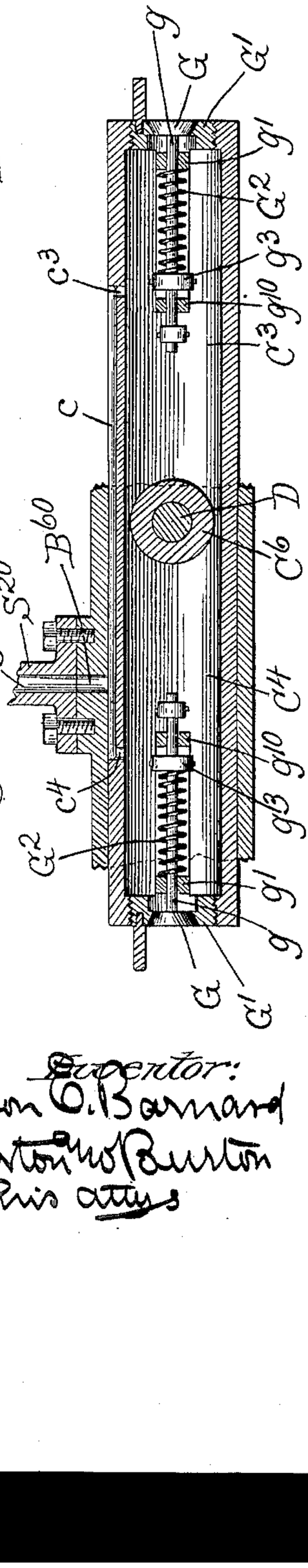


Fig. 5.



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(No Model.) 4 Sheets—Sheet 3.

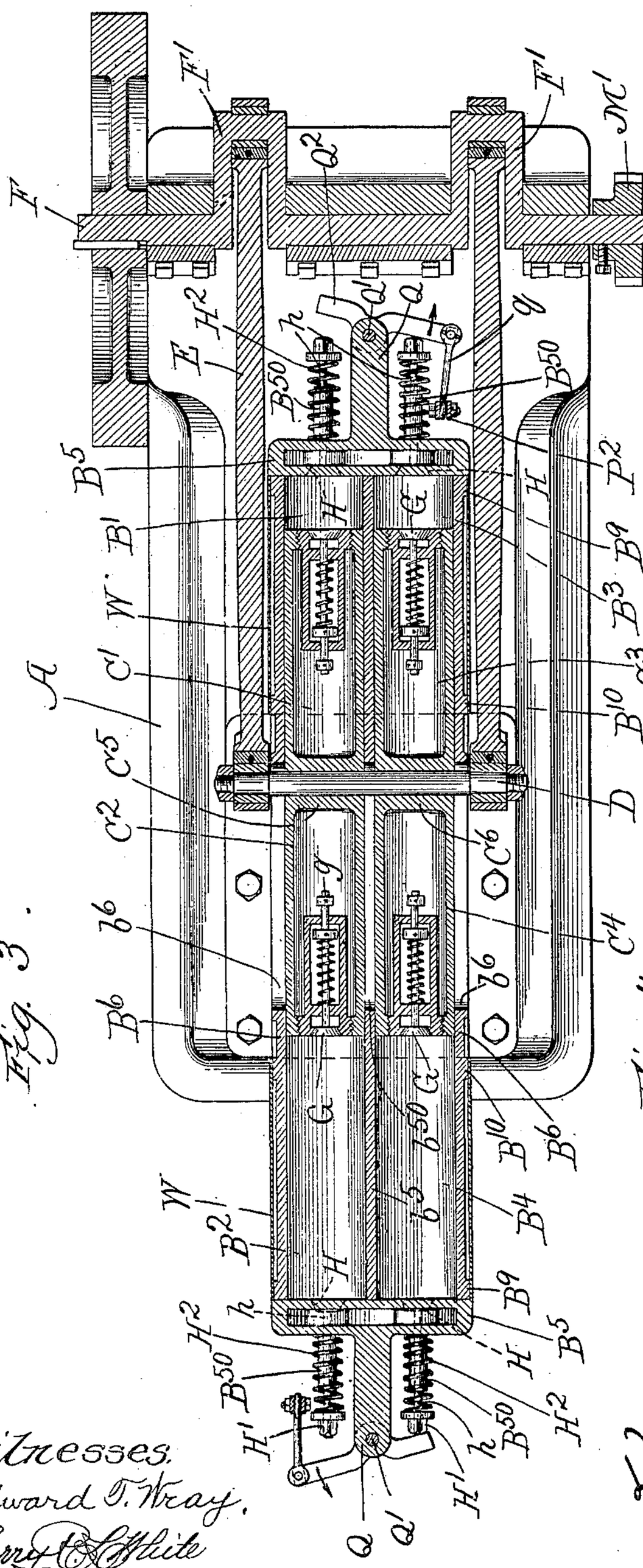

Fig. 3.

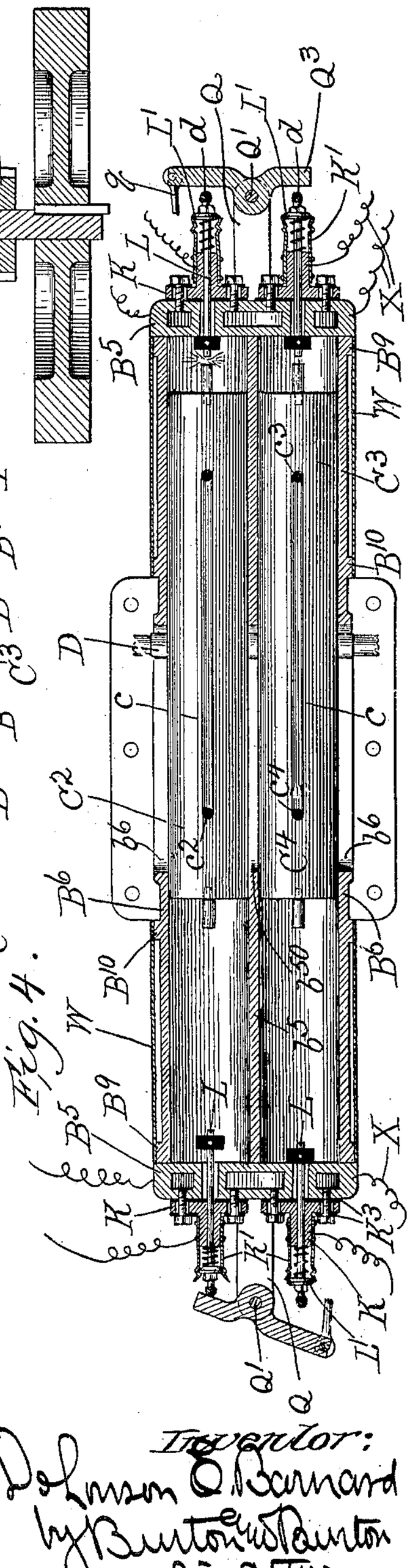

Fig. 4.

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(No Model.) 4 Sheets—Sheet 4.

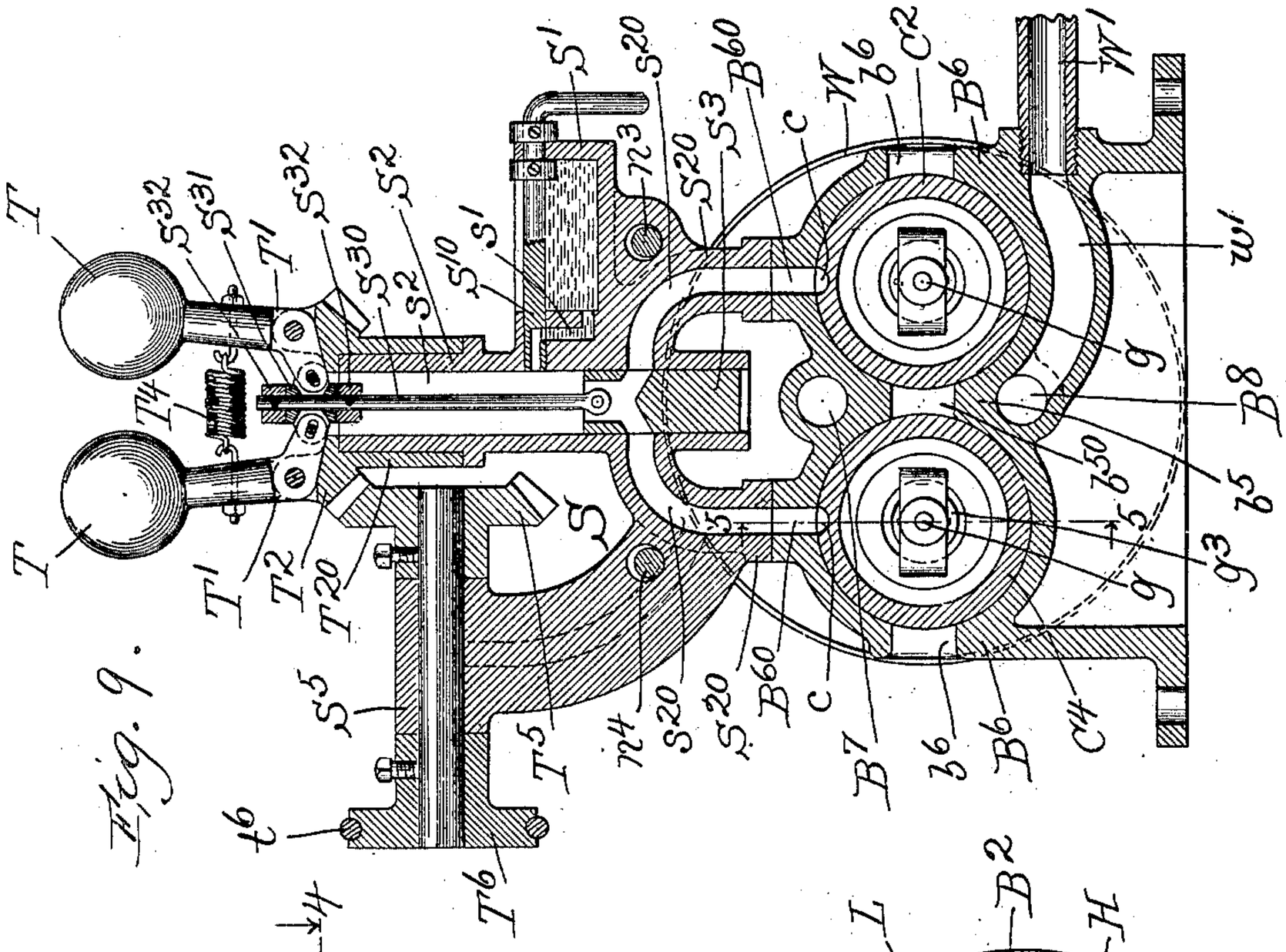

Fig. 9.

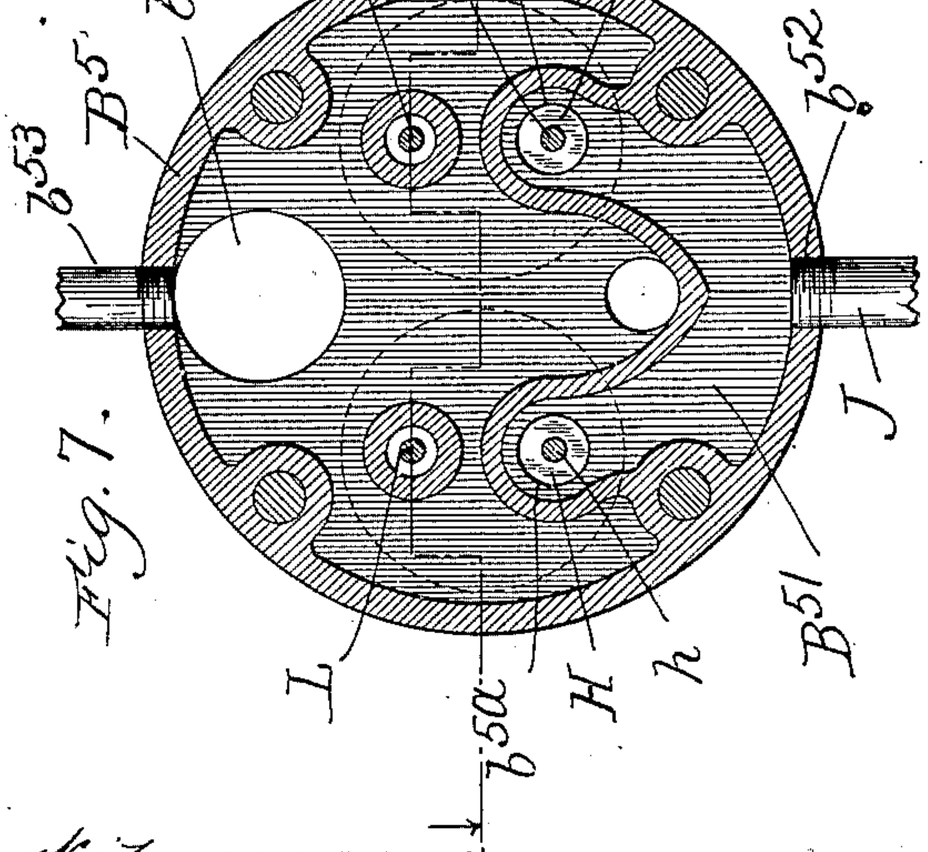

Fig. 7.

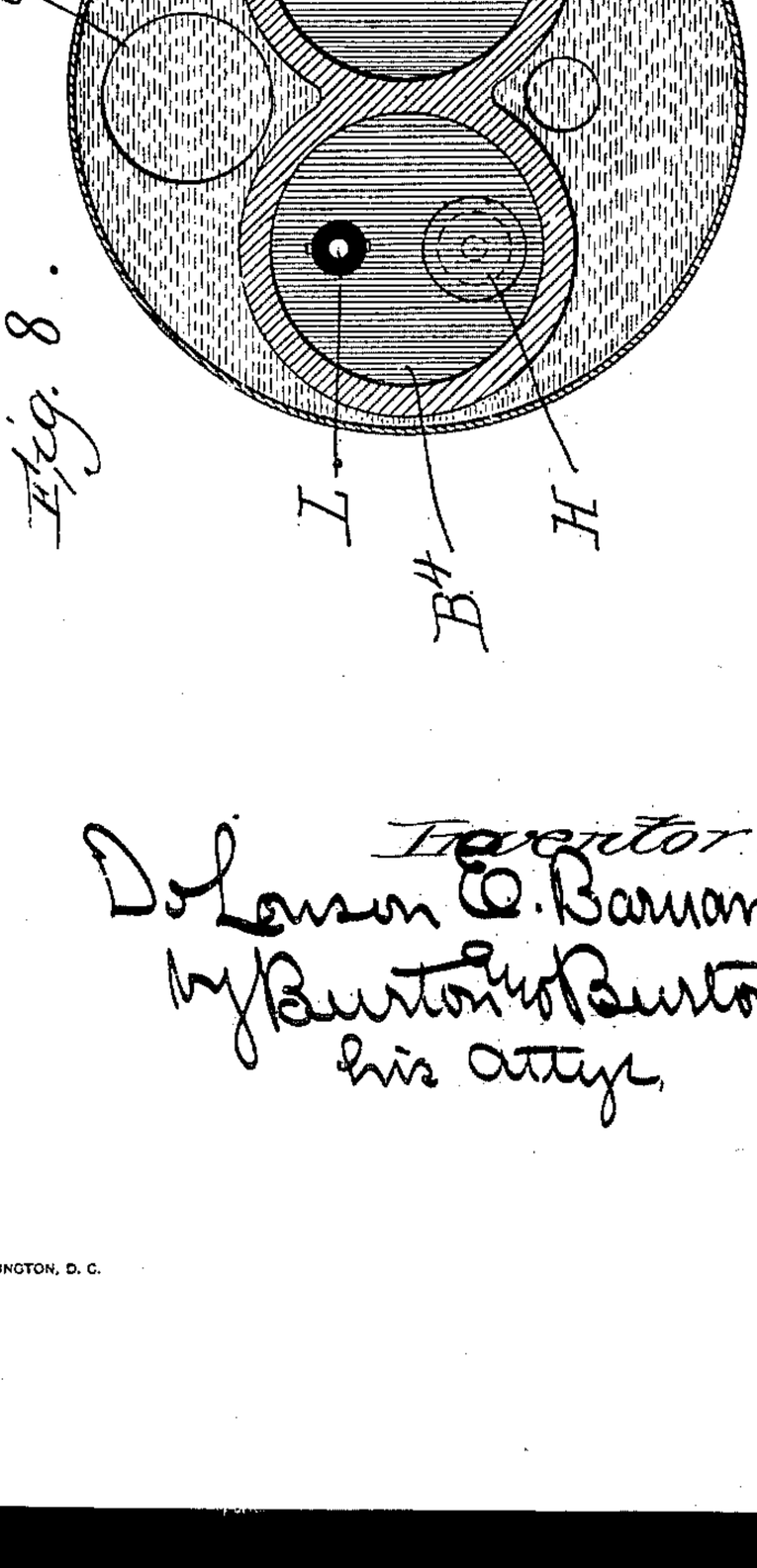

Fig. 8.

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THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

UNITED STATES PATENT OFFICE.

DE LONSON E. BARNARD, OF BELOIT, WISCONSIN.

GAS-ENGINE.

SPECIFICATION forming part of Letters Patent No. 659,911, dated October 16, 1900.

Application filed June 11, 1898. Serial No. 683,156. (No model.)

To all whom it may concern:

Be it known that I, DE LONSON E. BARNARD, a citizen of the United States of America, and a resident of Beloit, in the county of Rock and State of Wisconsin, have invented certain new and useful Improvements in Gas-Engines, of which the following is a specification, reference being had to the accompanying drawings, forming part thereof.

In the drawings, Figure 1 is a side elevation of my improved engine with one of the fly-wheels removed. Fig. 2 is a plan of the same. Fig. 3 is a section at the line 3 3 on Fig. 1. Fig. 4 is a detail axial section of the cylinders, the section being offset, so as to cut axially through the igniting devices, as at the line 4 4 on Fig. 7. Fig. 5 is an axial section of one of the cylindrical double pistons and its guide-bearing between the cylinders, as at the line 5 5 on Fig. 9. Fig. 6 is a detail section, on an enlarged scale, of the igniting device. Fig. 7 is a section through the double-cylinder head at the line 7 7 on Fig. 1. Fig. 8 is a section through the double cylinder and water-jacket at the line 8 8 on Fig. 1. Fig. 9 is a section at the plane indicated by the line 9 9 on Fig. 1. Figs. 10, 11, 12, and 13 are detail elevations of the four eccentrics which operate the exhaust and igniting devices, same being shown at corresponding positions and their operating-shaft being shown in cross-section.

In my improved engine I employ four cylinders, each of which is provided with an independent piston, the action in each being of the type known as "four-cycle"—that is, the operations necessary to the result—to wit, drawing in the charge, compressing and exploding the charge, retreating under the explosive action, and expelling the gases of explosion or exhausting—requiring each one movement of the piston, so that two full reciprocations—that is, two movements in each direction—are necessary to the complete cycle. The mechanism is arranged to cause these four operations to take place at each half-revolution of the main shaft—that is, at each travel of the piston in each direction—a different operation being performed in each cylinder and theorder of rotation in all being the same, so that, for example, while cylinder No. 1 is receiving the charge the charge is compressed and exploded in cylinder 2, the piston is retreating under the explosion in cylinder 3, and the gases of combustion are being expelled in cylinder 4.

A is the base, on which the engine is mounted.

B′, B², B³, and B⁴ are four cylinders arranged in pairs, individuals of which are side by side, the pairs facing each other endwise, corresponding individuals of the two pairs being conaxial. The cylinders B′ and B² face each other endwise and are conaxial. Cylinders B³ and B⁴ face each other endwise and are conaxial, and the two axes are parallel. Cylinders B′ and B³ lie side by side, and cylinders B² and B⁴ lie side by side. Structurally cylinders B′ and B² constitute a continuous cylinder, and cylinders B² and B³ constitute also a continuous cylinder laterally adjacent to the first, but the longitudinal middle portion of each being merely a guideway or slide bearing for the cylindrical pistons which travel in the respective cylinders and being apertured, as hereinafter described, for the cross-pin or cross-head, by which the movement of the pistons is communicated to the mechanism, they are functionally four cylinders, as described. They are, however, all formed in one casting, which is adapted to be bored from end to end to form the four cylindrical chambers, which are closed at the opposite ends by suitable heads to complete the chambers. These heads will be hereinafter described in detail in connection with the devices mounted therein. The four pistons C′, C², C³, and C⁴ for the cylinders B′, B², B³, and B⁴, respectively, are themselves hollow cylinders and are each nearly equal in length to the cylinders in which they respectively reciprocate. The cylinders C′ and C² are, moreover, structurally only a single cylinder, and similarly the cylinders C³ and C⁴ are structurally but one cylinder, said cylinders having, however, at the middle point of their length transverse posts C⁵ C⁶, respectively. These posts do not constitute diaphragms between the cylindrical chambers of the double-piston cylinders to which they pertain, but

merely extend transversely through the otherwise continuous cylindrical cavity. The posts C^5 C^6 are axially bored through and receive the cross-head D, which connects the pistons together, and extending through the longitudinal aperture b^{50} in the partition-wall b^5 and through the corresponding longitudinal apertures b^6 b^6 in the opposite outer walls B^6 B^6 of the middle portion of the double cylinder-casting, comprising the four cylinders B′, B^2, B^3, and B^4, serves as the connection for the pitmen E E, which at opposite sides of the cylinders are connected to corresponding cranks F′ F′ on the main shaft F, which is located at the outer end of one pair of the cylinders B′ and B^3, for example, and has its journal-bearings on the base-frame A. Upon the upper side of the cylinder-casting at the middle portion between the cylinder-chambers B′ B^3, on the one hand, and B^2 B^4, on the other hand, I mount the feed and governor mechanism, which will be presently described. For the present, however, it will be sufficient to state that said mechanism comprises ducts which lead in a precisely similar manner to corresponding apertures B^{60} B^{60} in the upper side of the said intermediate portion of the cylinder-casting, so that the explosive charge conducted to said apertures is delivered in a precisely similar manner onto the exterior of the pistons C′ C^2, on the one hand, and C^3 C^4, on the other hand. Each of the continuous cylinders, which constitute, respectively, the pistons C′ and C^2 and the pistons C^3 and C^4, has at the upper side a longitudinal groove *c*, which extends for an equal distance both ways from the middle point of the length of the cylinder, so that a portion of its length is outside the cavity of each of the pistons. From these grooves apertures *c′*, c^2, c^3, and c^4 lead into the cavities of the pistons C′, C^2, C^3, and C^4, respectively, and the length of the grooves *c* is as great as the full travel of the pistons, so that the grooves are never out of communication with the ports B^{60} B^{60}, respectively, and are therefore each always in position to admit an explosive charge which may be in position to be drawn or forced into said apertures B^{60}. Such explosive charges, it will be observed, are received not immediately into the cylinders B′, B^2, B^3, and B^4, but into the cavities of the pistons. These cavities are closed except as to the said apertures and certain valved openings leading into them at the head or inner end of each piston.

For convenience the valve and seat which are employed in each piston are constructed complete and fitted and adapted to be screwed into the piston. They are all precisely similar, and the description of one will suffice for all. G is one of these valves. G′ is its seat and guide-frame, which is provided at the end having the seat with a peripheral thread, by which it is adapted to be screwed into a threaded opening in the end of the piston. The valve G has a small stem *g*, which is provided with two guide-bearings *g′* g^{10} in the frame G′, and between its bearings it is provided with a spring G^2, coiled around the stem, stopped against the bearing *g′* and against a stop-collar g^3, which is fast on the stem inside the frame—that is, between the bearings *g′* and g^{10}. The action of the spring, it will be seen, is to seat the valve G inward, and the outward movement of the valve compresses it and unseats the valve. The tension of the spring G^2, which may be adjusted by adjusting the stop-collar g^3, is designed to be sufficient only to hold the valve seated against a limited suction, which will be experienced when the piston retreats or is drawn outwardly from the cylinder, the latter being closed, so that such retreat produces a partial vacuum in the cylinder. In such retreating movement, therefore, any explosive charge which may have been admitted to the piston-chamber, or which, being in any passage leading to the aperture *c*, is within reach of the suction which will be experienced through the piston-chamber when the valve G is open, will be drawn into the cylinder to supply the partial vacuum.

B^5 B^5 are the cylinder-heads. They are chambered for water circulation, as hereinafter explained, but for the purpose of the action in other respects may be considered as merely solid heads, which are properly secured, closing the ends of the cylinders. In each head and at the center of each of the cylinders closed by it there is mounted an exhaust-valve H. These exhaust-valves are all alike, and the description of one, with its appurtenances, will suffice for all. From the head of the cylinder long bosses B^{50} B^{50} project at positions suitable for the location of the exhaust-valves, and these bosses are axially bored to afford guide-bearings for the stems *h* of the exhaust-valves H, respectively. The valves seat outwardly on the inner face of the head, and their stems extending out through the bosses B^{50} are threaded at the outer ends for the nuts H′ H′, which serve as stops for the springs H^2 H^2, which are coiled around the bosses B^{50} and stopped at the inner end on the head B^5, the outer end being stopped by the nuts H′, the tension of the springs being controlled by adjusting said nuts. Both the exhaust-ports b^{5a} in each head lead into the exhaust-passage B^{51}, and the final exhaust-pipe J is connected through an aperture b^{52} in the periphery of the head, which leads into the exhaust-chamber B^{51}. These exhaust ports and valves are located just below the horizontal center of the cylinders, and at about an equal distance above the said horizontal center I locate the igniting devices, which will now be described. Onto the outer side of the head B^5, I bolt fast the brackets K K, which are merely cylindrical posts with suitable flanges for secur-

ing them to the head. These posts are bored axially, and the bore is continued through the head, a suitable water-cavity of the head being located at a proper point for this purpose. To the opposite sides of the post K, I secure two very stiff springs K′ K′, which extend beyond the end of the post and have near the end deep notches k^{10} k^{10}, facing each other, and have their ends finished with sloping surfaces facing each other diverging from the outer margin to the notches, respectively. A plunger L, fitted to the bore of the cylindrical bracket K, extends through the same and into the explosion chamber or cylinder, at the end of which the bracket is mounted. This plunger has near the outer end a disk flange L′, having a V-shaped margin adapted to enter the notches k^{10} k^{10}, the diameter of the disk flange being suitable to permit it to enter between the two springs and be seated in the notches, and the slope of the V-shaped edges being adapted to coöperate with the slopes at the edges K^{11} at the ends of the springs, so that when the plunger has pushed inward it may force apart the spring and become engaged with the notches, as indicated. A spring K^{12} may be employed coiled around the stem of the plunger between the disk flange and the end of the cylindrical bracket K, operating with a tendency to resist the inward movement of the plunger. As will hereinafter appear, this spring may be dispensed with when the structure is in all other respects such as herein shown—that is, comprising the springs K′ with their notches and sloping ends. The bracket K is insulated from the cylinders, the insulating-washer being indicated at K^3. The outer end of the plunger is also provided with a contact-point *d*, screwed into the head in position to collide with the end of the plunger.

I will now describe the mechanism for controlling the exhaust-valves and the igniting devices.

In the frame A there is journaled a shaft M, parallel with the main shaft and located above it, and rotary motion is communicated to said shaft M from the main shaft by gears M′ M^2, which give to the shaft M one revolution for each two revolutions of the main shaft. On this shaft M are four precisely similar eccentrics N′, N^2, N^3, and N^4. Rods n' n^2 connect the eccentrics N′ and N^2 to mechanism mounted on the head of the proximate cylinder and rods n^3 and n^4 similarly connect the eccentrics N^3 and N^4 to mechanism mounted on the end of the remote cylinder. The mechanism on the two heads is precisely similar and the description of that upon either head will suffice for the other. P is a bracket mounted on the outer surface of the head and supporting a bolt or shaft P′, which extends horizontally and protrudes at both ends and provides fulcrums for two similar levers P^2 P^3, which are connected at their upper ends respectively to the rods n' n^2. Q is a bracket also mounted on the head below the bracket P and affording support for the vertical bolt or shaft Q′, both ends of which protrude from the bracket and constitute fulcrums for similar levers Q^2 Q^3. The lower ends of the levers P^2 P^3 are connected by links *q q* to the corresponding but oppositely-seated ends of the levers Q^2 Q^3, respectively, which, being placed in reverse position and each being provided at one end with a lateral offset, are adapted for connection of said links in the same plane, one of said offsets turning up and the other down when the levers are in position. The identity of form of the levers Q^2 Q^3 is a matter of structural convenience, as they have different functions. The lever Q^2 is designed to operate the exhaust-valves, while the lever Q^3 operates the igniters. The lever Q^2 stands in the horizontal plane of the ends of the exhaust-valve stems *h*, and in its intermediate position, when the levers extend directly crosswise of the direction of the stroke of the pistons, it is a little distance from the ends of both the stems. When it is rocked in one direction about its fulcrum, it collides with one valve and opens it, and when it receives a reverse movement it releases that valve and collides with the other. The eccentric N′, which operates the lever P^2, and thereby the lever Q^2, makes, with its shaft, one revolution for each two revolutions of the main shaft. A quarter-revolution, therefore, of the eccentric corresponds to each movement in each direction of any one piston. This eccentric is set on the shaft so that the quarter-revolution which corresponds to the inward compressing and exploding movement, for example, of the piston in cylinder B′ is that quarter during which the eccentric is passing over the center of the shaft on the side remote from the eccentric-rod, and thereby the lever Q^2 is at this stage withdrawn to the maximum distance from the end of the exhaust-valve of said cylinder and the reverse movement has commenced, so that the valve is left closed, and said movement of the piston produces a compression and explosion in cylinder B′, ignition being effected as will presently be explained. It will be seen that the described movement of the lever Q^2 causes it during the same quarter-revolution of the eccentric above described to open the companion exhaust-valve of the adjacent cylinder B^3 and close it again during said quarter-revolution. This cylinder B^3, therefore, is being exhausted by the inward movement of its piston at this stage, the next quarter-revolution of the eccentric, corresponding to the next half-revolution of the main shaft and to the retreating movement of the pistons in cylinders B′ and B^3, causing the lever Q^2 to approach and pass through an equal distance beyond a position at which it stands directly transverse to the axis of the move-

ment of the pistons and is out of contact with the stems of both valves. Both valves are therefore closed during this movement, during which the piston in cylinder B′ is being driven out by the force of the explosion which occurred at the end of the compressing movement which preceded it and the cylinder B^3 is taking in a new charge by the suction caused by the withdrawing movement of its piston, this charge being received from the piston-chamber. During the next quarter-revolution of the eccentric, which corresponds to the next inward movement of the pistons in the cylinders B′ and B^3, the lever Q^2 is performing that part of its oscillation which causes it to open the exhaust-valve of the cylinder B′ and to move through the portion of its path of movement most remote from the stem of the exhaust-valve of cylinder B^3, which valve is therefore still closed. In this movement compression preparatory to explosion is taking place in cylinder B^3 and cylinder B′ is being exhausted or relieved of the gases of explosion. During the next quarter-revolution of the eccentric-shaft, corresponding to the second retreating movement of the pistons in the cylinders B′ and B^3, the lever Q^2 is moving in the opposite direction through the same portion of its path of movement which it traversed during the second quarter-revolution, and during this movement, therefore, the exhaust-valves of both these cylinders B′ and B^3 are closed, the piston being forced outward by the force of the explosion in cylinder B^3 and a new charge being taken in from the piston-chamber in cylinder B′. The eccentric N^3, which operates the corresponding parts at the opposite end, is set on the shaft ninety degrees behind the eccentric N′, so that during each quarter-revolution of the eccentric-shaft the eccentric N^3 is performing with respect to the exhaust-valves of the cylinders B^2 and B^4 the action which has just been finished at the other end with respect to the exhaust-valves of cylinders B′ and B^3. It will therefore be seen that each of the actions which make up the full cycle of action in each cylinder takes place successively in the several cylinders following in the same order. Thus explosion occurring first in B′, next in B^2 at the opposite end, next in B^3 at the same end as B′, and last in B^4 at the opposite end, and the pistons all moving as one and transmitting to the cross-head which connects them the impulses which are received transmit an impulse derived from explosion at each half-reciprocation—that is, at each movement in each direction.

S is a casting comprising the gasolene-supply chamber and feed-passages leading to the cylinders and having the governing mechanism mounted upon it and operating in and with respect to such passages.

S′ is a gasolene-supply chamber which communicates with any source of supply and is provided with an overflow-orifice, so that the gasolene is maintained at a uniform height in said reservoir. s' is a duct leading from said reservoir into the air-inlet passage s^2. s^{10} is a valve which controls this passage, and which may be set to limit the flow of gasolene as may be found necessary in order to give the proper proportion of vapor and air for explosive mixture. The air-passage s^2 extends through the vertical member S^2 of the casting S and has two branches s^{20} s^{20} leading in the branches S^{20} S^{20} to the lower ends thereof, where said passages register with the ports B^{60} B^{60}, respectively. S^3 is a piston-valve which operates in the passages s^2. It has a Y-duct opening at the upper end and laterally at opposite sides, the lateral openings being in position such that they are adapted to register with the mouths of the branch ducts S^{20} S^{20} when the piston-valve is at the lowest position, and thus afford the freest communication from the passage s^2 below the inlet of the duct s' to the two ports B^{60} B^{60}. The valve S^3 has a stem S^{30}, which extends up through the passage s^2, and at the upper end has a collar S^{31}, stopped between fixed collars S^{32} S^{32} and adapted for pivotal connection with the lever-arms T′ T′ of the governor-balls T T, which are fulcrumed on the upper end of the beveled gear T^2, which has a long sleeved hub T^{20}, by which it is journaled on the upper portion of the member S^2 of the casting S, being suitably stopped longitudinally thereon. The arms of the governor-balls are connected by a spring T^4, tending to draw them together and resist their separation which the rotation of the beveled gear carrying the balls with it tends to produce. Such rotation is communicated to the beveled gear and governor-balls by the beveled gear T^5, which is journaled in the bracket-arm S^5 and is driven directly or indirectly from the main shaft, as by a belt t^6 over the pulley T^6 on the shaft of the gear T^5, as seen in the drawings.

For the purpose of cooling the cylinders I provide a cylindrical jacket W, encompassing each pair of cylinders B′ and B^3 and B^2 and B^4. The integral casting comprising both cylinders of either pair is formed with suitable flanges B^9 B^{10}, adapted to seat such cylindrical jacket and afford facility for water-tight junction of the latter with the casting. The heads B^5 have their cavities respectively provided with communication through the inner plate of the head with the water-space about the cylinders, such communication being made through the aperture b^{54}, and the escape of the water is provided for by an aperture b^{53} in the periphery of the head at the upper side. The cooling-water is introduced to the water-jacket from a common source of supply W′ at the lower side of each of said jackets W. This is most easily accomplished by connecting the water-supply pipe W by the

duct W′ into the lower of the two ducts B^7 B^8, which are formed in the casting, extending between the flanges B^{10} and B^{10}, and thus constituting communication between the water-spaces about the cylinders. The upper duct B^7 serves to afford circulation between the two water-spaces, whereby the temperature is more perfectly equalized.

X X X X are the electric-circuit wires leading to the igniters. The return or ground-wire connection may be made from any point on the frame.

I claim—

1. In a gas-engine, four cylinders in each of which the action is of the four-cycle type which are conaxial two and two, the two axes being parallel; four pistons for said four cylinders respectively, the cylinders and pistons so arranged that the pistons enter the cylinders at the proximate ends of the latter, the pistons being chambered and provided with valved passages from such chambers at the heads of the piston into the cylinders respectively, the outer surfaces of the two pistons of each longitudinal pair being continuous and being provided with a continuous seat between the cylinders; and a gas-inlet passage leading through such seat to the piston-surface and through the piston-wall into their chambers respectively.

2. In a gas-engine, four cylinders which are arranged in two pairs, the individuals of each pair being side by side, the two pairs having their corresponding individuals conaxial and longitudinally separated; four pistons rigidly united and moving as one and adapted to reciprocate in said four cylinders respectively, their path of reciprocation extending into the interval of such longitudinal separation of the cylinders, a fixed bearing-surface adjacent to the path of reciprocation of each longitudinal pair of pistons at said interval, each said pair having a surface of suitable longitudinal extent to maintain continuous contact with said bearing-surface throughout the entire range of reciprocation of the pistons, the pistons being chambered and having communication through their heads with the cylinder-chambers; respectively; and ducts from their chambers leading to said continuous contact-surface, the gas-supply duct leading through said fixed bearing-surface and adapted to register thereat with said piston-ducts.

3. In a gas-engine, four cylinders arranged in two pairs, individuals of which are side by side, the two pairs having their corresponding individuals conaxial and longitudinally separated; four pistons united together and moving as one in said four cylinders respectively, their path of reciprocation extending into said interval of separation of the cylinders; a fixed bearing-surface adjacent to the path of reciprocation of each longitudinal pair of pistons, each such pair having a bearing-surface of suitable extent to maintain continuous contact with said bearing-surface throughout the entire range of reciprocation of the pistons, the pistons being chambered and having communication at their inner ends with the cylinder-chambers respectively, and having ducts from their chambers leading to such extended bearing-surface; a gas-supply duct leading through said fixed bearing-surface and adapted to register with the mouth of the piston-duct; a governing device comprising an air-passage and an oil-inlet leading thereinto; gas-passages therefrom leading to the said fixed bearings respectively; a valve in said air-passage beyond the oil-inlet; and a centrifugal governing device which operates said valve.

4. In a gas-engine, four cylinders formed integrally in two longitudinal pairs, the individuals of each pair being conaxial, and formed by one continuous bore of uniform diameter throughout; four pistons for said four cylinders connected and adapted to move as one, the longitudinal middle portion of the cylinder-casting having longitudinal slots all at the plane in which the axes of all the cylinders are located; a cross-head which connects the two longitudinal pairs of pistons, extending through said slots, the two pistons of each longitudinal pair having their cylindrical surfaces continuous, and having a continuous internal chamber; a gas-duct leading through the bearing-surface of the pistons at the middle point of their path of reciprocation; and a duct leading from the piston-chambers to corresponding point in the bearing-surfaces of the piston, the pistons having communication through their heads respectively with the cylinder-chambers.

5. In a gas-engine, in combination with the four cylinders arranged as described, the pistons therefor, and the driving connections from the piston to the main shaft; a shaft driven by connection with the main shaft at half the speed of the latter; exhaust-valves at the opposite ends of the cylinders; lever connections for operating them; eccentrics on the driven shaft and links which connect them to the levers, said eccentrics being timed to open the valves respectively during the portion of the rotation of the eccentric which corresponds to the movement in one direction of the pistons respectively, the two valves at each end being controlled by one and the same eccentric, and operated at opposite ends of a lever which is actuated by the eccentric, the two eccentrics for the two ends respectively being oppositely mounted on the shaft.

In testimony whereof I have hereunto set my hand, in the presence of two witnesses, at Chicago, Illinois, this 28th day of May, 1898.

DE LONSON E. BARNARD.

Witnesses:

CHAS. S. BURTON,

BERTHA C. SIMS.