No. 896,893. PATENTED AUG. 25, 1908.

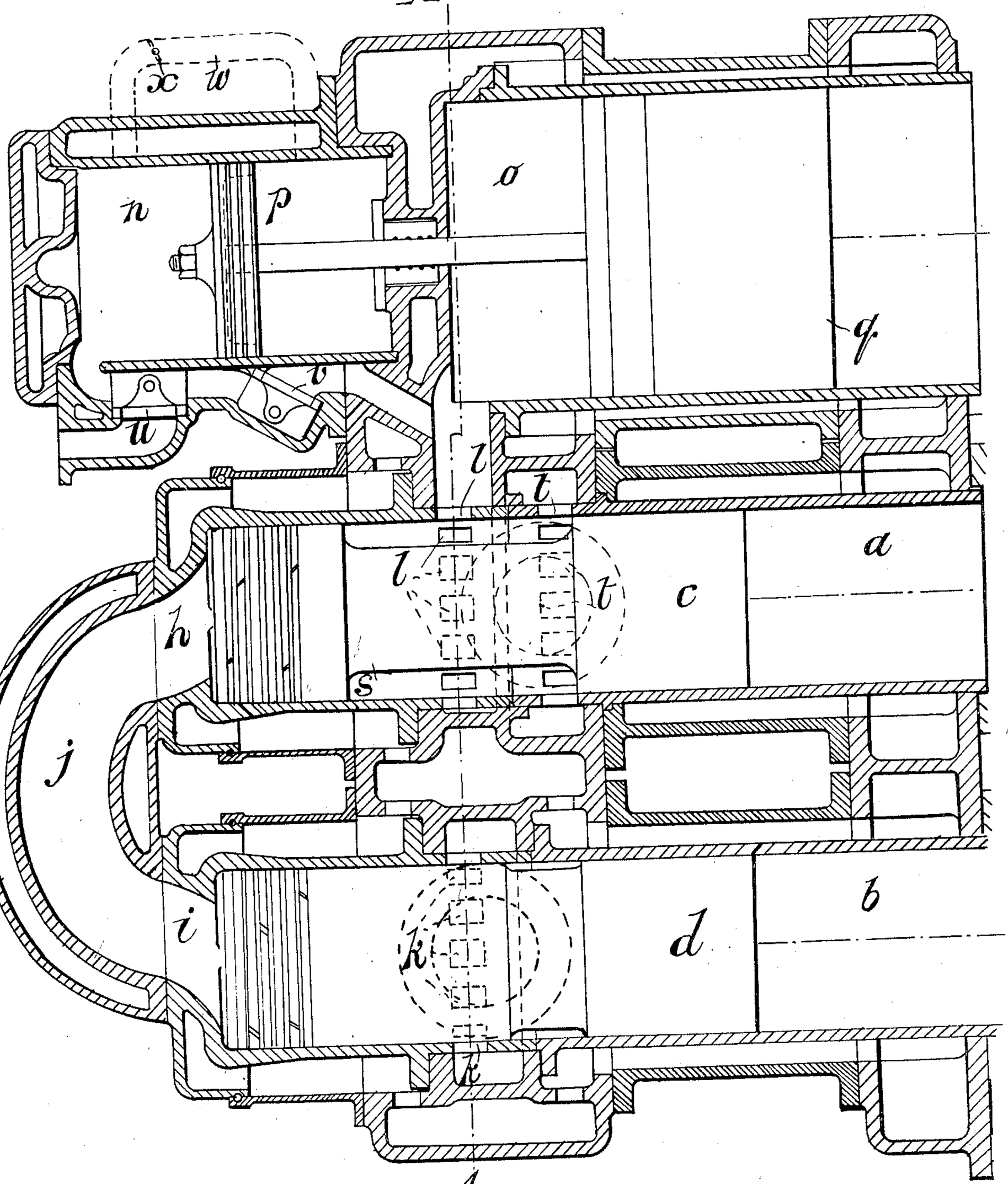
D. CLERK.

INTERNAL COMBUSTION ENGINE.

APPLICATION FILED FEB. 15, 1904.

5 SHEETS—SHEET 1.

Fig. 1.



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No. 896,893. PATENTED AUG. 25, 1908.

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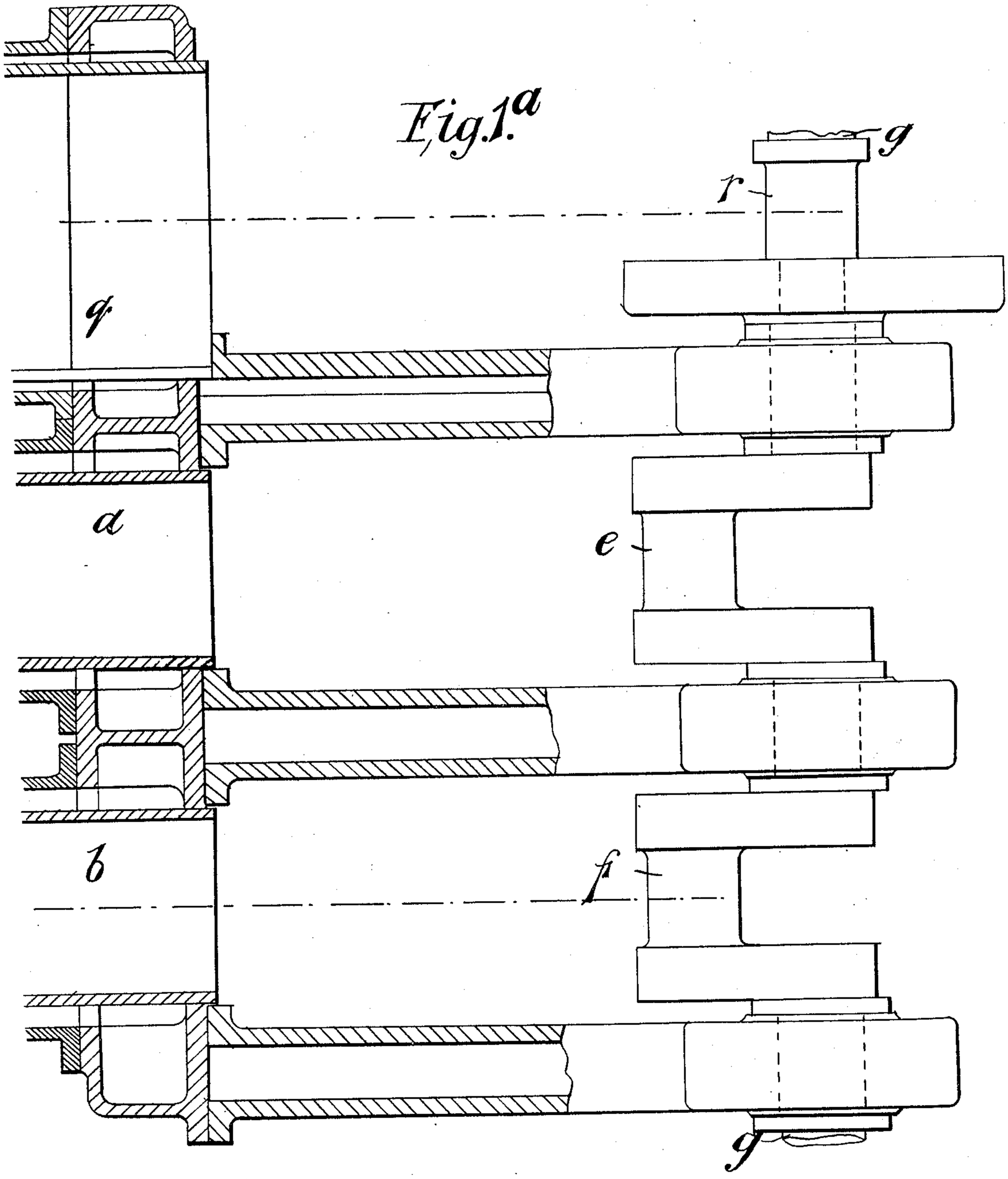
5 SHEETS—SHEET 2.

Fig. 1a



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5 SHEETS—SHEET 3.

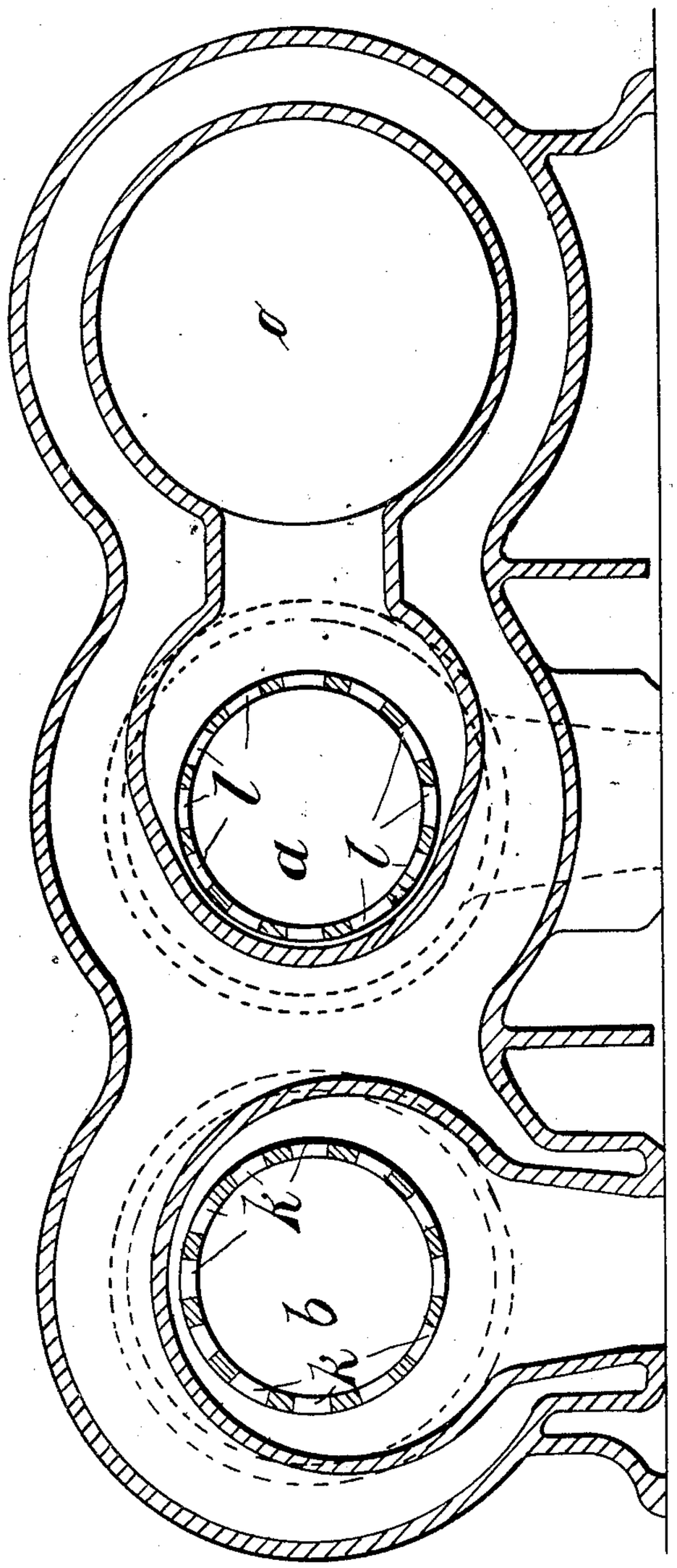

Fig. 2.

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5 SHEETS—SHEET 4.

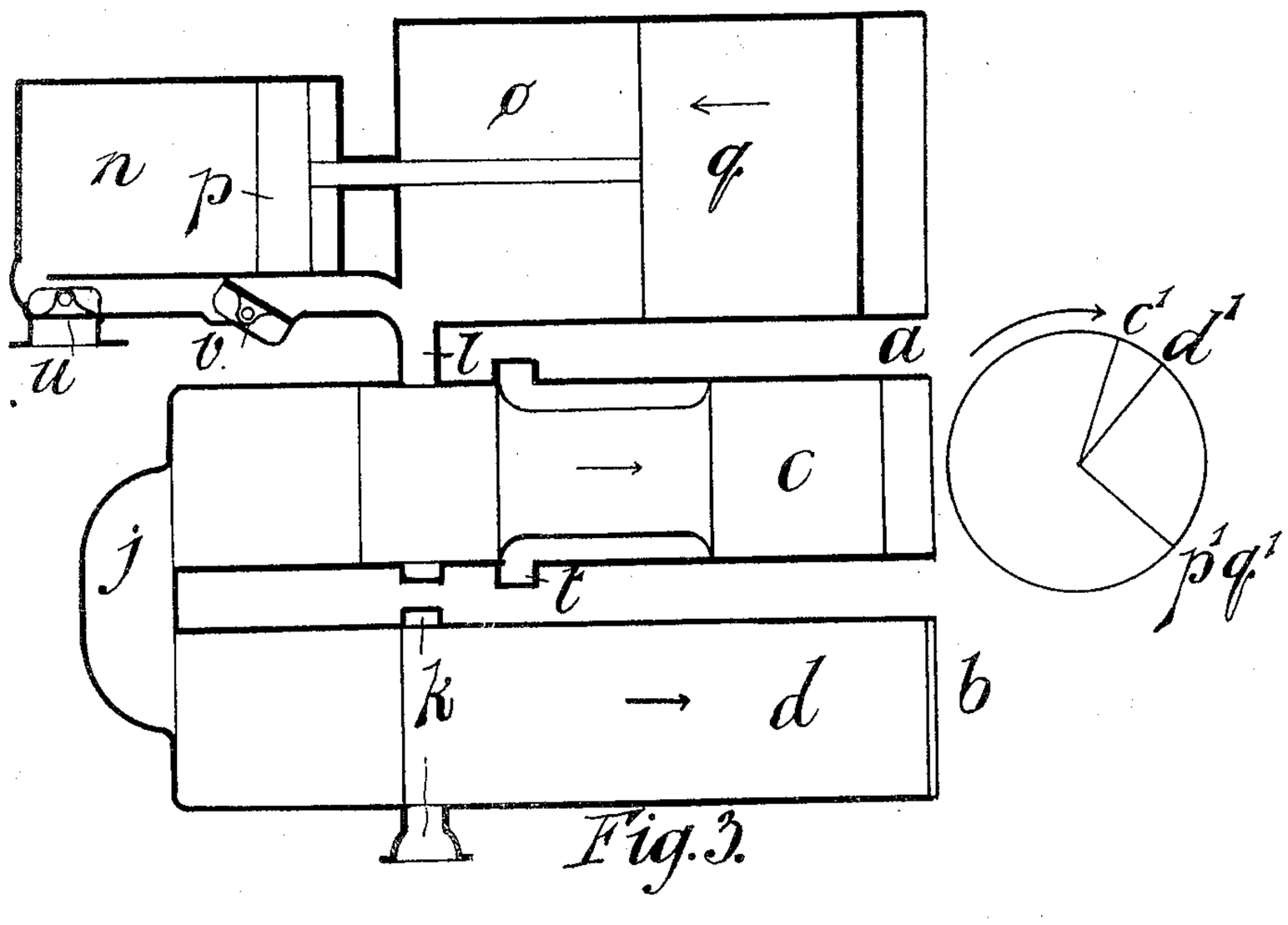

Fig. 3.

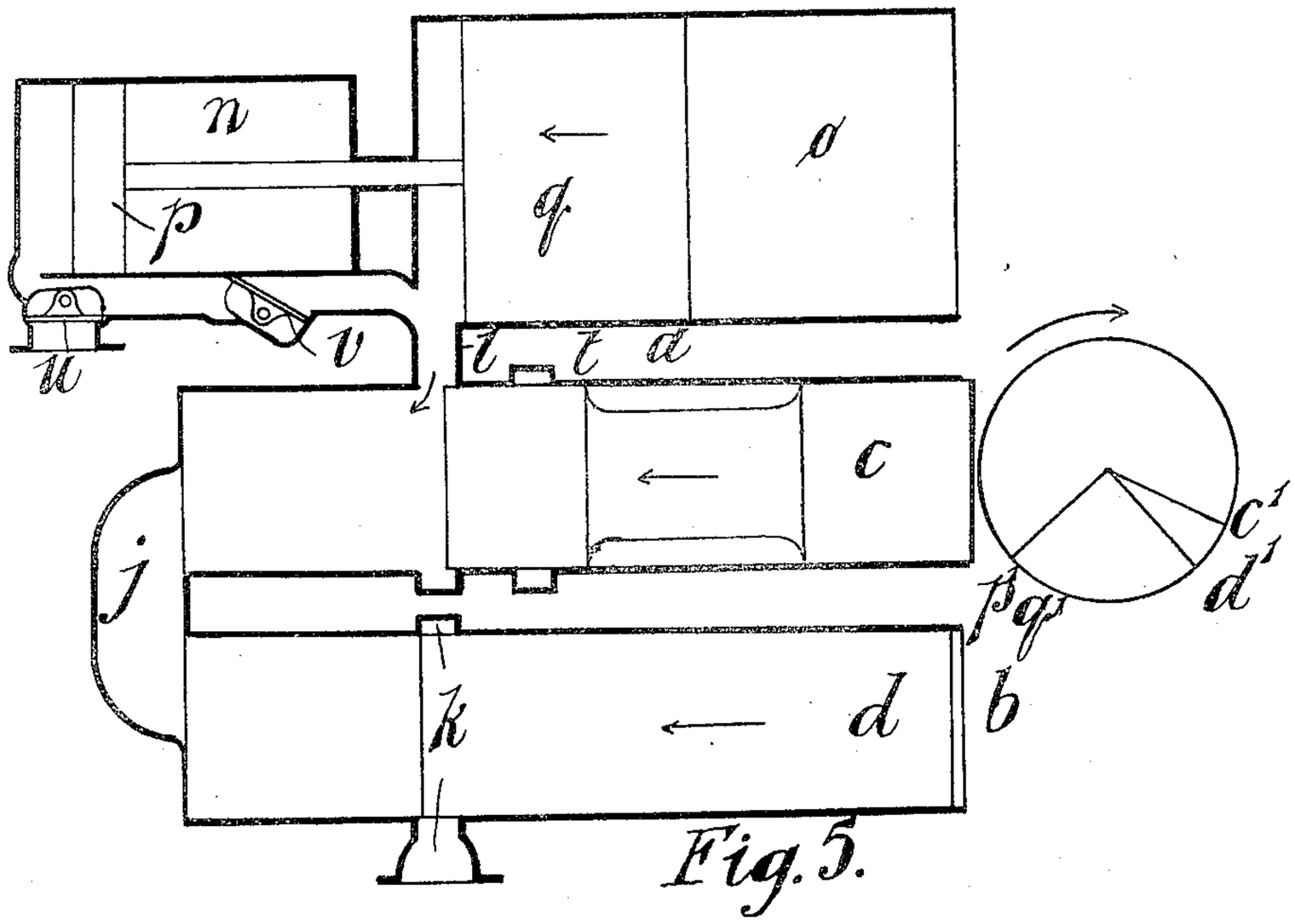

Fig. 5.

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INTERNAL COMBUSTION ENGINE.

APPLICATION FILED FEB. 15, 1904.

5 SHEETS—SHEET 5.

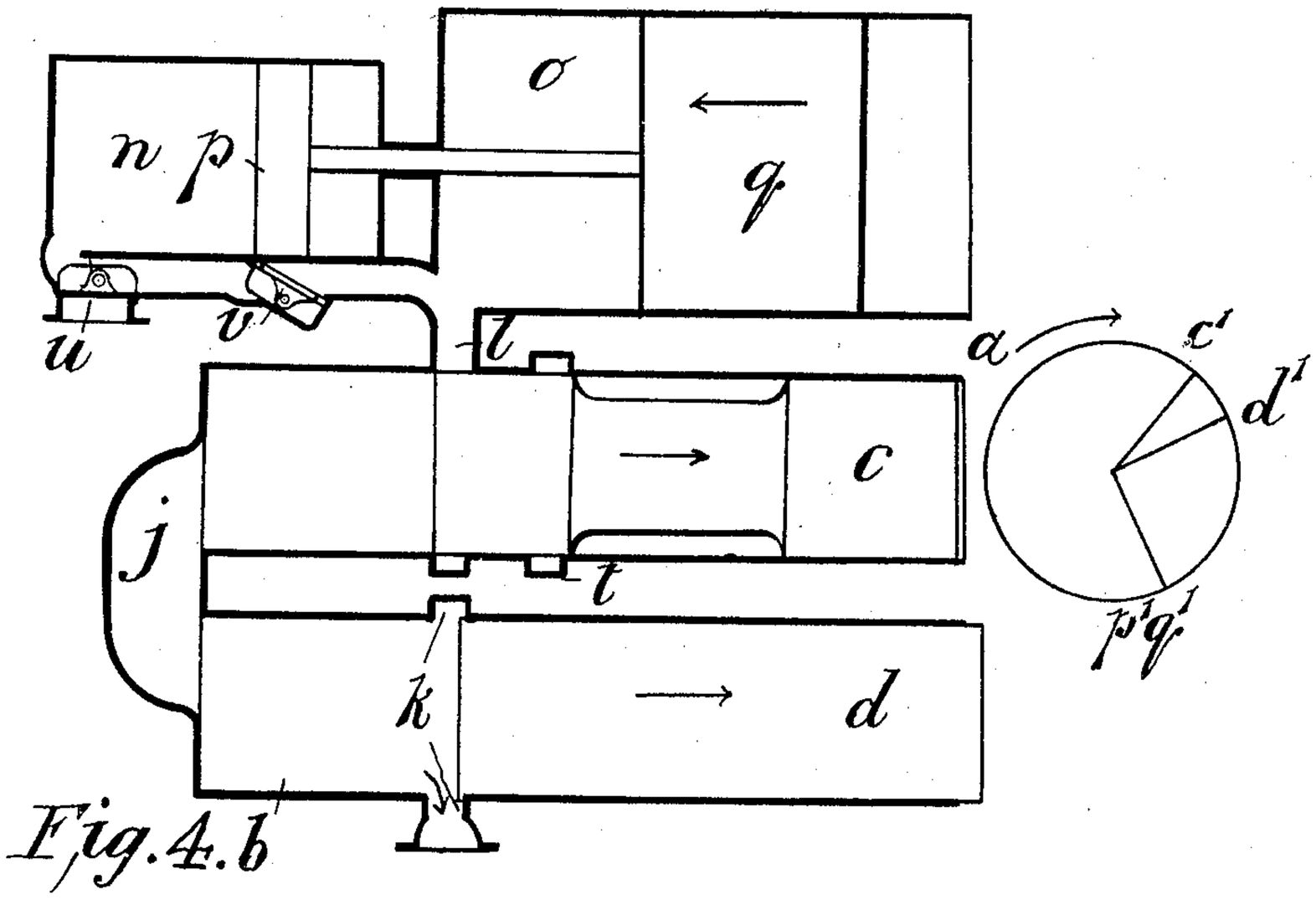

Fig. 4. b

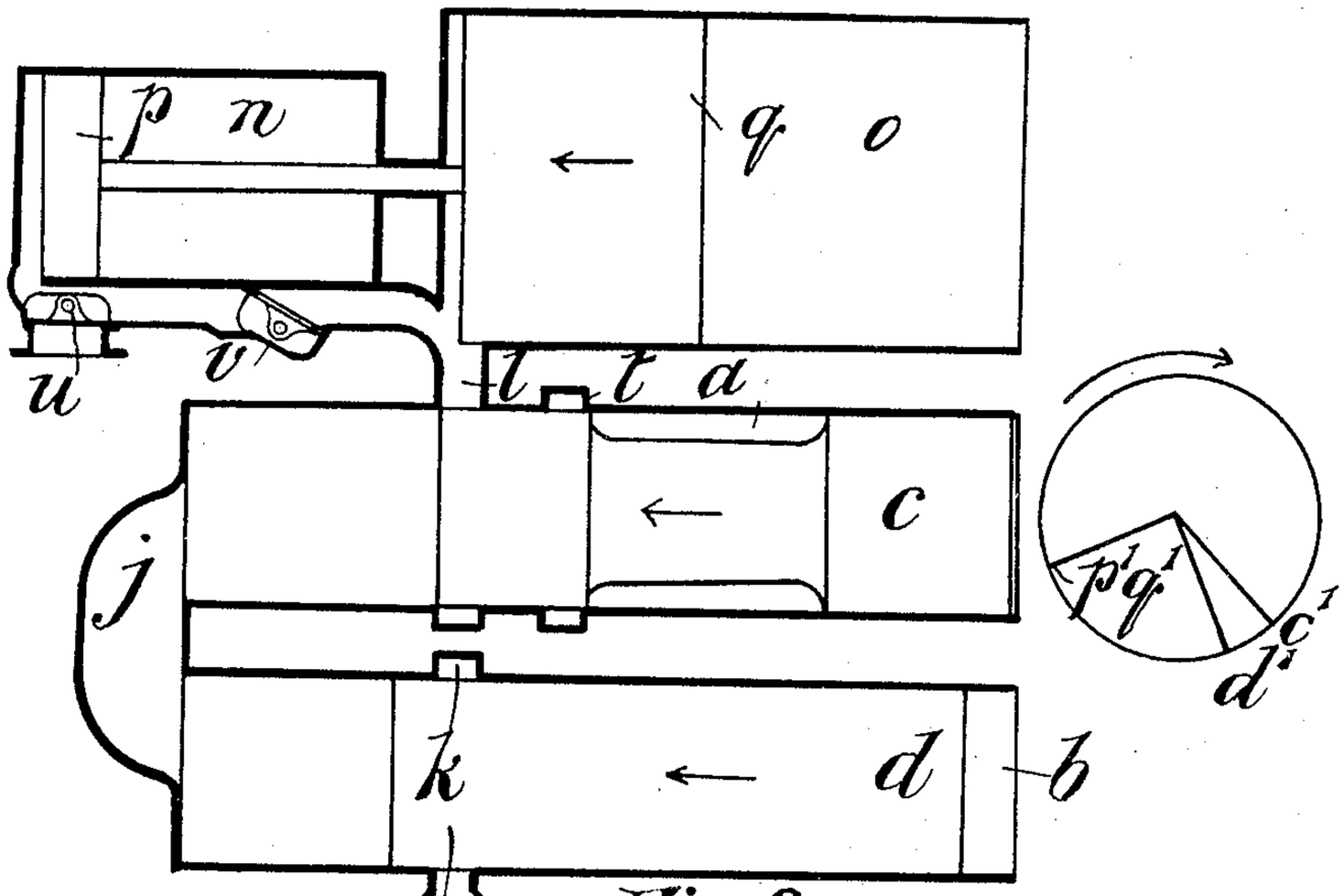

Fig. 6.

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UNITED STATES PATENT OFFICE.

DUGALD CLERK, OF LITTLE WOOLPITS, ENGLAND.

INTERNAL-COMBUSTION ENGINE.

No. 896,893. Specification of Letters Patent. Patented Aug. 25, 1908.

Application filed February 15, 1904. Serial No. 193,723.

To all whom it may concern:

Be it known that I, DUGALD CLERK, a subject of the King of Great Britain and Ireland, and residing at Little Woolpits, Ewhurst, in the county of Surrey, England, have invented certain new and useful Improvements in Internal-Combustion Engines, for which I have made application in Great Britain, No. 3,663, bearing date February 16, 1903, and of which the following is a specification.

My invention relates to internal combustion engines in which the burned gases are swept out of the cylinder and replaced by the incoming charge.

My object is to produce a gas engine in which a long distance intervenes between the inlet ports and the exhaust ports, so as to prevent loss of charge at the exhaust and further to dispense with openings into the cylinder other than those controlled by the pistons.

My invention consists generally in employing two cylinders abreast in conjunction with one another in such a way that practically the whole length of both cylinders separates the incoming charge from the outgoing exhaust, while similar connecting rods couple the pistons to suitably disposed cranks on the same shaft.

My invention also consists in giving the piston in the cylinder by which the exhaust is discharged a lead in relation to the other by suitably disposing their respective cranks so that the inlet ports of the other cylinder are open after the exhaust ports are closed whereby supercompression of the charge may be simply effected.

My invention further consists in an engine having two cylinders in each of which there operates a motor piston; the cylinders are connected at their rear ends by a large passage which forms the compression space, and each motor piston overruns ports placed in the circumference of the cylinder. One piston overruns its ports sooner than the other, and the exhaust discharges by those ports. The other piston overruns its ports a little later, and the charge enters by them and sweeps the exhaust gas out of the cylinder by the other ports while filling the cylinder with fresh charge. The charge is obtained by air and gas compressed separately, and caused to flow from a pipe or reservoir into one cylinder by air and gas ports.

The accompanying drawings illustrate an engine arranged according to one modification of my invention Figure 1 being a sectional plan of a portion of the machine and Fig. 1[a] is a similar view of the remaining portion, the two figures together constituting a sectional plan of the entire engine, Fig. 2 an end sectional elevation on the line A A, Fig. 1, while Figs. 3 to 6 are diagrams illustrating the relative positions of the motor pistons and gas and air pistons at various points during a cycle of operations.

In carrying my invention into effect according to one modification, I provide two cylinders, *a*, *b*, parallel to each other having pistons *c*, *d*, connected to two separate cranks, *e*, *f*, on the same shaft *g*, one being set a little in advance of the other. The rear ends of the cylinders terminate in conical passages *h*, *i*, which are connected by a curved passage *j*. The curved passage and the two cones form the compression space which is common to both cylinders. One piston, *d*, on its out stroke overruns ports, *k*, in its cylinder *b*, and the exhaust discharges down to atmospheric pressure; a little later the other piston overruns ports *l*. The ports *l* are supplied from displacer cylinders *n* and *o*, fitted with displacer pistons *p* and *q*, respectively. The one cylinder *n* is for gas and is smaller than the other *o*, which is used for air, the gas charge being arranged so that the gas pressure does not rise above atmosphere until the air charge has been considerably compressed. Both displacer pistons are rigidly connected and operated by a crank *r* which is at about a right angle in advance of the motor cranks *e f*, and the motor cylinders are charged first with air then with gas and air in accordance with the well known "Clerk" cycle, while the exhaust gases are entirely displaced. The proportions of the air and gas cylinders are such as to allow of the complete discharge of the exhaust gases at each stroke. The return stroke compresses the charge into the common compression space and the charge is ignited preferably by the electric spark.

As the pistons *c d*, operate on cranks nearly at right angles to the cranks driving the displacer pistons, one of them, *c*, is utilized to serve as a charging valve for the air pump. It is for this reason formed with a portion *s* of reduced diameter so that on the suction stroke of the air pump air can enter the air pump cylinder, via inlet ports *t*, and the charging ports *l*, the ports *t* being at this time uncovered by the rear portion of the

piston *c*. Therefore except for the suction and discharge valves *u* and *v*, for the gas pump, it will be obvious that the engine requires no other valves than its own pistons. To enable it to govern, the gas inlet valve *u* is controlled by the governor in such manner that the gas charge sent into the cylinder is reduced in volume as the speed of the engine increases.

The engine gives one impulse for each motor cylinder at every forward stroke, and the frequency of the explosions is maintained under all loads; governing is effected by reducing the power of the impulses—not by reducing the number.

The cycle of operation is clearly indicated by the diagrams, Figs. 3 to 6, wherein Fig. 3 shows the relative positions of the pistons *c d*, and displacers *p*, *q*, and the angular relations of their respective crank pins *c'*, *d'*, and *p' q'*, at a point near the termination of the outward power stroke. The piston *d*, is just about to uncover the exhaust ports *k*, and the displacer piston *q*, is compressing air. In Fig. 4 the exhaust ports are uncovered and the piston *c*, is just about to uncover the charging ports *l* to admit an air charge for scavenging, such charge escaping by the exhaust ports *k* before the piston *d* returns and covers them as shown in Fig. 5. At this instant the gas valve *v* is opened and a gas and air charge is forced by the displacer pistons through the charging ports *l* into the motor cylinders. The piston *c* continuing to move inwardly then cuts off the ports *l* as shown in Fig. 6. Compression of the charge follows, simultaneously with an admission of air to the air pump via ports *t* and *l* and admission of gas to the gas pump, the pistons *p* and *q* being by this time on their outward suction stroke and the valves *u* and *v* being respectively open and shut. When both the motor pistons *c*, *d* have passed the dead centers, ignition occurs, the resulting explosion forcing the motor pistons outwardly on their power stroke, whereupon the whole cycle of operations is repeated. As only one side of the displacer *p* is used for displacing gas a by-pass *w* may connect the two parts of the cylinder *n*, such by-pass being fitted with a throttle valve *x* controlled by the governor so that when the speed of the engine becomes excessive more or less of the gas charge may be allowed to pass to the opposite side of the piston *p*. In such a case the valve *u* may be replaced by an ordinary non-return valve on the gas inlet.

The valve *u* of the first mentioned modification is shown as a grid valve but a piston valve may be substituted therefor. In some cases the cylinders may be arranged at an angle to one another and work on the same crank pin. This arrangement gives the required lead of the one piston in relation to the other, and the displacer cylinder may be still further angularly displaced or arranged on a second crank pin alongside.

By my invention I obtain the advantage of a very long effective cylinder in relation to its diameter, so as to readily charge by displacement, without loss of charge to exhaust ports while also obtaining a compact engine.

It will be obvious that my invention is applicable with engines operating with light or heavy oils instead of gas. In that case the pump *m* may or may not be used. The light or heavy oil being for example vaporized or sprayed into air passed at the proper time through a vaporizer or equivalent by that pump, or in case pump *n* is omitted the spraying takes place direct into the passage *l* at the proper times and in proper quantities to form the required proportion of mixture.

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

1. An internal combustion engine comprising two adjacent working cylinders; a common compression space connecting their rear ends; a piston for each working cylinder; inlet ports in one of said cylinders and outlet ports in the other thereof, which ports are adapted to be overrun by their respective pistons; an air compressor having its own cylinder and piston, a connection between said air compressor cylinder and one of said working cylinders, this connection being controlled by one of the pistons; a crank shaft common to the three pistons; the relative motions of the pistons being determined to effect, after the opening of the exhaust ports, the scavenging of the waste gases, then the closure of the exhaust ports before the closure of the air passage from the compressor, whereby air at considerable pressure above atmosphere is compressed into the working cylinders during the early part of the ordinary compressing stroke of the engine and after the exhaust openings have been closed, and means for delivering combustible into the compressed air in the compression space.

2. An internal combustion engine comprising two adjacent working cylinders; a common compression space connecting their rear ends; a piston for each working cylinder; inlet ports in one of said cylinders and outlet ports in the other thereof, which ports are adapted to be overrun by their respective pistons; an air compressor having its own cylinder and piston; a connection between said air compressor cylinder and one of said working cylinders, this connection being controlled by one of the pistons; a crank shaft common to the three pistons; the relative motions of the pistons being determined to effect, after the opening of the exhaust ports, the scavenging of the waste gases, then the closure of the exhaust ports before the closure of the air passage from the com-

pressor, whereby air at considerable pressure above atmosphere is compressed into the working cylinders during the early part of the ordinary compressing stroke of the engine and after the exhaust openings have been closed, and a gas compressor for delivering the combustible into the compressed air charge after said exhaust ports have been closed.

3. An internal combustion engine comprising two adjacent cylinders connected at their rear ends by a common combustion space, inlet ports in one cylinder and outlet ports in the other, which ports are adapted to be over run by the respective pistons, two piston-controlling cranks set at slightly different angles to each other, an air compressor delivering air into the cylinders at a pressure considerably above that of the atmosphere, and operated from a third crank, the position of which is such in relation to the other cranks that air delivered to the other cylinders first scavenges and then forms a precompressed charge early in the compression stroke of the engine, and means for delivering a charge of combustible into the compressed air, substantially as described.

4. An internal combustion engine comprising two adjacent cylinders connected at their rear ends by a common compression space, one cylinder being provided with inlet ports and the other with outlet ports adapted to be over run by their respective pistons, separate compressors for gas and air, so adapted that, first, a charge of air is delivered to the cylinders for scavenging, and then after closure of the exhaust a mixed charge of gas and air at considerable pressure above atmosphere, one of the motor pistons being adapted to act as a suction valve for the air compressor, substantially as described.

5. An internal combustion engine comprising two adjacent cylinders connected at their rear ends by a common compression space, inlet ports in one cylinder and outlet ports in the other, such ports being overrun, one set slightly in advance of the other by their respective pistons, air ports in one cylinder also overrun by the respective piston, an annular space on said piston adapted to put said inlet ports into communication with the main inlet ports, and an air compressor and a gas compressor both connected to said main inlet ports, the latter being controlled by a valve, substantially as described.

6. An internal combustion engine, comprising a pair of adjacent cylinders connected at their rear ends by a common compression space, inlet ports in one cylinder and outlet ports in the other, air inlet ports in one cylinder, an air compressing cylinder arranged alongside said last named cylinder, and communicating with said inlet ports, and an air compressing piston working in said air compressing cylinder, the pistons of the aforesaid engine cylinders controlling the inlet and exhaust to and from the cylinders and one of said pistons controlling the admission of air to the air compressor, and means for supplying gas, substantially as described.

7. An internal combustion engine, comprising two adjacent cylinders connected at their rear ends by a common compression space, inlet ports for one cylinder and outlet ports in the other, an additional set of ports in said first named cylinder pistons in said cylinders, the pistons in the cylinder having a double set of ports being provided with a cutaway central portion, one set of said ports being in communication with the atmosphere, air and gas compressing cylinders both in communication with the other set of ports, connected pistons working in said cylinders for compressing the air and gas therein and valves controlling the admission of gas to and its exit from the gas compressing cylinder, the admission of air to the air compressing cylinder and its exit therefrom being controlled by the said piston in the adjacent cylinder, substantially as described.

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

DUGALD CLERK.

Witnesses:

ALBERT E. PARKER,

R. SMITH.