No. 704,060. Patented July 8, 1902.

F. LISTER.

INTERNAL COMBUSTION ENGINE.

(Application filed July 27, 1901.)

(No Model.) 4 Sheets—Sheet 1.

Fig. 1

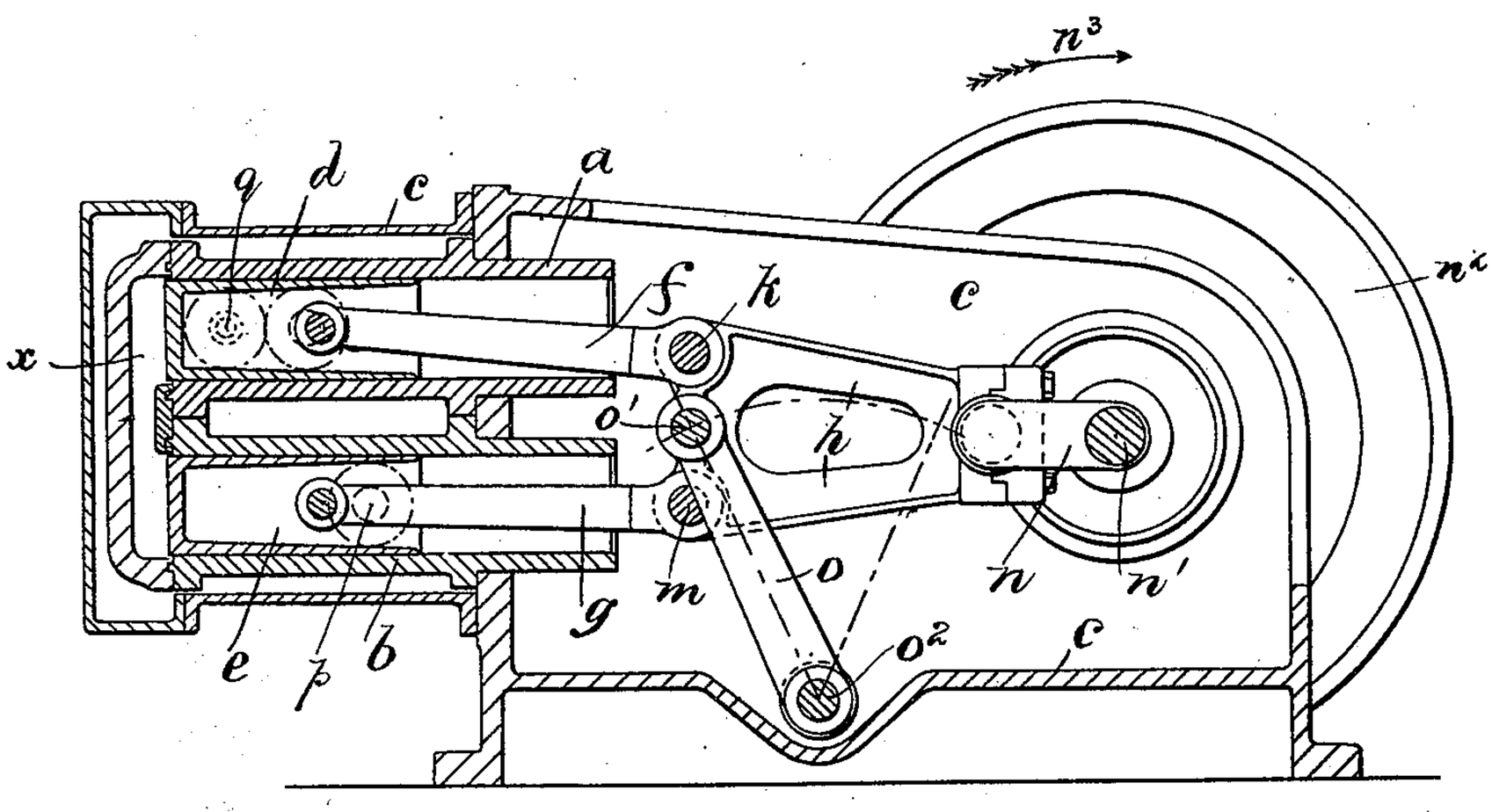
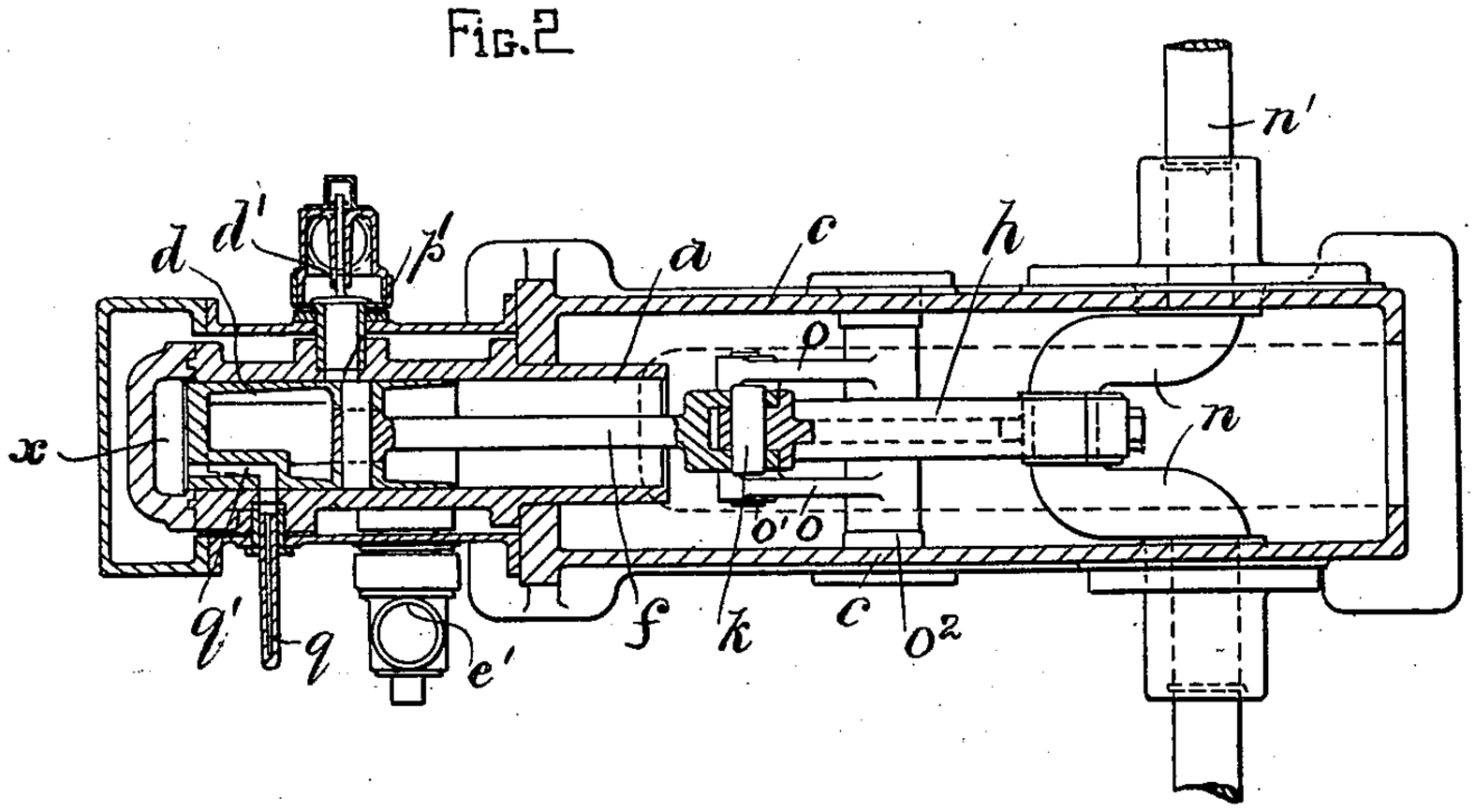


Fig. 2



Witnesses
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Fig. 3

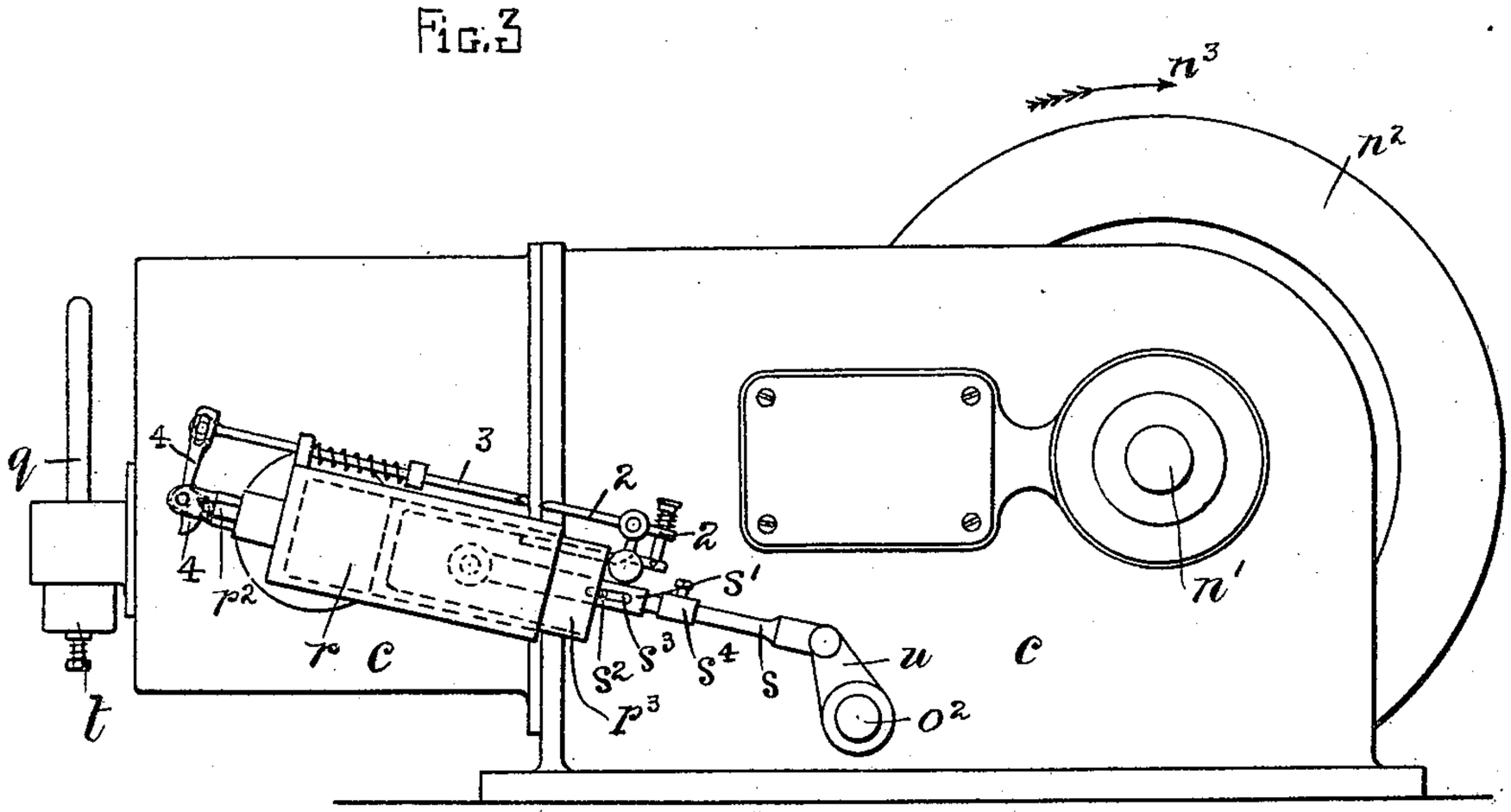

Fig. 6

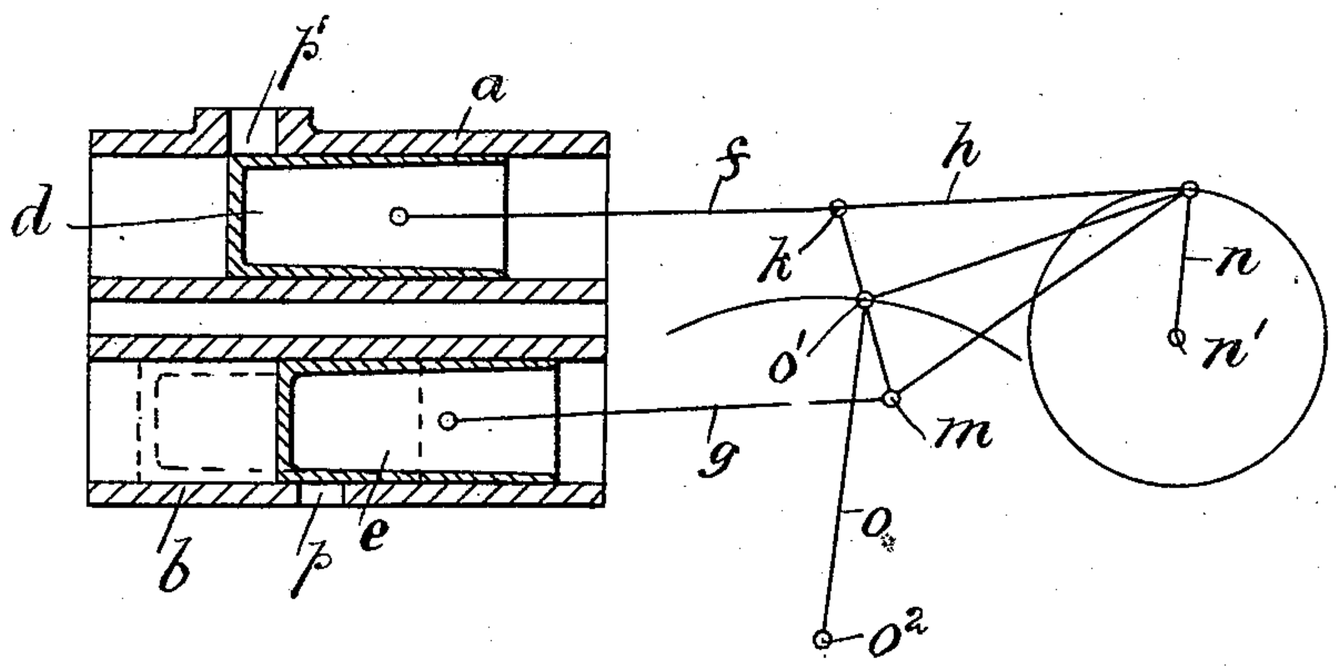

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Fig. 4

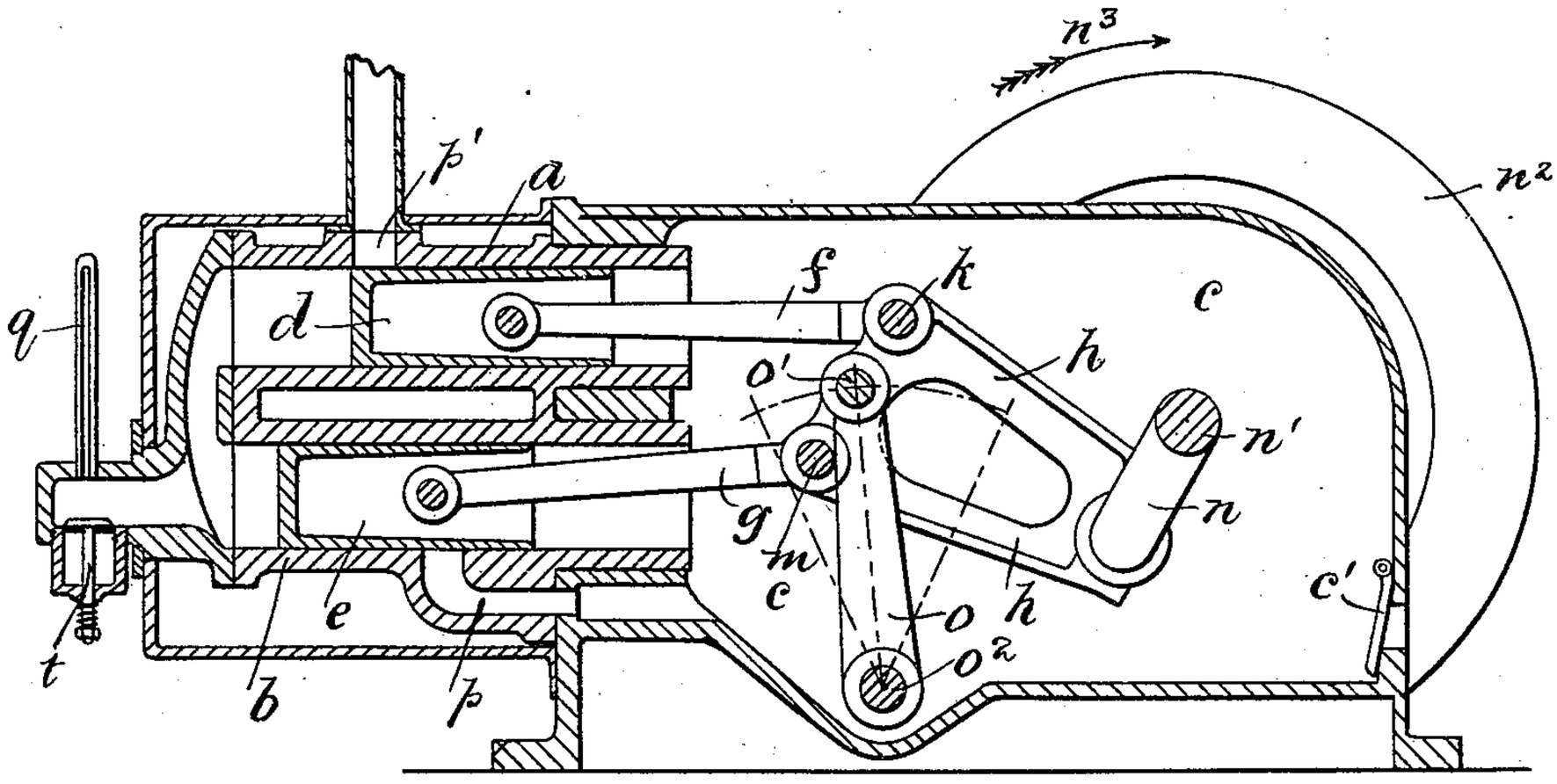
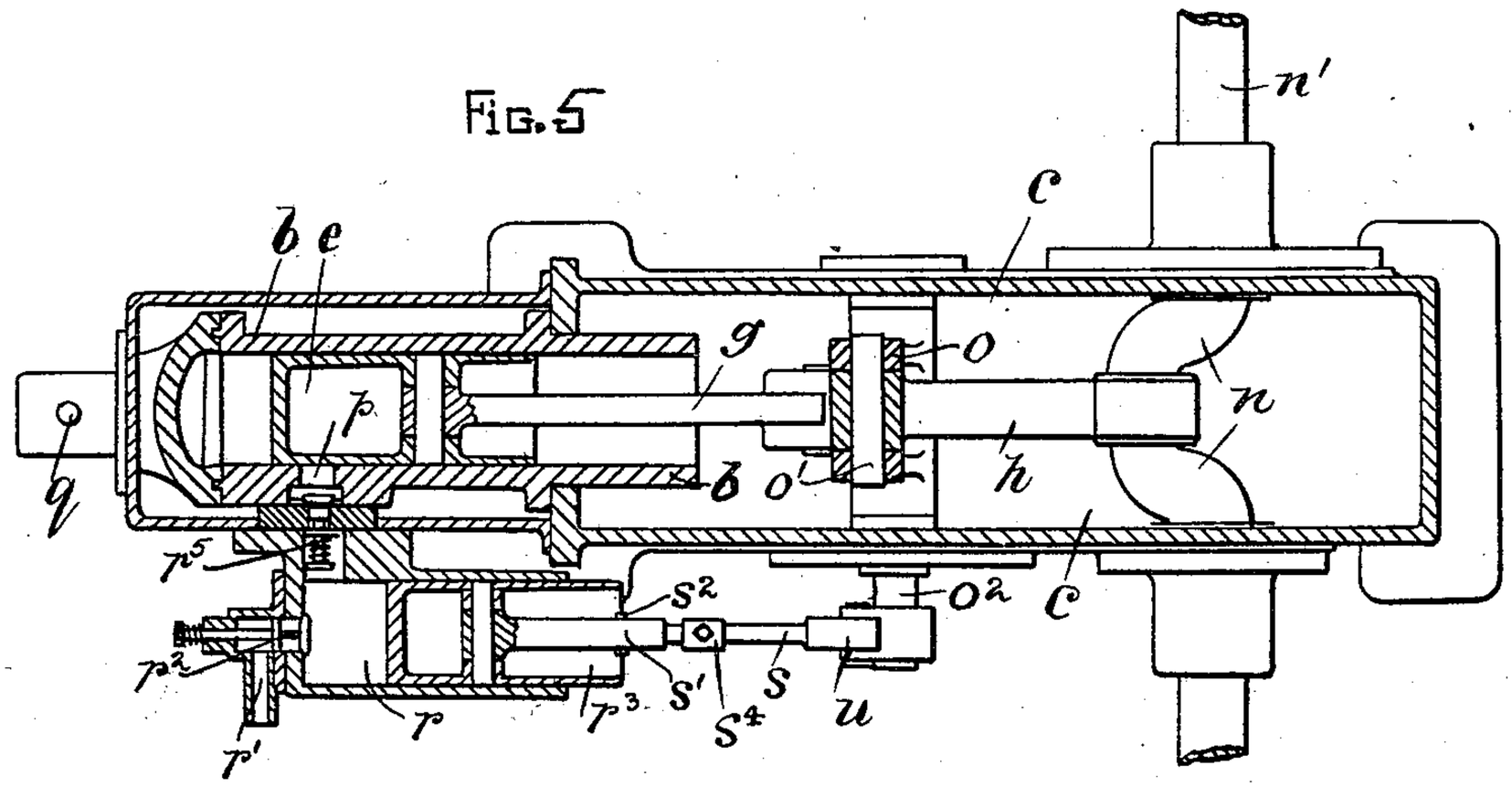


Fig. 5



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(No Model.) 4 Sheets—Sheet 4.

Fig. 7

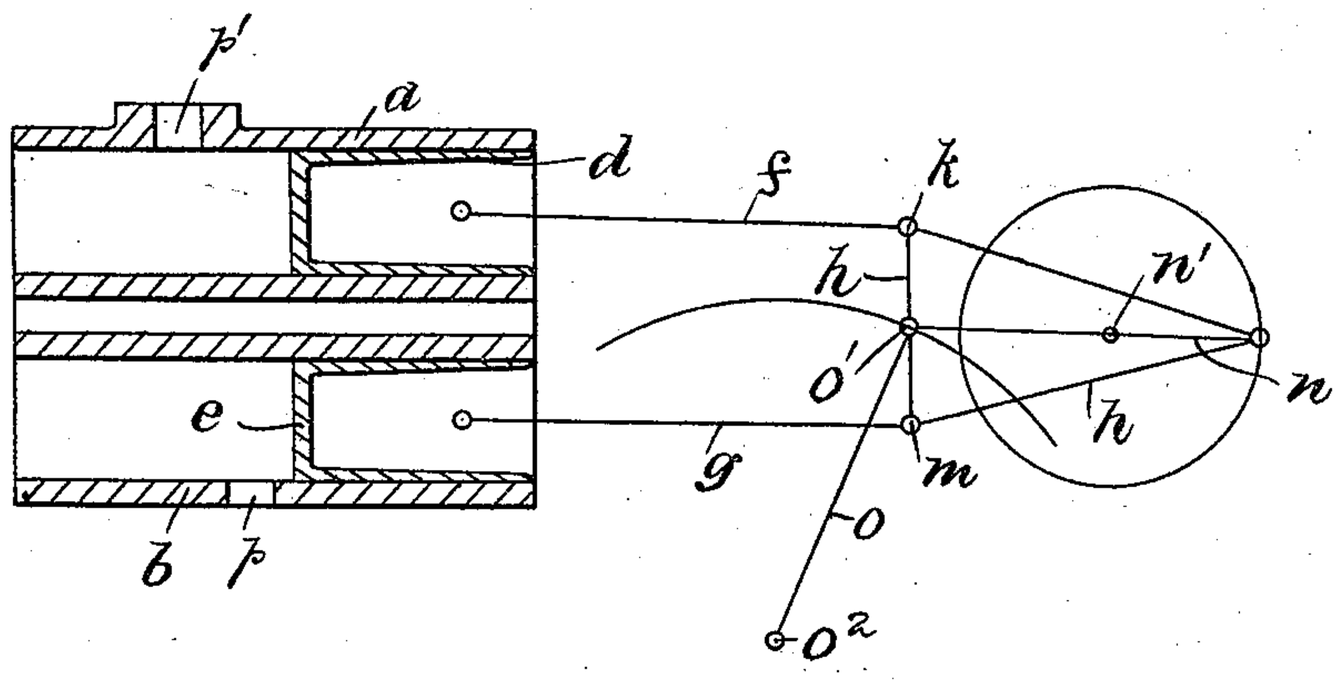
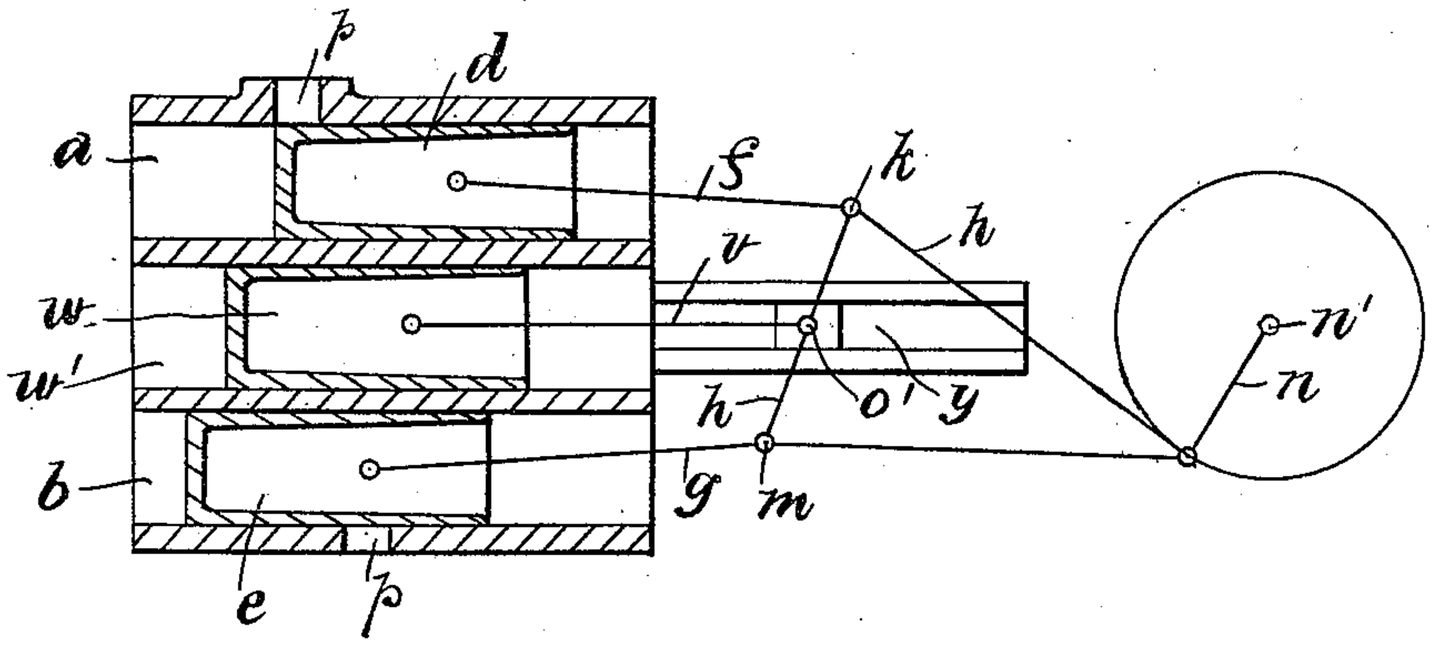


Fig. 8



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UNITED STATES PATENT OFFICE.

FRANK LISTER, OF KEIGHLEY, ENGLAND.

INTERNAL-COMBUSTION ENGINE.

SPECIFICATION forming part of Letters Patent No. 704,060, dated July 8, 1902.

Application filed July 27, 1901. Serial No. 69,925. (No model.)

To all whom it may concern:

Be it known that I, FRANK LISTER, a subject of the King of Great Britain, and a resident of Skipton Road, Keighley, in the county of York, England, have invented certain new and useful Improvements in Internal-Combustion Engines, of which the following is a specification.

My invention relates to gas, oil, and like explosion or internal-combustion engines; and it consists in the improvements hereinafter described and claimed, said improvements having for their object, first, to cause an effective explosion for each revolution of the crank and to permit the exploded gases to expand to a larger volume before escaping than the volume of the charge of combustible or explosive gases prior to its compression, and, secondly, to effect the discharge of the spent gases from the combustion-chamber in such manner as to leave the explosive mixture of gases therein as free from contamination by the spent gases as possible.

Figure 1 is a sectional elevation of a gas, oil, or like explosion or internal-combustion engine constructed in accordance with my invention. Fig. 2 is a sectional plan thereof. Fig. 3 is a side elevation of a modified form of my improved engine. Figs. 4 and 5 are sectional side and top views, respectively, of parts illustrated by Fig. 3, the pistons being shown in their relative positions at the commencement of compressing the charge. Fig. 6 is a diagram of my improved engine, showing the relative positions of the pistons at the commencement of the exhaust. Fig. 7 is a similar diagram to Fig. 6, but shows the pistons at the extremity of their outward stroke. Fig. 8 is also a similar diagram to Fig. 6, but shows the addition of another cylinder to act as hereinafter described.

Similar figures and letters of reference indicate similar parts throughout the several views.

To attain the object of my invention, it is essential that at least two cylinders and their operating-pistons and a common explosive-chamber be employed, and as two such cylinders and the parts operating in connection therewith are sufficient to show how my invention may be carried into effect I have limited the drawings to this arrangement, (with the exception of Fig. 8,) since from the following description it will be seen how the additional cylinders and parts may be made use of to arrive at the same or similar results. These cylinders *a b* (having an explosive-chamber *x* common to both) I preferably mount in their casings or supports *c* to be about parallel to each other, so that their pistons *d e* may be coupled by the rods *f g* to the triangular piece or three-armed lever *h* by the pins *k m*, said piece *h* having its outer arm or end coupled to the crank *n*, while it is supported by the lever *o*, to which it is pivotally connected by the pin *o'*, said lever *o* being mounted upon the shaft o^2, carried by the casing or support *c*. On the crank-shaft *n'* is mounted the usual balance-wheel n^2, and when such wheel is desired to be driven in the direction indicated by the arrow n^3 I form the feed-port *p* (for receiving the explosive mixture, such as air and coal-gas or other hydrocarbon) in the cylinder *b*, while I arrange the exhaust-port *p'* to occupy a position in the cylinder *a*, their positions relatively with each other and with their respective pistons *d e* throughout the differential movements of these latter being such as to enable the exploded gases or charge to expand beyond the volume at or from which its compression commenced, the said several relative positions being hereinafter more clearly defined.

When utilizing the suction of the pistons *d e* during their movements beyond their positions where the piston *d* uncovers the exhaust-port *p'* to draw in the explosive charge, I then mount valves *d'* and *e'* (see Fig. 2) in these exhaust and feed ports *p' p*, respectively, the former, *d'*, being arranged to allow free exit for the spent gases, but to prevent ingress into the cylinder, while the latter, *e'*, is arranged to allow ingress of explosive mixture, but to prevent the egress of same on its explosion or when under pressure in the cylinder, and when making use of this arrangement of devices I mount the ignition-tube *q* in the position shown by Fig. 2 and broken lines, Fig. 1, so that by having an opening or passage *q'* made in the piston *d* to lead to said ignition-tube *q* I am enabled to cover the pas-

sage in the walls of the cylinder to said tube q by the piston d at a time when the explosive charge therein is at a comparatively low pressure in both of them and open or uncover said passage by bringing the opening q' opposite same when or after the pressure thereof has been considerably increased, by which means the explosive mixture, of increased pressure, can force its way into said ignition-tube against the pressure of gases therein, thus more certainly effecting ignition of the charge.

When not making use of the suction of the pistons d e, as above described, I then dispense with the valves d' and e' and make use of the pump r, (for supplying the gas or hydrocarbon from or through the inlet r', in which is mounted a back-pressure valve r^2,) the air-feed port p, leading into the inclosed casing c, into which the valve c' allows air to enter, the ignition-tube q, and the relief-valve t, as shown by Figs. 3, 4, and 5. The piston r^3 of said pump r is operated by the adjustable compound rod s, pivotally connected to the lever u, which is fixed upon the shaft o^2, which derives its oscillatory motion from the lever o, secured thereon, as this receives its motion from the lever h. The rod s is formed in two parts s' s, the part s sliding within the part s', so that by the pin s^2, which is secured to the part s, taking into and sliding in the slot s^3, made in the part s', this latter is moved to bring the piston r^3 always to the same position outwardly, while by the hoop s^4 being adjusted and secured on the part s at a greater or less distance from the end of the part s' the piston r^3 is respectively moved less or more into the pump-cylinder r. Hence a less or greater quantity of hydrocarbon is supplied to the cylinders d e through the back-pressure valve r^5, as may be found desirable.

The actions of the several parts above described are as follows: The pistons d e, starting on the explosion of the charge from their positions where they have compressed same, as shown by Fig. 1, move under the pressure of such explosion until the position shown by Fig. 6 is reached, after which the exhaust-port p' is opened and the spent gases escape thereby. Still the pistons continue to move outwardly until the extremity of their movement is reached, as shown by Fig. 7, this extra movement from the positions shown by Fig. 6 to those shown by Fig. 7, in case the devices shown by Figs. 1 and 2 are used, creating sufficient suction to draw into the cylinder an explosive charge through the port p. On the return of said pistons d e from the position shown by Fig. 7 by the continued rotation of the crank n the piston e will be first brought to cover the feed-port p, while the piston d will continue to move until the exhaust-port p' is reached, and during the return movements so far of this latter piston d it will have pressed or forced such of the spent gases as followed it beyond said exhaust-port out of same and against the advancing of the fresh charge taken in.

When the devices shown by Figs. 3, 4, and 5 are made use of, the advancing movements of the pistons, as above described, are utilized to increase the pressure of air within the casing c, (which is inclosed,) so that on the air-feed port p being reached and uncovered by the moving of the piston e this air within the casing c will rush through the cylinders b and a and charge them ready to receive the hydrocarbon, thus making a better explosive mixture and one less contaminated with the spent gases, the return of the pistons d e to the covering of the ports p p', as above described, in this case also aiding the discharge of spent gases from the cylinders. When the pistons d e have returned until they have reached the positions shown by Fig. 4, at which time the piston d will have just closed the exhaust-port p', the compressing of the explosive charge commences and continues until the position shown by Fig. 1 is reached, at which time the explosion takes place and the cycle of actions recommences.

From the foregoing description it will be seen that the piston e leads or moves in advance of the piston d throughout their respective movements and that by reason of this action the compression of the explosive charge is commenced with a less volume behind the pistons in the cylinders than is the volume of exploded gases therein when said pistons have been forced and moved outwardly until the piston d has reached and uncovered the exhaust-port p', the difference in this volume of gases within the cylinders being shown by the difference in the distances between the end of the cylinder and the piston e in broken and full lines, Fig. 6, or in full lines in both Figs. 4 and 6, in both cases the piston d being in the same position.

Instead of supporting the lever h by the lever o I may mount the supporting-pin o' upon the connecting-rod v of the piston w, which I arrange to operate in the cylinder w', situated between the cylinders a b, and this rod v I rigidly secure to the piston w and form it to slide in the supports y, secured to the fixed framework or casing of the mechanism, in which case the movements of the several parts are freely allowed and an extra cylinder is provided, or, again, I may employ two cylinders such as the one at w', one to have its piston's rod to support one end of the pin o', while the other will support the other end of same.

To govern the actions of the engine when I employ the pump r for supplying the hydrocarbon or other combustible part of the charge, I make use of an ordinary momentum-governor lever 2 and mount same upon the piston r^3, so that when its rate of speed is higher than desired it will come into the path of motion of the rod 3 to force it by the cam-lever 4 and operate the back-pressure valve r^2,

opening same and forcing the charge in the cylinder r back into the main or inlet r', thus not feeding it to the explosion-chamber x.

Having thus described the nature and object of my said invention, what I claim is—

1. In an engine of the class described, a cylinder having an inlet-port, a cylinder having an exhaust-port, pistons operating in said cylinders, a crank-shaft, an intermediate rigid connecting-piece extending rearward from the crank toward the two pistons and pivotally connected with the crank and pistons, and means for guiding said intermediate piece in a predetermined path during its reciprocations, whereby said crank-shaft is coupled to said pistons so that one piston leads the other, substantially as herein specified.

2. In an engine of the class described, a cylinder having an inlet-port, a cylinder having an exhaust-port, an explosion-chamber common to these cylinders, pistons in said cylinders, a crank-shaft and an intermediate connecting-piece extending rearward from the crank toward the two pistons and pivotally connected with the crank and pistons, and means for guiding said connecting-piece in a predetermined path during its reciprocations to enable one piston to lead the other.

3. In an engine of the class described, two cylinders having a common explosion-chamber, pistons in said cylinders, connecting-rods on said pistons, a triangular piece or three-armed lever pivotally connected to said rods and a crank to which said triangular piece is pivotally connected, in combination substantially as herein set forth.

4. In an engine of the class described, a plurality of cylinders, pistons for said cylinders, rods pivotally connected to said pistons, a crank, a triangular piece, connecting said rods to said crank, and a lever for supporting the triangular piece in combination substantially as herein specified.

5. In an engine of the class described, a plurality of cylinders, pistons to operate in the same, piston-rods, a crank-shaft, rigid connections separate from the crank-shaft and interposed between said crank-shaft and the piston-rods, and means for controlling the movements of said connections, whereby one piston will lead the other.

6. In an engine of the class described, a plurality of cylinders, feed and exhaust ports having valves mounted within them in connection with said cylinders, pistons constructed to operate in said cylinders and other means in conjunction with said pistons whereby after expansion and exhaust of the waste gases during movement of the pistons in one direction the charge is induced to enter the cylinders by the continued motion of said pistons and the other parts in the same direction whereby said pistons may be coupled to the crank and said crank in combination substantially as specified.

7. In an engine of the class described, a plurality of parallel cylinders, pistons operating in said cylinders, a crank, a rigid connecting-piece for coupling said crank and said pistons together, means for controlling the movements of said connecting-piece, and a pump for supplying the charge to said cylinders and means for operating said pump in combination substantially as herein specified.

8. In an engine of the class described, a plurality of parallel cylinders, pistons for same, a crank, a rigid connecting-piece for coupling said crank to said pistons, means for controlling the movements of said connecting-piece, a casing for inclosing said crank and other parts, a valve mounted on said casing, an inlet-port leading from the interior of said casing to the interior of the cylinders and said casing in combination substantially as herein specified.

9. In an engine of the class described, a plurality of parallel cylinders, pistons for same, a crank, a rigid connecting-piece for coupling said crank to said pistons, means for controlling the movements of said connecting-piece a pump for supplying the charge to said cylinders, a governor on said pump whereby the charge when not required is forced back into the main, and means for operating same in combination substantially as herein specified.

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

FRANK LISTER.

Witnesses:
JOHN WHITEHEAD,
PICKLES BAILEY.