No. 756,458. PATENTED APR. 5, 1904.

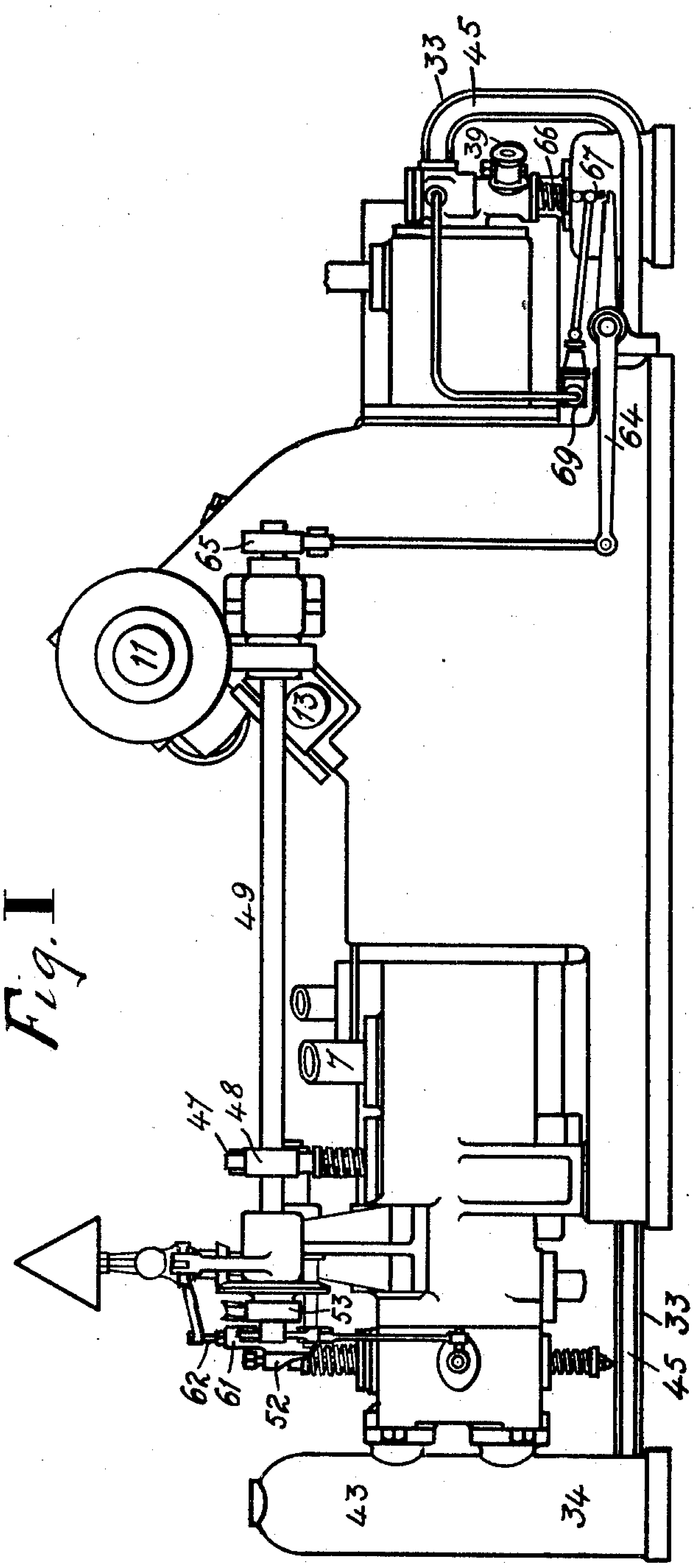
H. C. BERGEMANN.

GAS ENGINE.

APPLICATION FILED MAR. 4, 1902.

NO MODEL. 5 SHEETS—SHEET 1.

Fig. I



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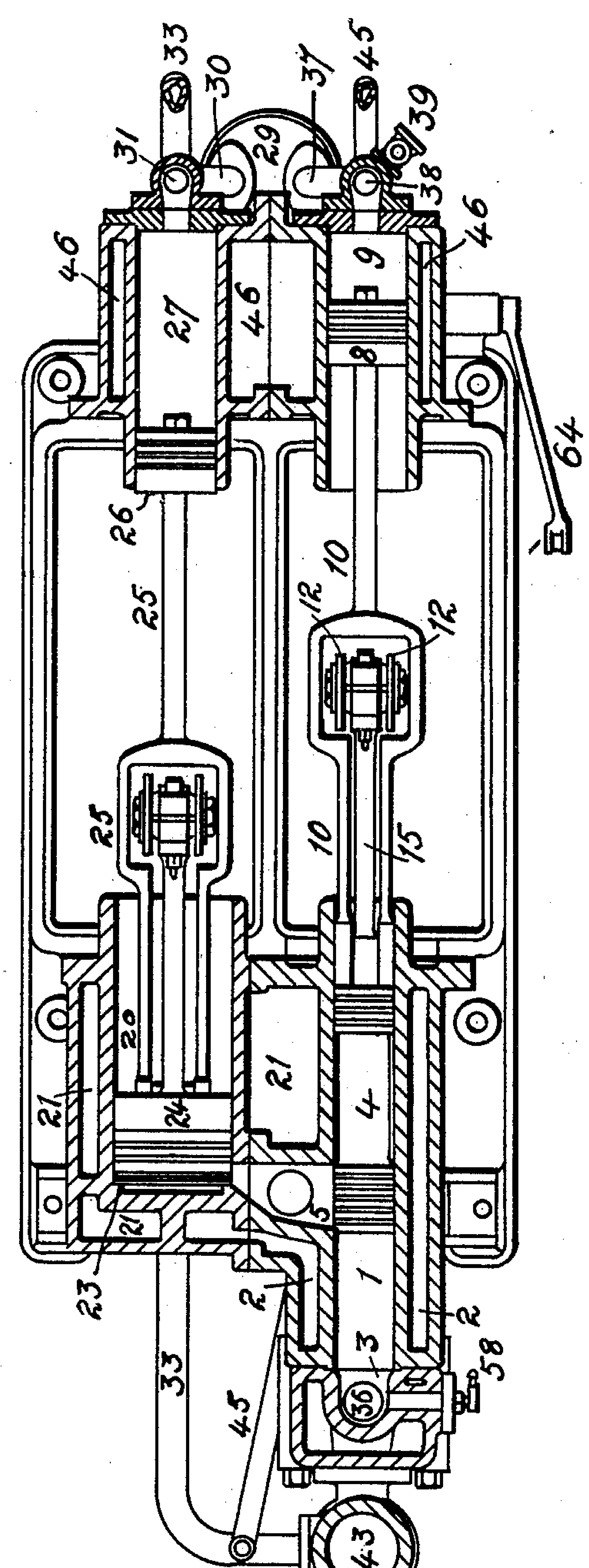
NO MODEL. 5 SHEETS—SHEET 2.

Fig. III



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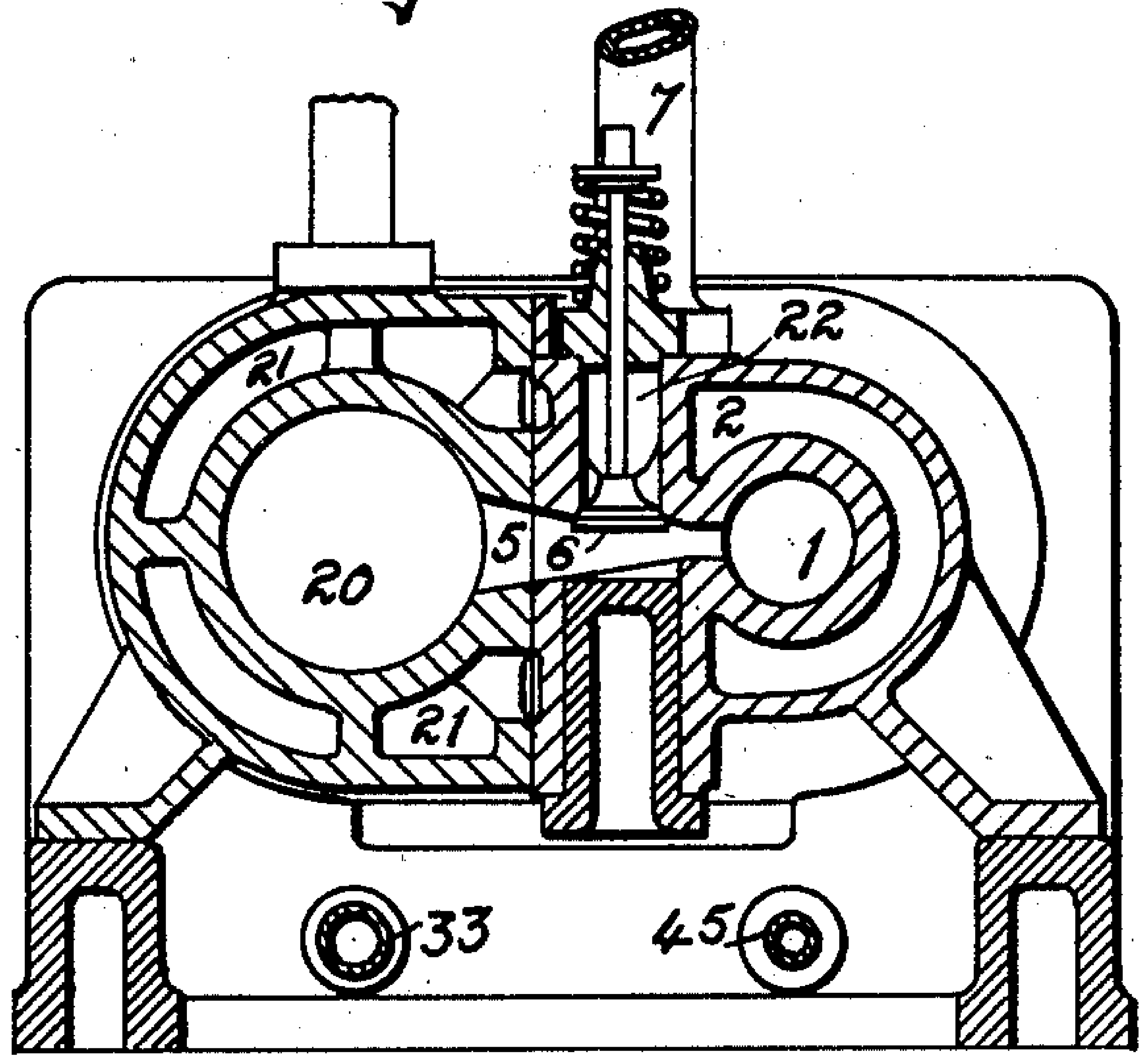
NO MODEL. 5 SHEETS—SHEET 3.

Fig. III



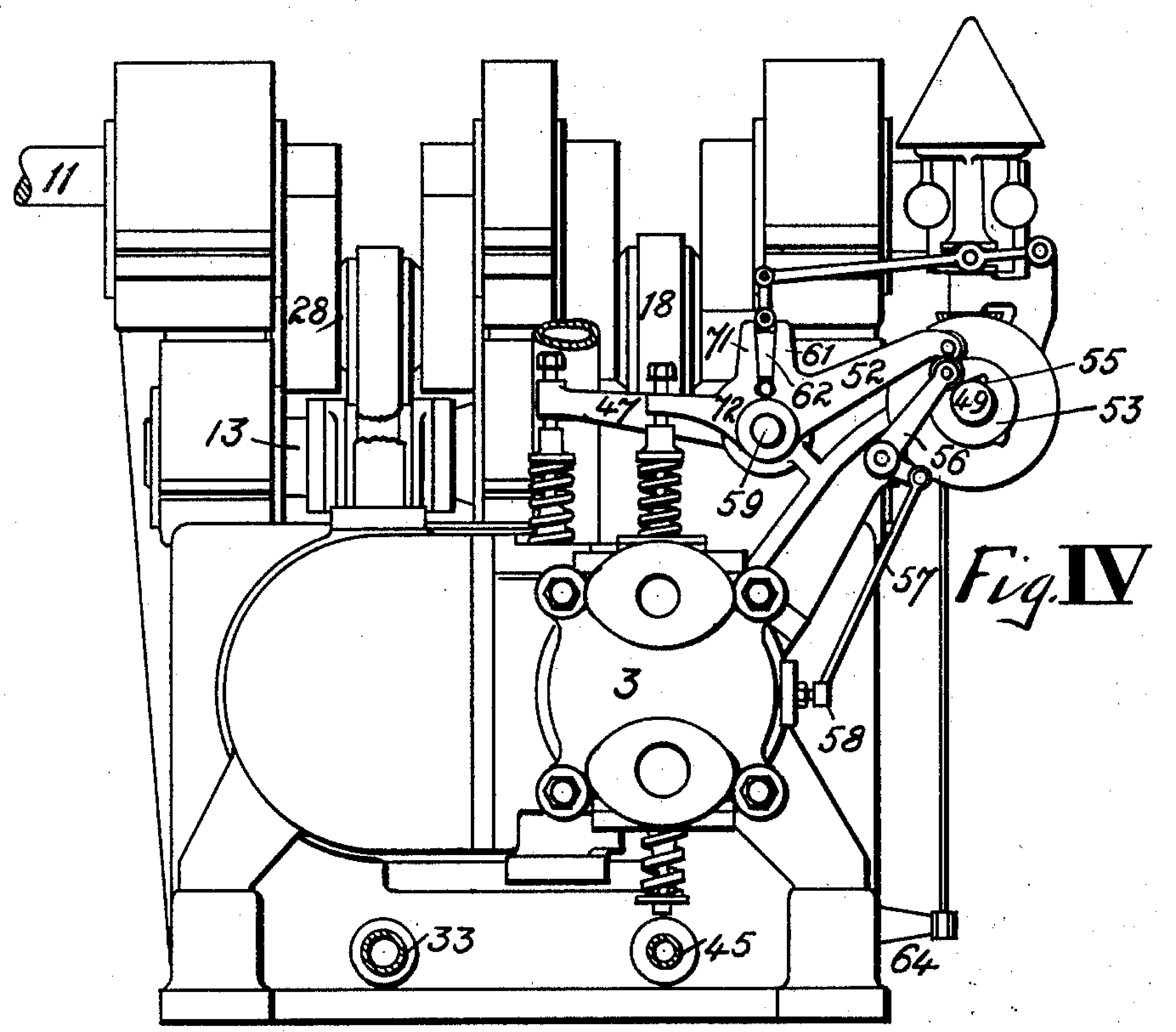


Fig. IV

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NO MODEL. 5 SHEETS—SHEET 4.

Fig. V

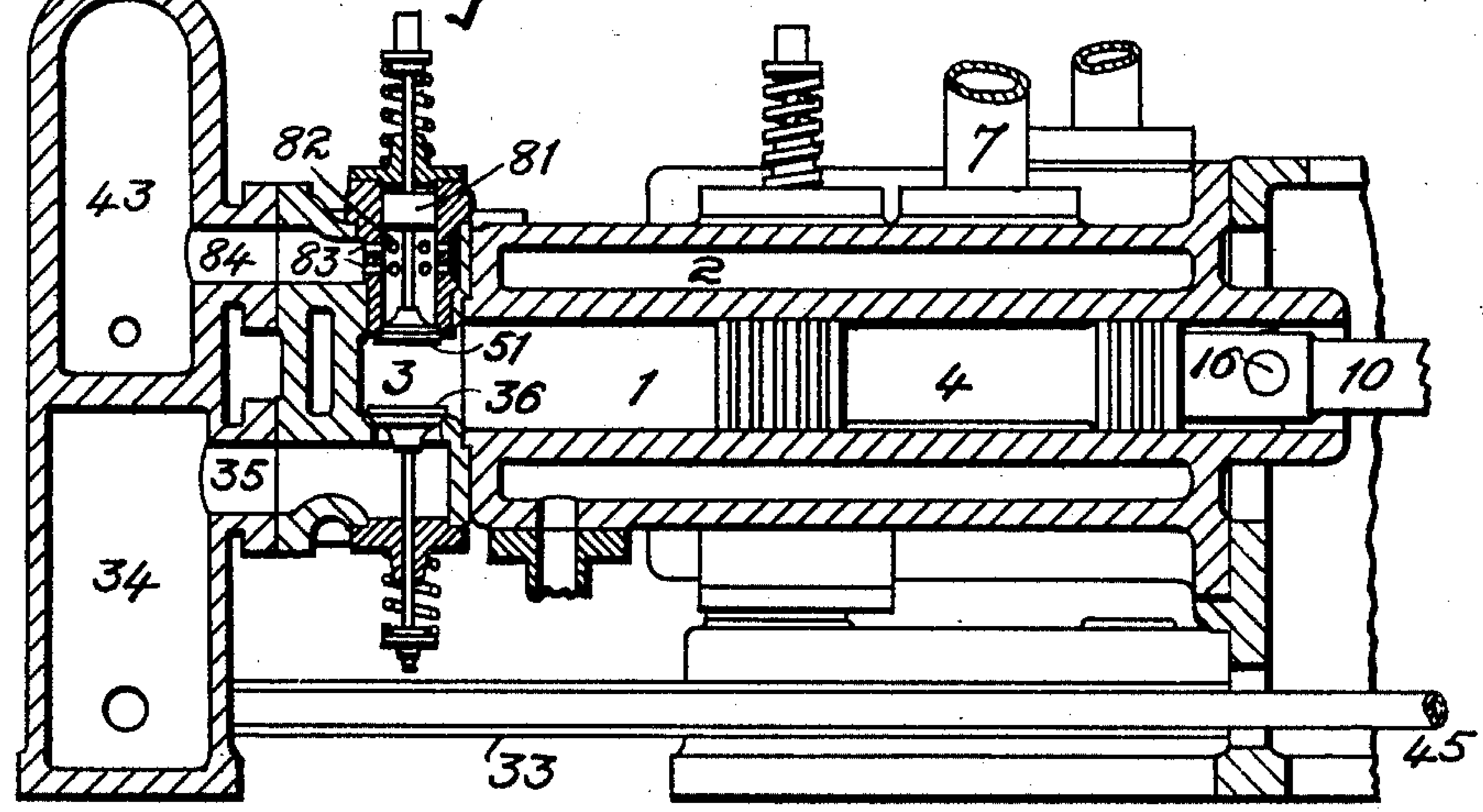
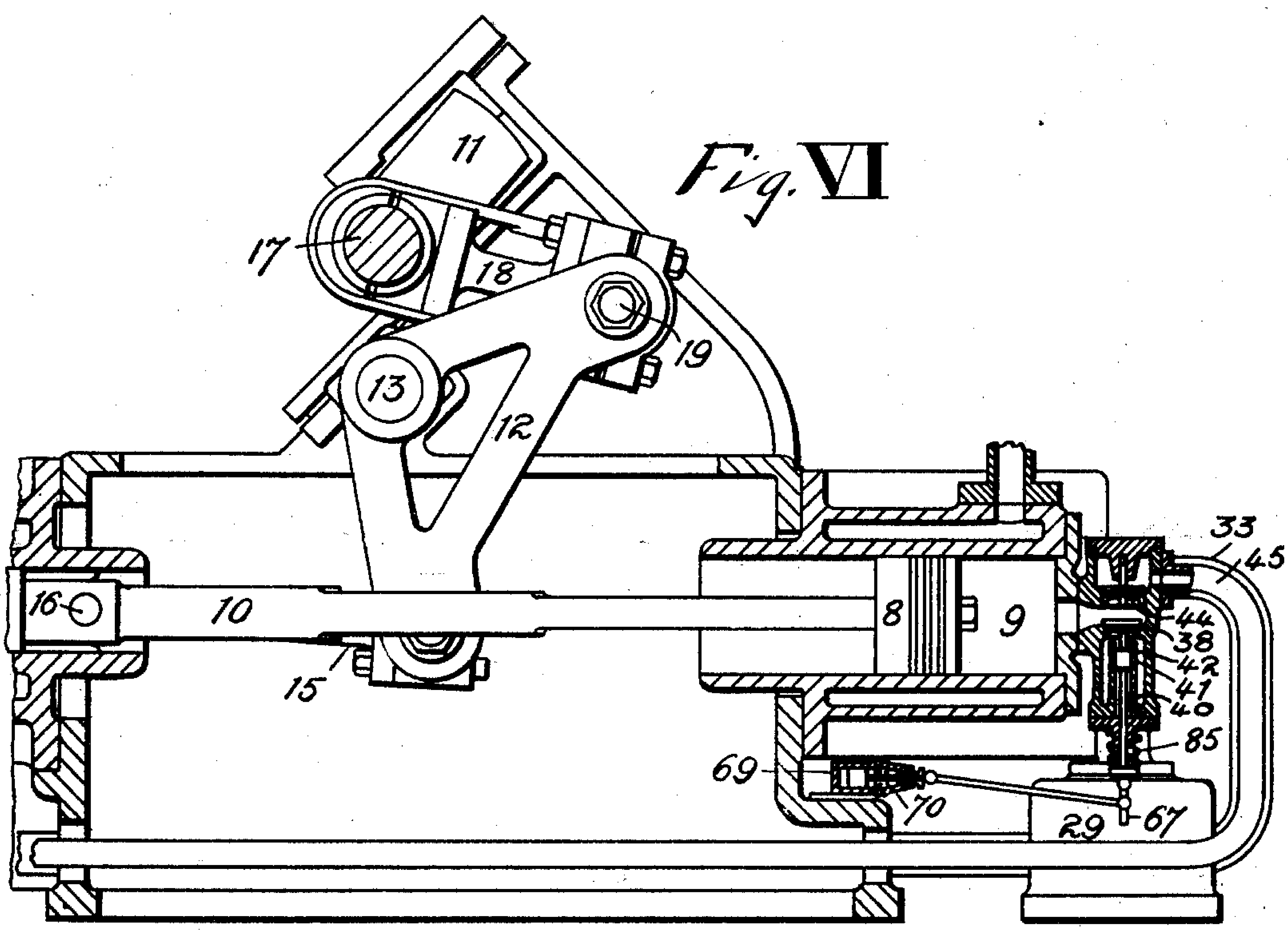


Fig. VI



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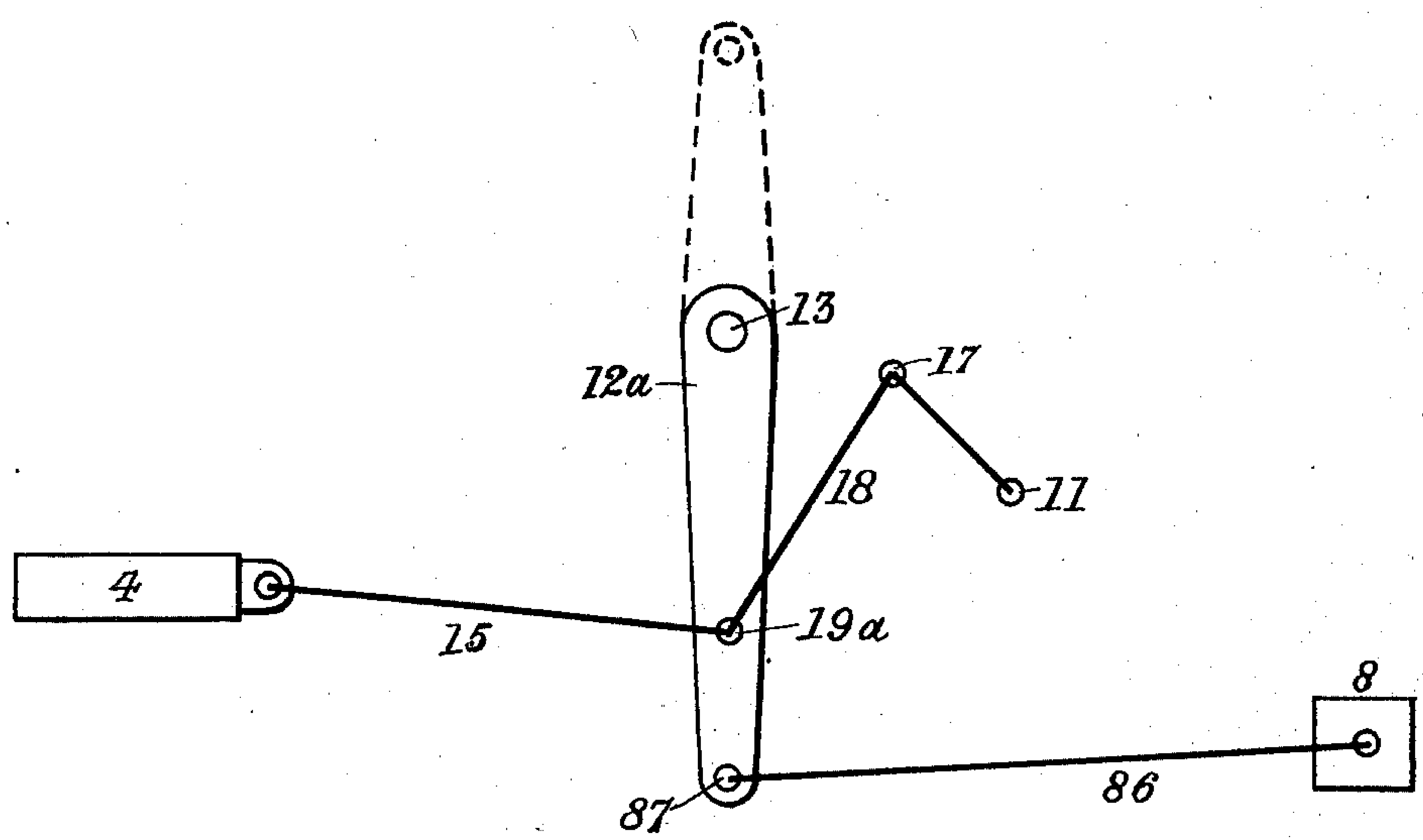
APPLICATION FILED MAR. 4, 1902.

NO MODEL. 5 SHEETS—SHEET 5.

FIG. VII.



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UNITED STATES PATENT OFFICE.

HENRY CHARLES BERGEMANN, OF ANNAN, SCOTLAND.

GAS-ENGINE.

SPECIFICATION forming part of Letters Patent No. 756,458, dated April 5, 1904.

Application filed March 4, 1902. Serial No. 96,726. (No model.)

To all whom it may concern:

Be it known that I, HENRY CHARLES BERGEMANN, engineer, a subject of the King of Great Britain, and a resident of Annan, in the county of Dumfries, Scotland, have invented certain new and useful Improvements in Gas-Engines, of which the following is a specification.

My invention relates to improvements in gas-engines whereby the advantages resulting from compounding are obtained, together with other advantages to be hereinafter described.

In order that my invention may be readily understood, I will proceed to describe it with reference to one particular case, as illustrated in the accompanying drawings, in which—

Figure I is a side elevation of a gas-engine. Fig. II is a horizontal section through the center of the cylinders. Fig. III is a cross-section through the high and low pressure cylinders. Fig. IV is an end elevation of the engine with certain parts removed. Fig. V is a vertical section through the high-pressure cylinder. Fig. VI is a section through the gas-mixing cylinder and also shows one link-motion in elevation. Fig. VII illustrates diagrammatically a modified arrangement of the principal parts of a gas-engine.

In the particular case illustrated in the drawings the two cylinders 1 and 20 are placed horizontally side by side. The high-pressure cylinder 1 is provided with a water-jacket 2 and with a combustion-chamber 3 at its inner end. The low-pressure cylinder 20 is also surrounded by a water-jacket 21. At one side of the high-pressure cylinder 1 there is a passage-way 5, which communicates with the low-pressure cylinder 20 and also through the exhaust-valve 6 between the cylinders with the passage 22 and the exhaust-pipe 7. This passage 5 is hereinafter termed the "exhaust-passage." The high-pressure piston 4 is long enough to entirely cover this exhaust-passage 5 when said piston is at the inside end of the cylinder, and the opening to the exhaust-passage is so placed in the high-pressure cylinder that it remains covered by the piston 4 until the latter has completed two-thirds of its outward stroke and has arrived at the position shown in the drawings. An air-reservoir 34 is connected through the combustion-chamber to the high-pressure cylinder by passage 35 when valve 36 is open. A gas-mixture reservoir 43 is similarly connected to the combustion-chamber 3 by passage 84, ports 83, and passage 82 when valve 51 is open. This valve is balanced by attaching to its spindle a small piston 81, working in the cylindrical passage 82. As the ports 83 are situated between the valve 51 and the small piston 81, it will be seen that the downward pressure on the valve is opposed by the upward pressure on the piston. The high-pressure piston 4 is rigidly connected to the piston 8 of a gas mixing and charging pump 9 by a divided rod 10, so that the rod and the two pistons reciprocate together. They are connected to the high-pressure crank by a system of links in the following manner: A link 15 is attached at one of its ends by pin 16 to the divided rod 10 and at its other end to the lower end of a bell-crank lever 12, pivoted on a rocking shaft 13. The other end of the bell-crank lever is connected by pin 19 and link 18 to the crank-pin 17. I prefer to make the length of the arms of the bell-crank lever and the length of the link 18, as well as the distance between centers of rocking shaft and crank-shaft all equal to the diameter of the crank circle. With these dimensions when the center of the crank-pin lies in the straight line joining the centers of crank-shaft and rocking shaft the high-pressure piston 4 travels at about twice the velocity of the crank-pin 17. When the crank approaches its outer dead-center, the movement of the high-pressure piston connected to it is extremely slow, so that the low-pressure piston has time to practically complete its stroke before the high-pressure piston has moved far on its return stroke. The pistons 4 and 8 have a length of stroke equal to one and one-eighth times the diameter of the crank circle.

The low-pressure piston 24 is connected by the divided rod 25 to the piston 26 of an air or scavenging pump 27. A system of links similar to that already described for actuating the high-pressure crank is employed to connect the divided rod 25 to the low-pressure crank-pin 28. The angle between the two cranks is about sixty-eight degrees, as it is desirable that the low-pressure crank should be on its dead-center or thereabout when the high-pressure piston is beginning to uncover the passage 5 between the two cylinders. The low-pressure piston-head is in this case covered by layers 23 of non-conductive material, such as asbestos, fire-clay, plumbago, or the like; but mixtures thereof or other protective material may be used. This covering is protected by thin plates of metal. The low-pressure cylinder end and the exhaust passage-way may also be protected in the same way.

The scavenging-pump 27 is provided with a suction-box 29, communicating by a passage 30 with the inlet-valve 31, and the pump is connected, through a delivery-valve and by pipe 33, to the air-reservoir 34, attached to the high-pressure cylinder. The gas mixing and charging pump is provided with an air-inlet valve 38, connected by passage 37 to the suction-box 29. The admission of gas is provided for by the gas-cock 39, passage 40, ports 41, and the piston-valve 42, which latter lifts with the valve 38. This pump is connected, through a delivery-valve 44 and a pipe 45, to the gas-mixture reservoir 43, attached to the high-pressure cylinder. The scavenging-pump 27 and the gas-mixing pump 9 are each provided with a water-jacket 46.

The side shaft 49, which is driven at the same speed as the main shaft, is provided with cams to operate, by means of suitable levers, the various valves and the like as and when required during the working cycle, as hereinafter described. Thus the exhaust-valve 6 is opened by a lever 47, operated by a cam 48 on the side shaft. The igniter is preferably a low-tension one of ordinary form—that is to say, of the type in which an inductive circuit carrying an electric current of considerable volume and low electromotive force is broken in the combustion-chamber. It is operated by means of a cam 55 on the side shaft 49, the lever 56, link 57, and lever 58.

The action of this form of apparatus is as follows: Assuming that the high-pressure crank 17 is just beyond its dead-center at the commencement of the outward stroke of the high-pressure piston 4 and assuming that an explosion of gas has just taken place, whereby a pressure of, say, six hundred pounds per square inch has been produced in the combustion-chamber, the cycle of operations will proceed in the following manner: As the piston 4 moves outward the heated gases expand in the high-pressure cylinder until the piston has completed in this case two-thirds of its stroke, when the pressure will be somewhere about one hundred and forty pounds per square inch. The further motion of the piston then begins to uncover the exhaust-passage leading to the low-pressure cylinder. At this point, therefore, the low-pressure crank is at its dead-center, because the low-pressure piston now receives its impulse from the gas-pressure. The charge of heated gas being now divided between the two cylinders has its pressure rapidly reduced to about fifteen pounds under the advantageous condition that this low pressure acts on a large piston-surface, and thereby tends to equalize the effort exerted upon the crank-shaft at different parts of the stroke. When the low-pressure piston 24 is almost at the end of its working stroke and the high-pressure piston 4 has just started on its return stroke, the exhaust-valve 6 in the exhaust-passage 5 is opened and the practically-exhausted gases from both cylinders are discharged into the atmosphere. As the high-pressure piston 4 is returning, but before it has closed the exhaust-passage 5, the air-valve 36 is opened and a volume of air from the reservoir 34 passes through the combustion-chamber 3 into the high-pressure cylinder 1 to sweep out the products of combustion, so that when the exhaust-passage 5 is closed on the high-pressure side by the continued motion of the piston 4 the high-pressure cylinder 1 is full of pure air. The valve 51 of the gas-mixture reservoir is then immediately opened and a charge of gas mixture admitted to the high-pressure cylinder, which charge mixes more or less with the pure air present and forms with it a suitable explosive mixture. During the remainder of the return stroke of the high-pressure piston this gaseous mixture is compressed, and the pressure may be up to, say, two hundred pounds per square inch when the stroke is completed—that is to say, immediately before explosion and when the engine is working up to its full power. Meanwhile the low-pressure piston 24 continues its return stroke and continues to exhaust into the air until nearly the end of its stroke, when the exhaust-valve 6 is closed in order that sufficient gas may be retained to compress to about the pressure at which on the next stroke the gases will exhaust from the high-pressure to the low-pressure cylinder at normal working load. By the time the low-pressure piston has completed its return stroke the high-pressure piston has again moved through two-thirds of its outward stroke. During the above operations the pistons of the air-pump and gas-mixture pump, which are respectively connected, as hereinbefore described, to the main pistons, have each made one inward and one outward stroke. Consequently the air-pump supplies one cylinder full of air to the reservoir at each revolution of the shaft, and the reservoir consequently discharges an equal quantity through the high-pressure cylinder at each stroke, part of which escapes through the exhaust; but as regards the gas-mixture supply it is obvious that this must be regulated in accordance with the work being done at any time, and the necessary regulation is effected in the following manner: The gas-inlet valve 51 to the high-pressure cylinder is opened by means of a lever formed in two parts 52 and 72, which are hinged on the pin 59, which supports them and are provided with horns 61 and 71, respectively. A wedge 62, hanging between the horns, is connected by lever 63 with the governor. The depth to which this wedge is inserted between the horns will determine the amount of motion imparted to the end 72 of the jointed lever, and hence to the gas-valve 51, when the end 52 of the said lever is moved through a constant distance at each revolution of the cam 53. By this means the governor controls the amount of gas mixture admitted to the cylinder at each stroke. Provision is made, however—as, for example, by a step in the wedge or by its total withdrawal—that no smaller quantity of gas mixture than that necessary to insure explosion shall be admitted to the combustion-chamber. Consequently when the engine is running very light the admission-valve 51 will occasionally not open at all and no explosion will take place. Except at full load, therefore, the gas-mixture pump is capable of supplying more gas mixture than is used at each revolution, and the pressure in the gas-reservoir will continually tend to increase unless the quantity of gas mixture delivered by the pump to the reservoir is regulated according to requirements—as, for example, in the following manner: The air and gas inlet valves 38 and 42 are held in their closed position by a spring 85, strong enough to resist the vacuum formed by the piston 8 on its outstroke, and the valves are lifted when required by a lever 64, operated by the cam 65 on the side shaft. This lever transmits its motion to the valve-stem 66 through a hit-and-miss arrangement, the loose piece 67 of which is under the control of a piston 68 in a small cylinder 69, which is in communication with the reservoir 43. With an excess of pressure in the reservoir the piston 68 is moved against the presure of a spring 70, and thereby places the movable piece 67 in the miss position, so that the valves 38 and 42 are not lifted and the pump 9 delivers no mixture on the following return stroke. In this way the quantity of gas mixture supplied is varied, but the proportion of gas to air in the reservoir 43 is kept constant. The proportion of gas to air can, however, be controlled by the attendant, who can regulate the relative quantity of gas admitted by means of the cock 39.

Having described one form of engine in which my invention may be embodied, I wish it to be understood that I do not confine myself to the precise details of construction hereinbefore described and illustrated, as it is obvious that these details may be varied to a very large extent without departing from the spirit of my invention. For example, the pistons of the gas-mixture and scavenging pumps instead of being directly connected to the main pistons of the engine may be operated in any other suitable manner. The link-motions also may be varied by altering the angle between the arms of the bell-crank lever and the relative lengths of the links and lever-arms. Thus in Fig. VII is shown diagrammatically an arrangement in which certain of these modifications are introduced. The bell-crank lever is here reduced to a swinging lever 12^a, which may be considered as being produced by reducing the angle between the arms of the bell-crank lever until both arms coincide. The rocking lever 12^a is attached to the rocking shaft 13 and carries the pin 19^a, which corresponds to both the upper and lower pins of the bell-crank lever in the form hereinbefore described. A link 15 connects the piston 4 with pin 19^a, whence motion is transmitted to the crank-shaft 11 by the connecting-rod 18. The piston 8 of the mixing-pump is connected to the lower end of the swinging lever by the connecting-rod 86 and pin 87. It will be seen that both the crank-shaft and the pumps are in a lower position with respect to the working cylinder than is the form of engine first described. The side shaft may conveniently be correspondingly lowered.

Instead of modifying the bell-crank lever in the manner just described by moving the upper arm thereof until it coincides with the lower arm, as illustrated in Fig. VII, it may be modified by moving the arm in the opposite direction until it is in line with the lower arm, as shown by the dotted lines, or the upper arm may occupy any intermediate position between these two extremes. In this intermediate position the upper arm may lie to the right of the lower arm, as shown in Fig. VI, or it may lie to the left thereof.

The angle between the cranks and the ratio between length of stroke and diameter of crank circle will depend among other things upon the particular link-motion used and upon the position of the exhaust-passage in the high-pressure cylinder.

Having thus described my invention, what I claim as new, and desire to secure by Letters Patent, is—

1. The combination of a piston of a compound engine, a crank-shaft and crank, a link-motion connected with said piston and said crank and adapted to cause rapid motion of the piston on its outward stroke, stagnation at outer end of stroke and a slow return movement, substantially as and for the purpose set forth.

2. The combination of a high-pressure cylinder and a low-pressure cylinder of a compound gas-engine, a piston for each of said cylinders, a crank-shaft and cranks, connections between each of said pistons and their respective cranks such connections including a link-motion adapted to cause each piston to travel most rapidly near the middle portion

of its outward stroke, substantially as and for the purpose set forth.

3. The combination of a piston of a compound gas-engine, a crank-shaft and cranks, a suitably-mounted bell-crank lever, a link mounted between the pin of said crank and one end of bell-crank lever, a second link mounted between the other end of the bell-crank lever and a suitable point on the rod of said piston, substantially as and for the purpose set forth.

4. The combination of a piston of a compound gas-engine, a crank-shaft and cranks, a suitably-mounted bell-crank lever, a link mounted between the pin of the said crank and one end of the bell-crank lever, a second link mounted between the other end of the bell-crank lever and a suitable point on the rod of said piston, the length of the arms of the bell-crank lever and the length of the said first-mentioned link as well as the distance between the center on which the bell-crank lever rocks and the crank-shaft center being all equal to the diameter of the crank circle, substantially as and for the purpose set forth.

5. The combination of a high-pressure and low-pressure cylinder having a passage connecting the two, the pistons, crank-shafts and cranks, a link-motion connected between each of said pistons and their respective cranks and adapted to cause each of said pistons to travel through a greater distance than twice the diameter of the crank-pin circle during each revolution, substantially as set forth.

6. The combination of a high-pressure cylinder and a low-pressure cylinder of a compound gas-engine, a piston for each of said cylinders, a crank-shaft and cranks, connections between each of said pistons and their respective cranks such connections including a link-motion adapted to cause rapid motion of the piston on its outward stroke and a slow return stroke, and a valveless passage between the high and low pressure cylinders, substantially as and for the purpose set forth.

7. The combination of a high-pressure cylinder and a low-pressure cylinder of a compound gas-engine, a piston for each of said cylinders, a crank-shaft and cranks, connections between each of said pistons and their respective cranks such connections including a link-motion comprising a bell-crank lever suitably mounted with its arms projecting in the direction of the working stroke of the piston, a link mounted between the crank-pin and one end of the said bell-crank lever, a second link mounted between a point on the piston-rod and the other end of said bell-crank lever, the length of the arms of the bell-crank lever and the length of the said first-mentioned link as well as the distance between the center on which the bell-crank lever rocks and the crank-shaft center being all equal to the diameter of the crank circle, substantially as and for the purpose set forth.

8. The combination of a high-pressure cylinder and a low-pressure cylinder of a gas-engine, and a valveless passage between said cylinders and provided with an exhaust to the outer air and serving to both exhaust from high-pressure to low-pressure cylinder and from both cylinders to the atmosphere, substantially as and for the purpose set forth.

9. The combination of a high-pressure cylinder and a low-pressure cylinder of a compound engine, a piston for each of said cylinders, a crank-shaft and cranks, a crank motion connected between each of said pistons and their respective cranks and adapted to cause rapid motion of the piston on its outward stroke, stagnation at the outer end of the stroke and a slow return movement, whereby the low-pressure piston practically completes its stroke before the high-pressure piston returns, substantially as set forth.

In witness whereof I have hereunto set my hand in presence of two witnesses.

HENRY CHARLES BERGEMANN.

Witnesses:
W. G. IRVING,
CATHERINE IRVING.