No. 752,936. PATENTED FEB. 23, 1904.

A. VOGT.

INTERNAL COMBUSTION MOTOR.

APPLICATION FILED MAR. 24, 1902.

NO MODEL. 5 SHEETS—SHEET 1.

Fig. 1.

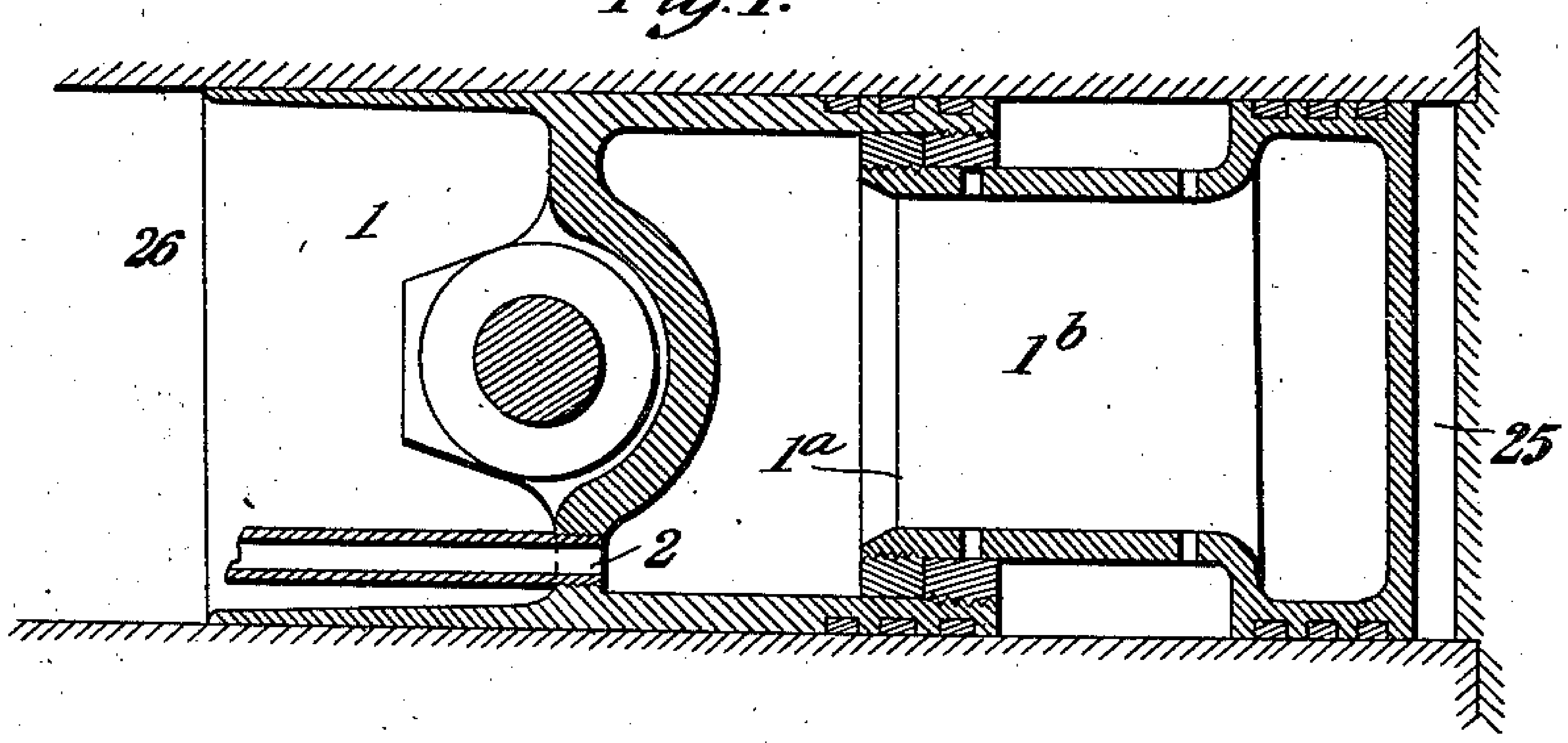
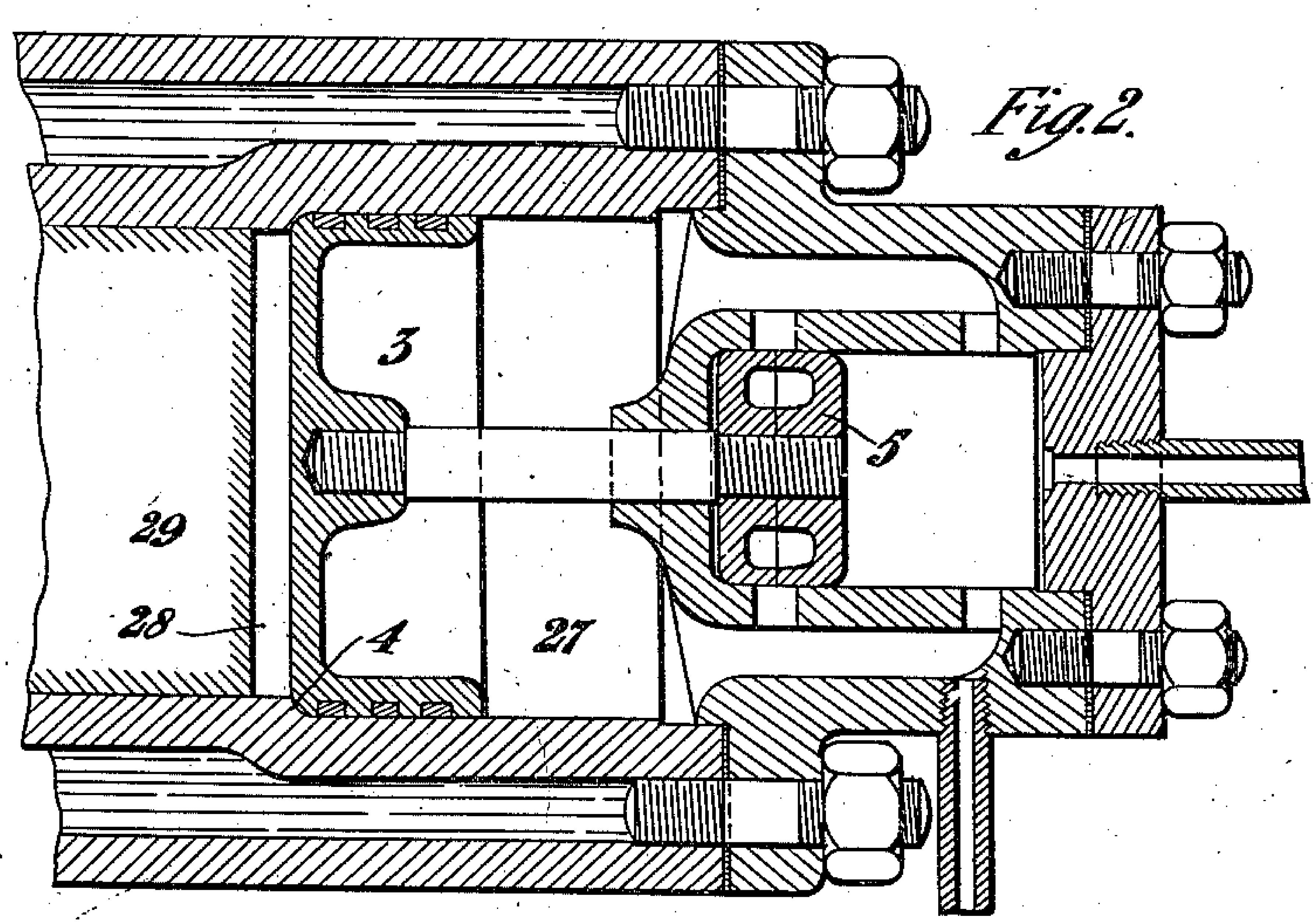


Fig. 2.



Witnesses:

R. H. Sommers

Inventor.

Adolf Vogt

By Henry Orth Jr.

Atty.

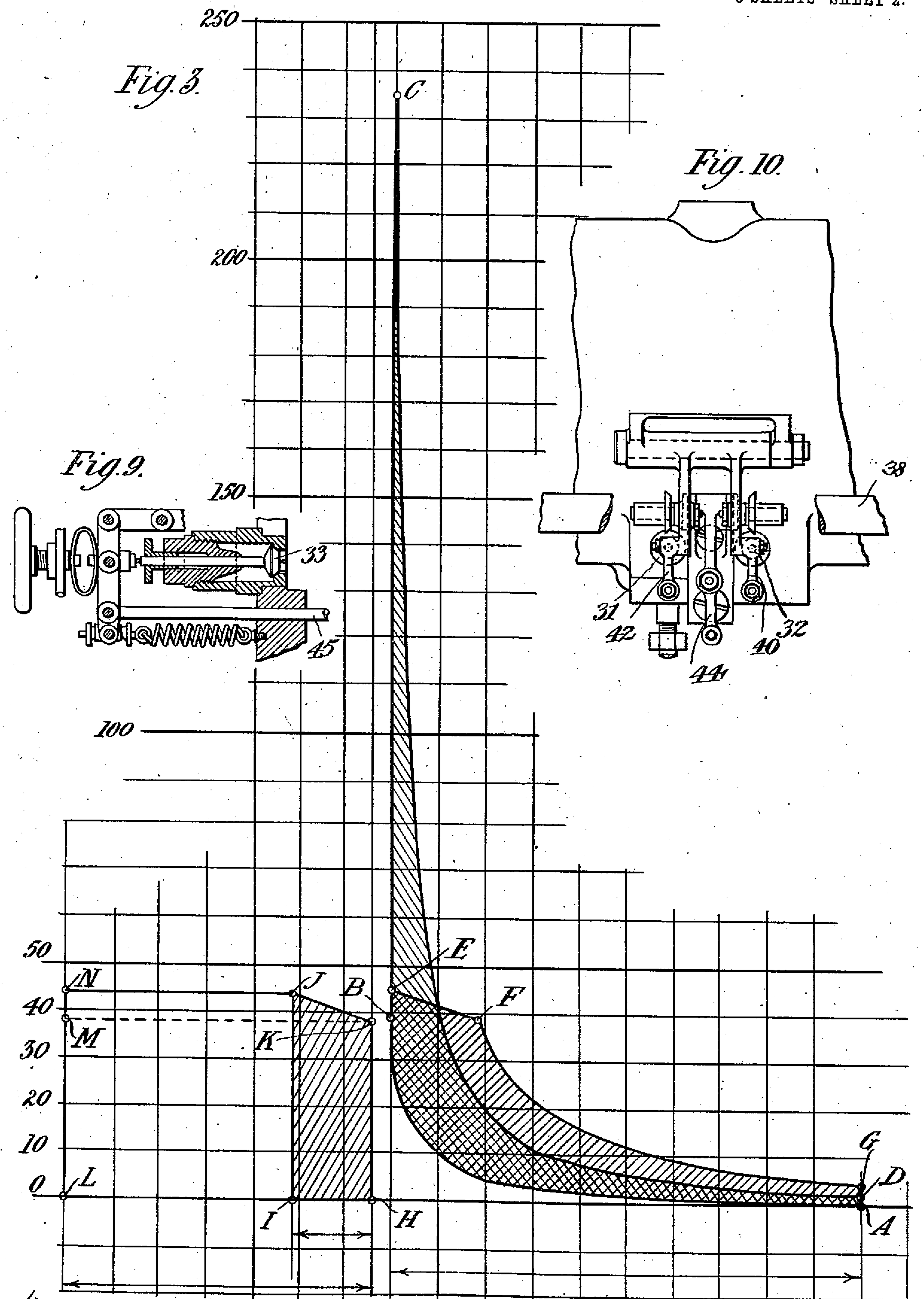
No. 752,936. PATENTED FEB. 23, 1904.

A. VOGT.

INTERNAL COMBUSTION MOTOR.

APPLICATION FILED MAR. 24, 1902.

NO MODEL. 5 SHEETS—SHEET 2.



Witnesses:

Inventor
Adolf Vogt
by Attys

No. 752,936.

PATENTED FEB. 23, 1904.

A. VOGT.

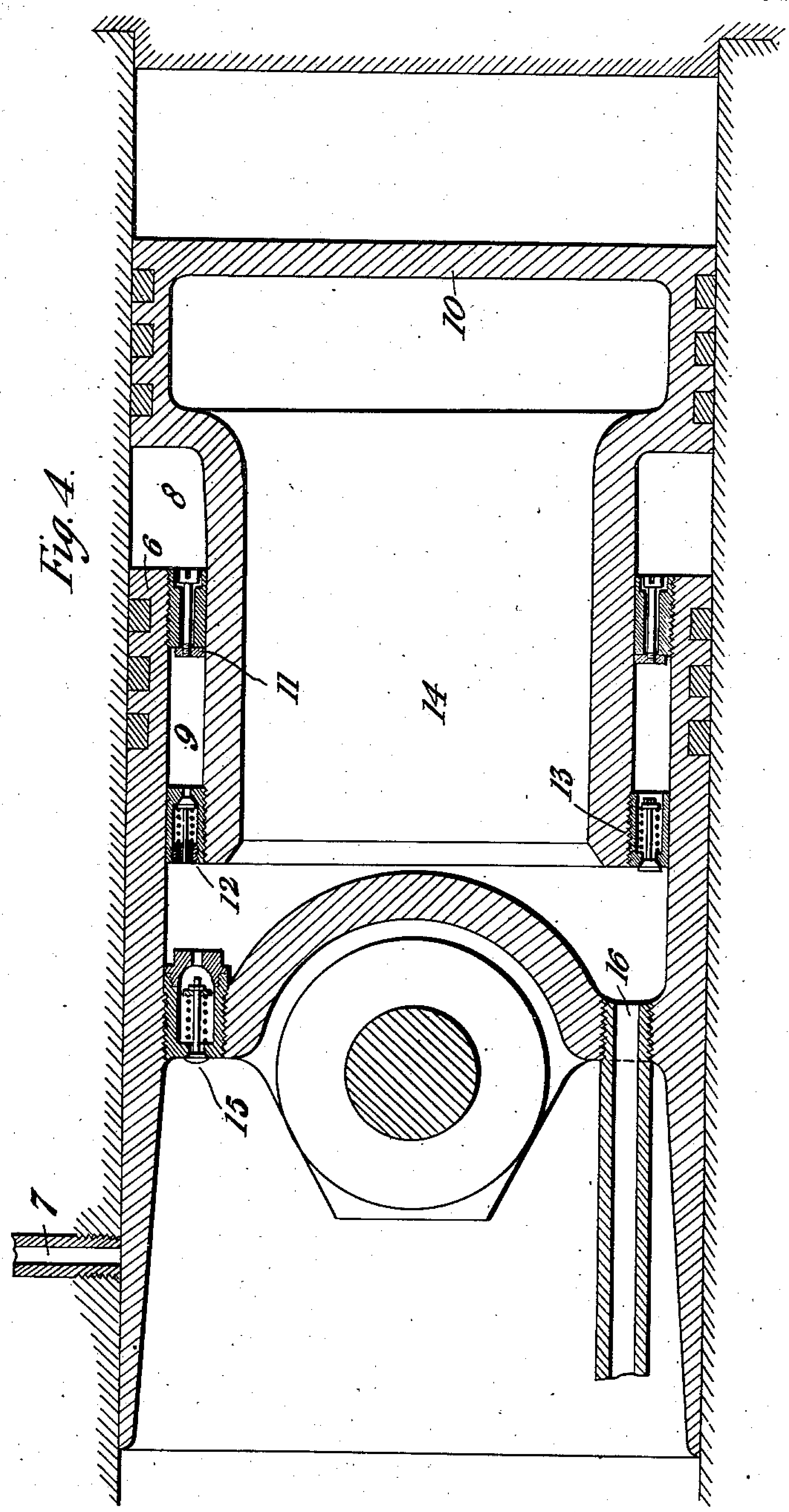
INTERNAL COMBUSTION MOTOR.

APPLICATION FILED MAR. 24, 1902.

NO MODEL.

5 SHEETS—SHEET 3.

Fig. 4.



Witnesses:
B. H. ...
R. W. Sommers

Inventor
Adolf Vogt
By Henry Orth Jr.
Atty.

No. 752,936. PATENTED FEB. 23, 1904.

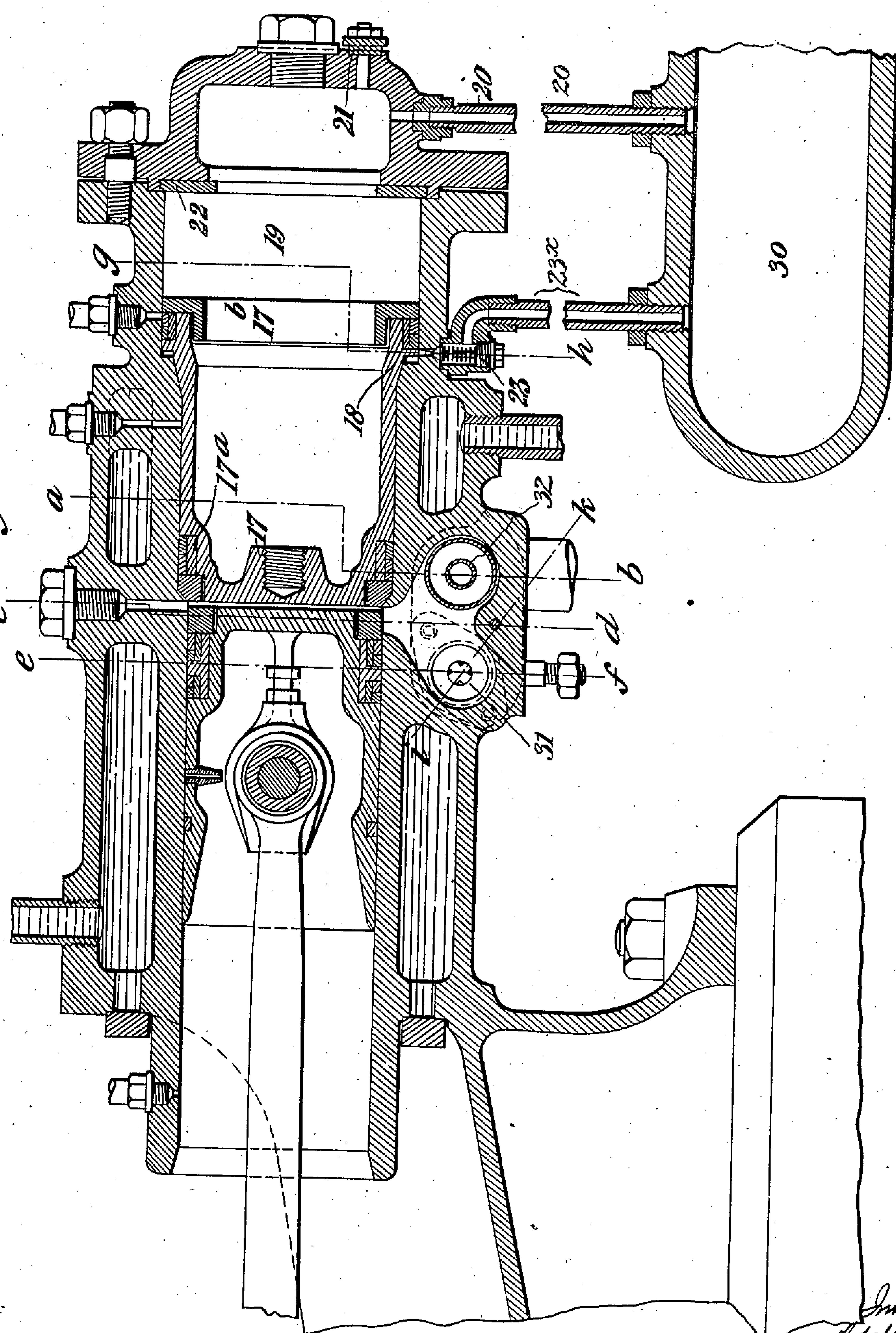
A. VOGT.

INTERNAL COMBUSTION MOTOR.

APPLICATION FILED MAR. 24, 1902.

NO MODEL. 5 SHEETS—SHEET 4.

Fig. 5.



Witnesses:
[illegible]
R. H. Sommers

Inventor
Adolf Vogt
By Henry Orth Jr
Atty.

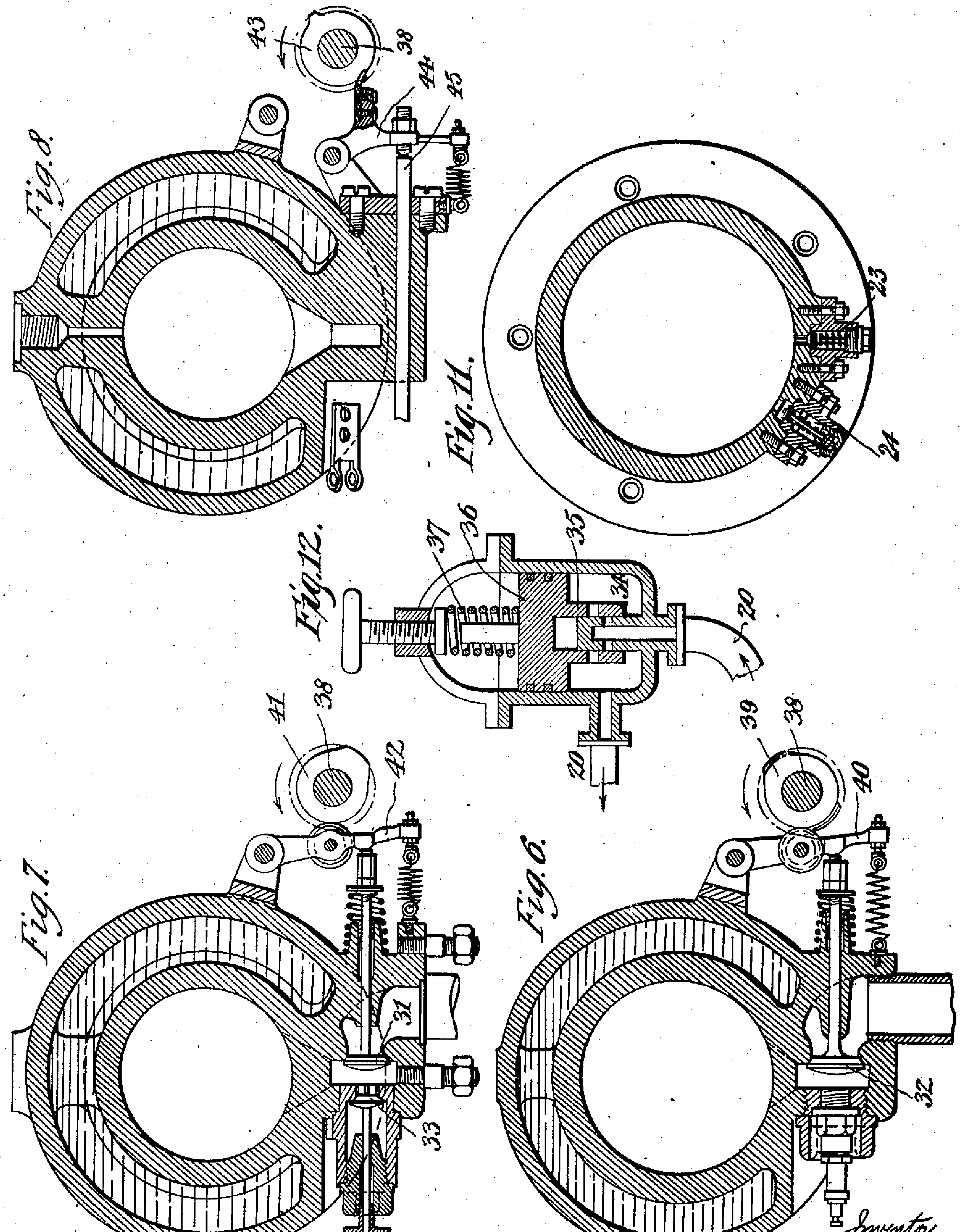
No. 752,936. PATENTED FEB. 23, 1904.

A. VOGT.

INTERNAL COMBUSTION MOTOR.

APPLICATION FILED MAR. 24, 1902.

NO MODEL. 5 SHEETS—SHEET 5.



Witnesses:

Inventor
Adolf Vogt
By Henry Orth Jr
Atty

No. 752,936. Patented February 23, 1904.

UNITED STATES PATENT OFFICE.

ADOLF VOGT, OF WEST NORWOOD, ENGLAND.

INTERNAL-COMBUSTION MOTOR.

SPECIFICATION forming part of Letters Patent No. 752,936, dated February 23, 1904.

Application filed March 24, 1902. Serial No. 99,813. (No model.)

To all whom it may concern:

Be it known that I, ADOLF VOGT, a citizen of Austria-Hungary, residing at 91 Thornlaw road, West Norwood, in the county of Surrey, England, have invented a certain new and useful Internal-Combustion Motor Working with Combustion at Approximately Constant Pressure, of which the following is a specification.

Internal-combustion motors may be divided into three groups, namely: (*a*) those working with combustion at constant volume, to which class most existing motors belong; (*b*) those working with combustion at constant temperature, to which class the Diesel motors belong, and (*c*) those working with combustion at constant pressure. This latter mode of working has been endeavored to be carried out; but no practical result has been obtained.

The process with combustion at constant volume has the disadvantage that high degrees of compression cannot be employed, as the explosion-pressure would then be too high to allow of a practical construction of the motor. It is, however, a desideratum to work with high degrees of compression, as the economical utilization of the heat produced is a function of the compression-pressure.

The employment of compression-pressures of the same height as the highest explosion-pressures employed at the present day is only possible with the two last above-named methods of working, as the operation could in this case be so carried out that the pressure during the combustion would not greatly exceed that of the compression.

The mode of working carried out by the Diesel motors—namely, with combustion at constant temperature—can only be imperfectly accomplished and possesses the disadvantage that the compression must necessarily be adiabatic. The temperatures that occur are comparatively high, as is also the temperature of the discharged gases, and the work of compression is considerable, so that it is also not possible to carry out this process even with approximate economic success.

The third above-named mode of working—namely, with combustion under constant pressure—which is rendered practically possible by means of my invention, is that which allows of the best utilization of the heat, as it can be effected with the lowest maximum and also mean temperatures, the compression temperature being reducible to slightly above 100° centigrade irrespective of the compression-pressure. As before stated, such a motor will work with the lowest maximum and mean temperatures for the same degree of heat utilization as compared with other machines of the same dimensions. The method of operating can be carried out in various ways, namely:

1. Adiabatic compression and gradual combustion with constant pressure, (see *Die Gasmachinen*, by R. Schöttler, Braunschweig, 1899, pages 214, 216, 221.) The motors referred to were not practically useful, as the process could not be carried out properly thereby.

2. Almost isothermic compression and gradual combustion with constant pressure.

3. Explosive combustion with constant pressure (*a*) with an adiabatic and (*b*) with almost isothermic compression.

The methods of operating referred to under 2 and 3 can be carried out according to my invention in two different ways, namely: (*a*) in compressing the combustible mixture either within or outside the cylinder and (*b*) by only compressing the air in the cylinder and blowing into this the combustible at a point near the dead-center during the shortest possible time and then igniting it. 2 and 3 (*b*) will certainly give the best results. With 3 (*a*) high degrees of compression is only possible when the combustible is introduced subsequently. This method might be practicable when forcing in sprayed liquid combustible, as in this case the combustible is at once vaporized and, as in the case of the Diesel motors, also at once ignited. With my improved method of working the total amount of the combustible can be introduced at the dead-center. The more rapidly it is introduced the better will be the action.

For satisfying all the above requirements it suffices according to my invention to render some part of the walls of the compression-space movable in such manner that while the combustible charge is being compressed it remains stationary; but when the pressure slightly exceeds the maximum compression-pressure on the ignition of the charge such part will yield as long as the excess of pressure continues and will thereby approximately maintain such pressure in the compression-space by the automatic increase of capacity thereof during the time of combustion. On the other hand, when the pressure in the said space has been again reduced nearly to the compression-pressure owing to the expansion consequent upon the forward motion of the motor-piston the said movable part will gradually resume its original position.

In the following description of my invention it will be shown in which manner the compression-space or the combustion-space can be so arranged as to fulfil the above-described mode of action. With normal motors operating without liquid either the rear part of the piston or, preferably, the cylinder-cover is made to give way. In motors operating with a liquid-piston the yielding part can be provided in the downward extension of the vertical explosion-chambers, or such extension may also be arranged laterally. This said yielding part must be loaded, by means of a spring device, to such an extent that it remains in its normal position up to the highest degree of compression-pressure. The spring must, however, yield as soon as the compression-pressure is exceeded in consequence of the ignition of the charge. The spring must be such that on compressing the same the pressure shall not increase to any considerable degree during the time that the said part recedes to its end position. Furthermore, the said spring must have as little mass as possible in order that for the compression of the same no special accelerating pressures may be requisite. This also holds good for the receding part of the walls, which should be made as light as possible. With the enormous pressures which will occur in such cases (on a piston-surface of one square decimeter they will amount already to 4,000 kilograms when the compression-pressure has reached forty atmospheres) steel springs do not appear suitable for this purpose. A pneumatic spring is certainly the most advantageous for the purpose, as it is almost without mass, will consequently act most rapidly, and is not subject to any wear, the medium being either air, gases, or vapors.

I will now describe my said invention with reference to the accompanying drawings, in which—

Figure 1 shows a section of part of a motor-cylinder in which the piston is constructed with a telescopically-sliding rearward extension. Fig. 2 shows a part section of a motor-cylinder the rear end of which is formed as a yielding piston. Fig. 3 is an indicator-diagram, showing the action of a motor constructed according to my invention. Fig. 4 shows a part section of a motor-cylinder the piston of which is provided with a sliding rear extension similar to Fig. 1. Fig. 5 shows a longitudinal section of a motor provided with a yielding auxiliary piston working in the cylinder-cover; Fig. 6, a section through the cylinder on line *a b*, Fig. 5, showing the discharge-valve; Fig. 7, a section on line *e f*, showing the valve for the combustible mixture and the starting-valve; Fig. 8, a section on line *c d*, showing one part of the starting-valve gear; Fig. 9, a section on line *i k*, showing the other part of the starting-valve gear; Fig. 10, a part side view showing the valve-gear; Fig. 11, a section at *g h*, showing the pump-valve of the yielding piston; and Fig. 12 is a section of a form of reducing-valve.

In Fig. 1 is shown a working piston 1, whose end 1^a is arranged to slide in and out of the other part. The hollow space 1^b thereof is filled through the pipe 2 with compressed air at a pressure which is sufficient to maintain the rear part of the piston in the outwardly-extended position indicated up to the end of the compression of the combustible charge, which will then be contained in the space 25 of the working cylinder 26. At the moment of combustion the part 1^a of the piston will of course be forced inward into the other part, so that no considerable increase of pressure need occur in the explosion-space 25. This rear end of the piston will then remain stationary relatively to the cylinder during the forward motion of the main piston-body until this part of the piston carries the rear part along with it. This will take place at the moment when the pressure in the explosion-space and that within the movable part of the piston become equal.

In Fig. 2 is shown an arrangement in which the rear end of the cylinder or the cover is made movable. In the space 27 behind the piston 3 is again contained compressed air of such a pressure that the piston 3 is maintained in the forward position shown until the end of the compression of the combustible charge, which will then be situated in the space 28. At the moment of combustion the piston 3 will move backward and in enlarging the space 28 proportionately to the increase in volume of the gases will thereby maintain the pressure approximately constant during the time of combustion. The working-piston 29 will then move forward and piston 3 follow it up in consequence of the air-pressure existing in space 27 behind it until the front end thereof, which is preferably formed to act as a valve, as shown, again bears upon the seat 4 of the cylinder. From this moment the adiabatic expansion will take place in consequence of the continued motion of the working piston. The small piston 5, connected to the piston 3, only acts as a buffer. It will be seen that by constructing piston 3 as a valve its rear part is of larger diameter than its front face, so that the pressure required to keep it up against its seat will be proportionately less than the pressure exerted by the compressed charge in space 27.

In Fig. 3 is shown an indicator-diagram representing the theoretical action of the motor. In this diagram the influence of the speed of the working piston upon the action has been neglected. With petroleum or benzol motors this will not have to be considered at all, in consequence of the rapid combustion. The compression is effected partially isothermically. If the motor were not arranged with a yielding cover to the cylinder, the explosion-pressure would, with the assumed compression of thirty-nine atmospheres, rise to about two hundred and thirty-five atmospheres, giving the diagram A B C D A. It has in this case been assumed that the yielding cover or piston has the same diameter as the working piston and that the pressure of the compressed air behind the yielding piston is equal to the maximum compression-pressure. In this case at the moment of ignition the pressure will rise from B to E in order to exercise the requisite accelerating pressure upon the yielding piston. This piston then moves from H to I, during which time the pressure of the air-cushion will rise from M to N, equal to from K to J, the yielding piston being brought to a standstill at the line I J. It is assumed that at this moment the working piston is still at the dead-center. The yielding piston or its air-cushion will have taken up the work, which is represented by the surface H I J K. Both the working piston and the yielding piston will now move forward until the former has arrived at F, at which moment the yielding piston will have arrived at H, when the pressures behind and in front of it will be equal. From the point F will commence the adiabatic expansion. The diagram A B E F G D A will then represent the work performed. As during the first moment of combustion the pressure has risen to E, the combustion will actually take place at constant pressure. The increase of pressure from B to E can be rendered very small by increasing the volume of the air-cushion and decreasing the weight of the yielding piston, which may be of aluminium, so that the line E F will become practically horizontal. By increasing the diameter of the yielding piston relatively to that of the working piston the stroke of the former can be reduced.

In Fig. 4 is shown an arrangement with expansible piston in which the compressed air is supplied automatically. At the outermost position of the main piston its edge 6 arrives opposite the pipe 7, through which the space 8 can be filled with air. During the combustion of the charge the rear part 10 of the piston is forced inward into the main part and the air contained in the space 8 will be forced through the annular valve 11 into the space 9. On the part 10 moving outward again the air will pass from the space 9 through the valves 12 and 13 (shown in two different arrangements) into the space 14 of the yielding piston. At 15 there is provided a loaded valve which allows the escape of any excess of air above the quantity required when the air in 14 has been compressed to the maximum degree by the inward motion of piston 10. In this case the pipe 16 will not be required for charging with compressed air. The surplus air might, however, also be forced through pipe 16 into a separate receiver, the valve 15 being in that case fitted to the latter. In this way compressed air is obtained automatically for starting the motor and for the spraying of water for cooling during the compression.

Figs. 5 to 11 show a gas-motor engine provided with a yielding auxiliary piston in the cylinder-cover. The yielding piston 17 is shown at Fig. 5 in its position of rest with a cushion of compressed air in chamber 19. 17^a is a soft packing for the end of this piston, such as galvanized asbestos, &c., or even leather. The rear end of the piston 17^b again acts as air-pump and also as buffer. The space which is formed between the yielding piston and the seat 18 during the yielding motion of the piston is connected with a pressure-valve 23 and a suction-valve 24, as shown at Fig. 11. From the pressure-valve 23 a pipe $23^\times$ leads to a reservoir of compressed air containing air at a higher pressure than that in space 19 behind the piston. The space 19 is connected, by means of pipe 20, with this air vessel, the pipe 20 being provided with a reducing-valve of any known construction, such as shown by way of example at Fig. 12, where the compressed air coming from the reservoir is admitted to chamber 34, (communicating with chamber 19 of the engine,) by means of ports controlled by a slide 35, attached to a piston 36, acted upon by a spring 37, so that when the pressure in 19 sinks below the normal piston 36 in sinking will cause slide 35 to open the ports, so as to admit more air-pressure, which maintains the pressure in space 19 at a constant degree when the yielding piston is in its position of rest. The rear end 17^b of the piston and chamber 19 being of larger diameter than the front part of the piston the pressure in 19 can be kept lower than the compression-pressure. At 21 there may be provided a loaded valve that opens at a maximum allowable compression-pressure in the motor, and thus allows excess of air to escape from the space 19 when the piston 17 arrives near the end of its yielding motion. In order to reduce the inertia of the mass, the body of the piston 17 can be made of aluminium. The motor is intended to act with a four-stroke cycle. The regulation thereof is effected by stoppage of the explosion charges, this being effected by shifting-cams, which may be also employed for starting the motor with compressed air. 22 is a plate of soft material which serves as an abutment for the yielding piston in the event of the pressure in the space 19 having sunk below normal. With motors working with such high compression the regulation may also be effected in such manner that the volume of the combustible charges is varied without varying the composition thereof. When the motor is running idle, there will be a less degree of compression; but, on the other hand, the expansion will be carried to atmospheric pressure with very small compression work and small loss of effect through friction. When the motor works with a small load, the combustion will, it is true, no longer work with constant pressure. If, as above described, only the air-supply is compressed in the cylinder and the combustible is forced in near the dead-center, the described pumping action of the yielding piston can be utilized for forcing the gaseous or liquid combustible into a reservoir at the requisite pressure instead of air, as described, from which reservoir it is then admitted into the charge of compressed air.

The construction and arrangement of the other parts of the motor forming no part of my present invention can be carried out in various other ways besides those shown and need, therefore, not be further described. In the arrangement shown, the counter-shaft 38, Figs. 6, 7, 8, 9, and 10, running at half the speed of the engine-shaft, carries, first, the cam 39, Fig. 6, for working the discharge-valve 32 by means of lever 40; secondly, the cam 41, Fig. 7, for working the inlet-valve 31 by means of lever 42; thirdly, the cam 43, Fig. 8, for working the starting-valve 33, Figs. 7 and 9, by means of lever 44 and rod 45.

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

1. In an internal-combustion motor, a compression and combustion space of the working cylinder having a part of its walls capable of yielding, and means for holding such part in position during the entire compression of the charges and only allowing it to yield to the combustion-pressure, substantially as described.

2. In an internal-combustion motor, a compression and combustion space of the working cylinder having a part of its walls capable of yielding, and an elastic cushion behind such yielding part that holds it in the forward position during the entire compression of the charges and only allows it to yield to the combustion-pressure, and causes it to move forward again as such pressure sinks, substantially as described.

3. In an internal-combustion motor, a compression and combustion space of the working cylinder having a part of its walls capable of yielding, a cushion of compressed air behind such part which allows it to yield only to the combustion-pressure and causes it to move forward again as such pressure sinks, and means whereby said part is made to act as an air-pump during the forward stroke for supplying compressed air to the air-cushion for making good leakage, substantially as described.

4. In an internal-combustion motor, a compression and combustion space of the working cylinder having a part of its walls capable of yielding, a cushion of compressed air behind such part which allows it to yield only to the combustion-pressure and causes it to move forward again as such pressure sinks, and means whereby said part is made to act as an air-pump during the forward stroke for supplying compressed air to an air vessel whence part of such compressed air is conveyed to the said air-cushion to make good leakage, substantially as described.

5. In an internal-combustion motor, an auxiliary piston constituting a yielding wall of the compression and combustion space of the working cylinder, a chamber in the cylinder-walls in which such piston works, and a cushion of compressed air in said chamber that keeps said piston in the forward position during the entire compression of the combustible charges and only allows it to yield to the combustion-pressure, and causes it to move forward again as such pressure sinks, substantially as described.

6. In an internal-combustion motor, a piston constituting a yielding wall of the compression and combustion space of the working cylinder, which piston works in a chamber containing a cushion of compressed air acting on said piston so as to keep it in the normal forward position until the maximum compression-pressure is exceeded, said piston being formed to act as a valve bearing against a seating in the said chamber when in the normal position so as to close said chamber against any escape of compressed air therefrom.

7. In an internal-combustion motor, a piston constituting a yielding wall of the compression and combustion space of the working cylinder, which piston works in a chamber containing a cushion of compressed air acting on said piston so as to keep it in the normal forward position until it is forced backward, after the completion of the compression of a charge, by the pressure of the ignited charge, means for causing said piston during its forward stroke to compress a separate body of gaseous fluid, and means for conveying said body of compressed gaseous fluid into a separate reservoir, substantially as described.

8. In an internal-combustion motor, a piston constituting a yielding wall of the compression and combustion space of the working cylinder, which piston works in a cham-

ber containing a cushion of compressed air acting on said piston so as to keep it in the normal forward position until it is forced backward, after the completion of the compression of a charge, by the pressure of the ignited charge, means for causing said piston during its forward stroke to compress a separate body of gaseous fluid, and means for conveying said body of compressed gaseous fluid into a separate reservoir at a higher pressure than the compression-pressure and a duct containing a reducing-valve connecting said reservoir with the chamber behind said piston, substantially as described.

9. In an internal-combustion motor, a piston constituting a yielding wall of the compression and combustion space of the working cylinder, which piston is of larger diameter than the working piston of the engine and works in a chamber which is of corresponding larger diameter than the working cylinder and contains a cushion of compressed air acting on said piston so as to keep it in the normal forward position during the compression of a combustible charge, but to allow it to yield to the increased pressure on the combustion of said charge, substantially as and for the purpose described.

10. In an internal-combustion motor, a piston constituting a yielding wall of the compression and combustion space of the working cylinder, the rear part of which piston is of larger diameter than the forward part thereof that forms the wall of the compression-space, a chamber in the working cylinder containing said piston and made of corresponding larger diameter at its rear part than at its forward part, and a cushion of compressed air contained in the rear part of said chamber and acting upon said piston so as to keep it in the forward position during the compression of the combustible charge but to allow it to yield to the increased pressure consequent on the combustion of the charge, substantially as and for the purpose described.

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

ADOLF VOGT.

Witnesses:

CHAS. D. ABEL,

GERALD L. SMITH.