No. 665,592.

Patented Jan. 8, 1901.

G. ARNOLD.

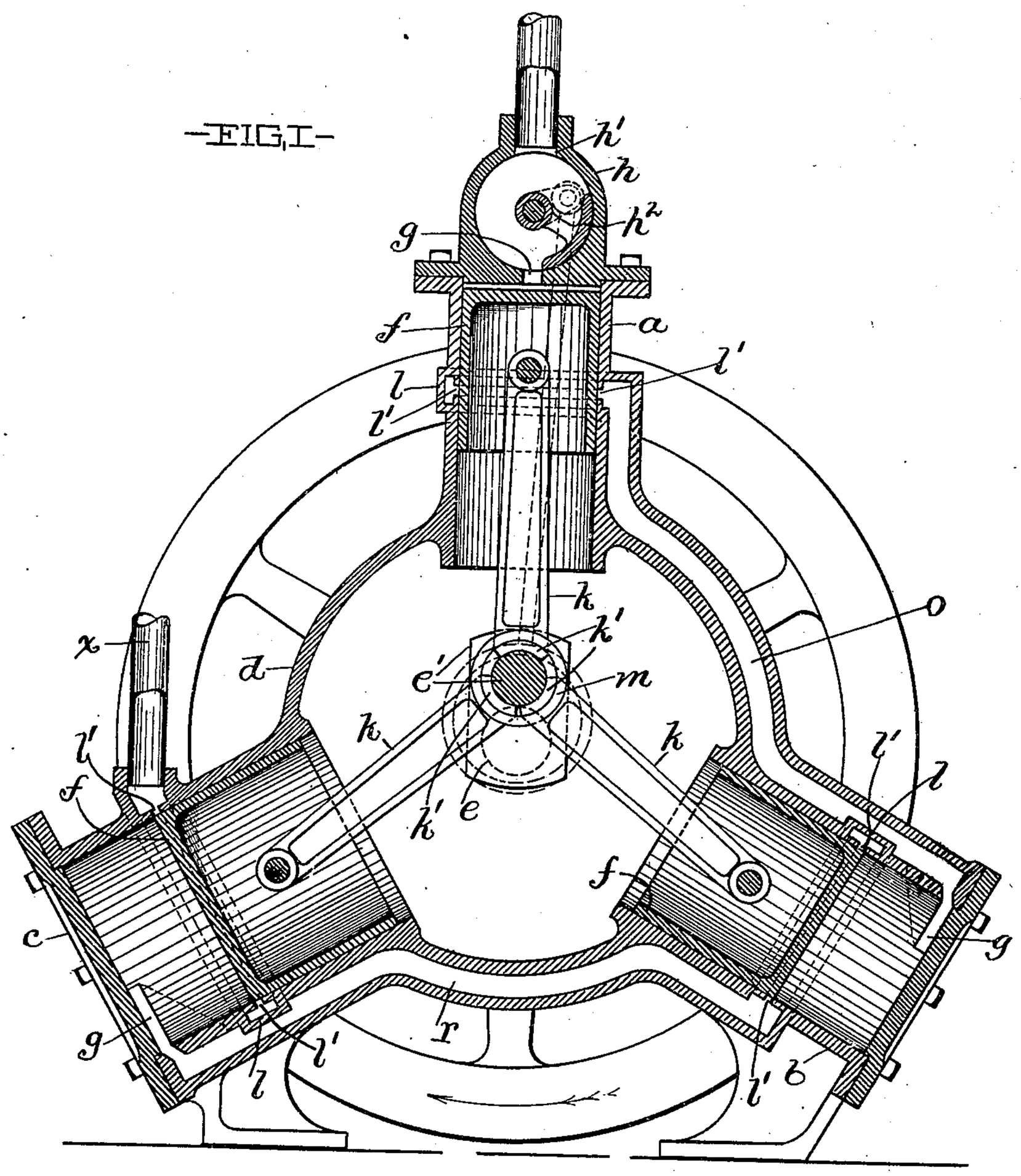
EXPANSION ENGINE.

(Application filed Dec. 28, 1899.)

(No Model.)

3 Sheets—Sheet 1.

—FIG. 1—



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3 Sheets—Sheet 2.

FIG. II

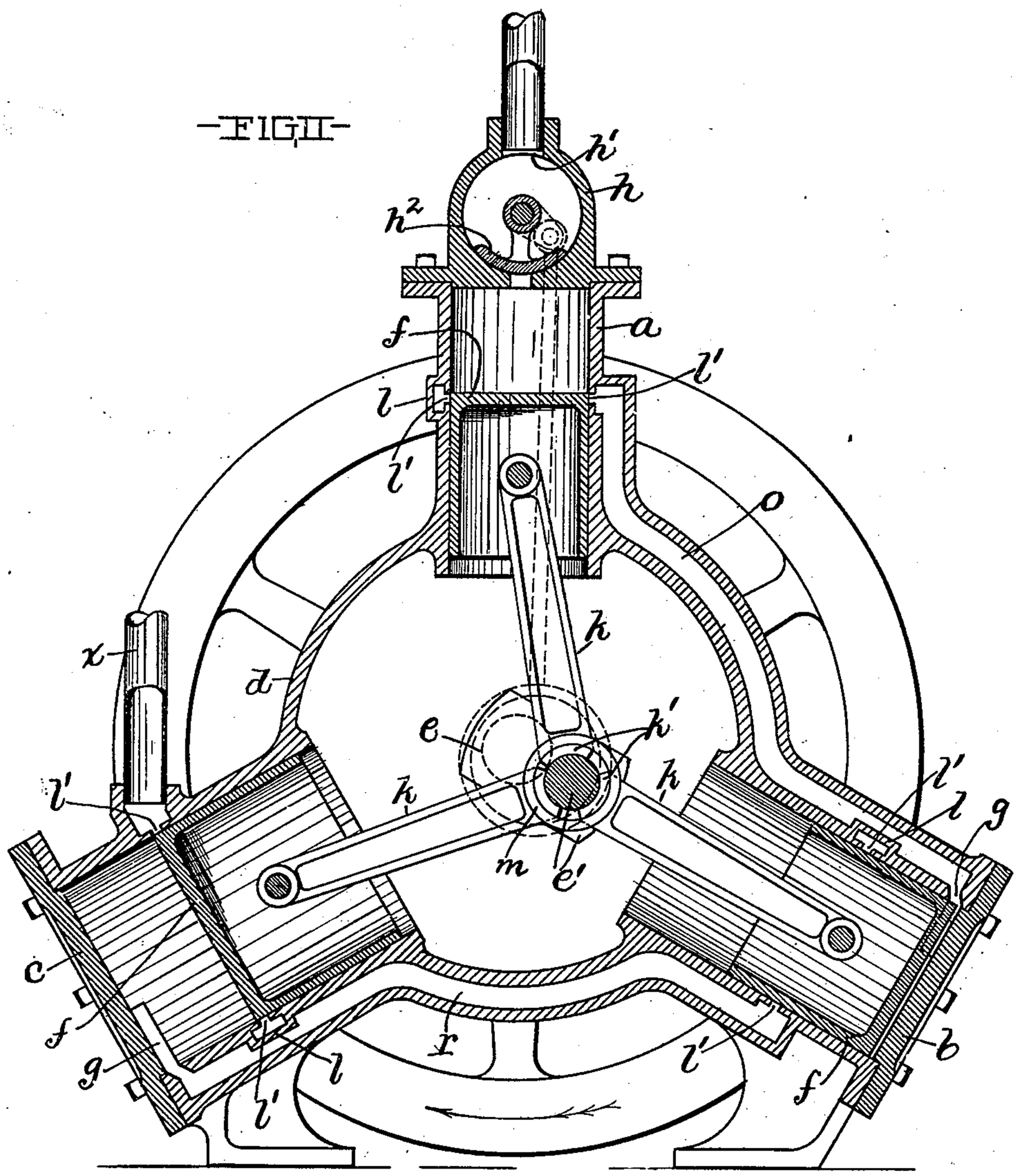

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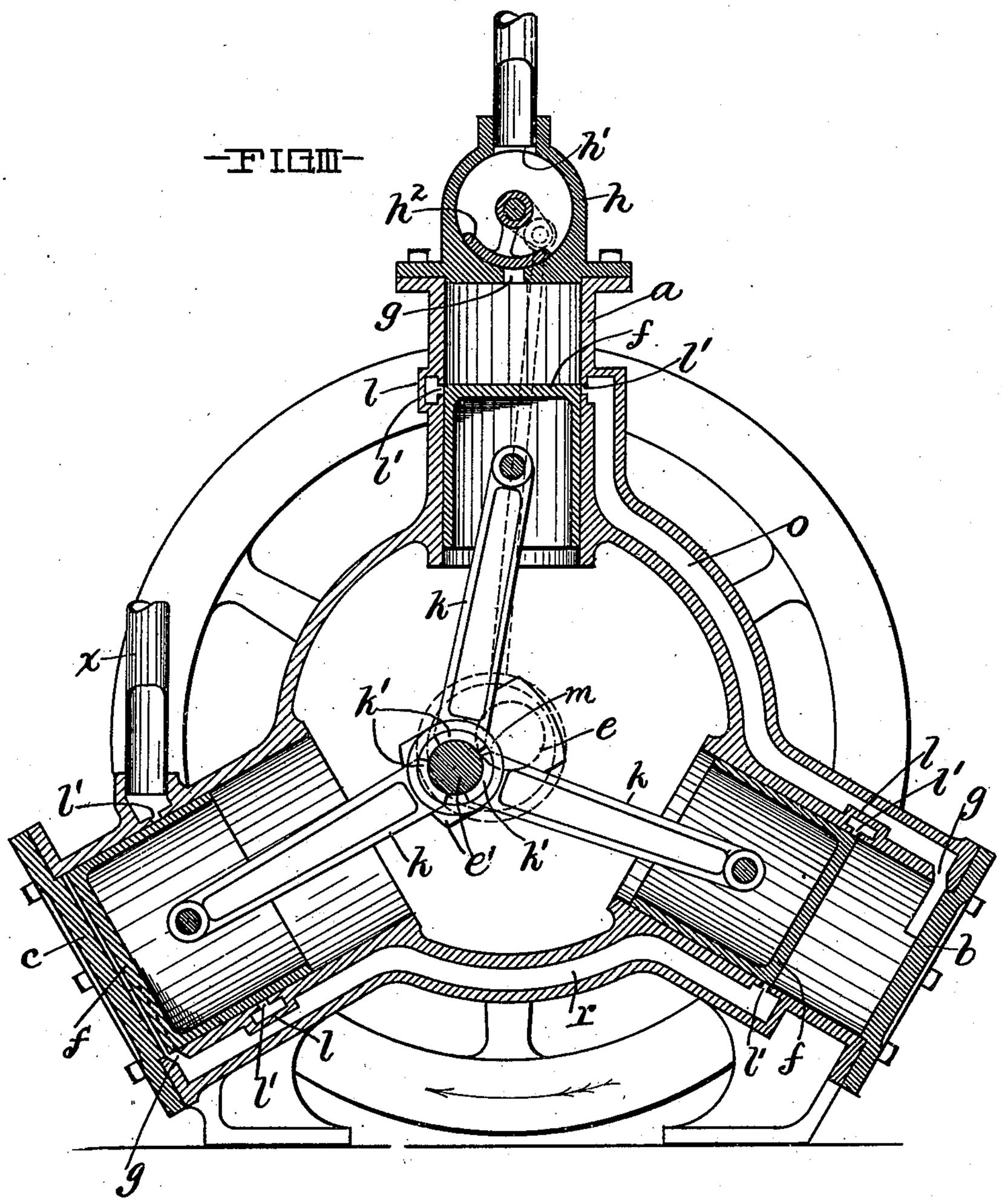
FIG III



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UNITED STATES PATENT OFFICE.

GEORGE ARNOLD, OF CLEVELAND, OHIO, ASSIGNOR OF ONE-HALF TO FREDERICK ARNOLD, OF SAME PLACE.

EXPANSION-ENGINE.

SPECIFICATION forming part of Letters Patent No. 665,592, dated January 8, 1901.

Application filed December 28, 1899. Serial No. 741,865. (No model.)

To all whom it may concern:

Be it known that I, GEORGE ARNOLD, a resident of Cleveland, county of Cuyahoga, and State of Ohio, have invented certain new and useful Improvements in Expansion-Engines; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it pertains to make and use the same.

My invention relates to improvements in expansion-engines operated by any expansive fluid under pressure.

The primary object of this invention is to construct an engine more especially designed for light work and comprising a primary cylinder, a secondary cylinder, and an uninterrupted passage-way from the exhaust-outlet of the primary cylinder to the fluid-pressure-receiving inlet of the secondary cylinder.

With this object in view and to the end of providing a construction that is simple, symmetrical, and convenient the invention consists in certain features of construction and combinations of parts hereinafter described, and pointed out in the claims.

In the accompanying drawings, Figures I, II, and III are elevations, mostly in central section, of an engine embodying my invention.

Referring to the drawings, *a*, *b*, and *c* designate different cylinders, respectively, and the three cylinders are arranged at equal intervals circumferentially of and radially to the engine-shaft *e*. Each cylinder is provided with a trunk-piston *f*, that is arranged to operate within the cylinder. The three cylinders are integral with the crank-case *d*, that contains the crank-bearing portion of the engine-shaft and within which the crank *e'* of the said shaft operates.

In the engine illustrated the outer end of each cylinder is the fluid-pressure-receiving end of the cylinder and is provided with a pressure-receiving port *g*, at which the fluid under pressure employed in the operation of the piston within the said cylinder enters the cylinder.

The cylinder *a* is the primary cylinder of the engine, and is consequently provided at its fluid-pressure-receiving end with a valve-casing *h*, that is provided with a fluid-pressure inlet *h'*, that contains a rotary valve h^2, operatively connected with the engine-shaft in any approved manner and adapted to control the supply of fluid-pressure to the port *g* of the said cylinder. The pistons of the cylinders are connected by means of pitmen *k* with the wrist of the crank of the engine-shaft. Each pitman, at its crank-connecting end, partially embraces the wrist of the crank, and a ring or collar *m*, that embraces lugs or flanges *k'*, formed upon the crank-connecting ends of the pitmen in the usual manner, positively holds the pitmen in connection with the crank. However, by the arrangement of the several cylinders in the manner hereinbefore described the pitmen, partially embracing the wrist of the shaft's crank, would in any event be held to the wrist during the operation of the engine.

Each cylinder is provided with a hollow exhaust-belt *l*, that surrounds the cylinder centrally or about midway between the ends of the cylinder, and the wall between the said chamber and the chamber of the cylinder is slotted laterally, as at *l'*, so as to connect the belt's chamber with the chamber of the cylinder.

The chamber of the exhaust-belt of the primary cylinder is connected by a passage-way *o* with the pressure-receiving port of the secondary cylinder *b*, and the exhaust-belt of the cylinder *b* is connected by a passage-way *r* with the pressure-receiving port of the remaining cylinder *c*, and the exhaust-belt of the latter is in open relation with the exhaust-pipe *x*. The secondary cylinder *b* is therefore an intermediate cylinder in the engine illustrated.

The arrangement of parts is such that the piston of each cylinder preparatory to its propulsion by fluid-pressure admitted to the said cylinder shall be at the starting-point and have its trunk covering the exhaust port or ports of the cylinder. The arrangement of parts is such, furthermore, as shown in Fig. 1, that when the piston of the primary cylinder *a* is at the beginning of its starting-point the piston of the cylinder *b* shall have just closed the exhaust-outlet of the said cylinder *b*, the piston of the remaining cylinder

shall be ready to uncover the exhaust-outlet of the cylinder *c*, and the valve of the valve-casing of the primary cylinder shall be open.

The operation of the engine is as follows: When the piston of the primary cylinder *a* is at its starting-point, fluid under pressure is admitted to the said cylinder, so as to propel the piston of the said cylinder. When the piston of the primary cylinder has moved far enough to be ready to uncover the exhaust-outlet of the said cylinder, as shown in Fig. II, the valve will be closed, the piston of the intermediate cylinder *b* will have returned to its starting position, and the piston of the cylinder *c* will have uncovered and again covered the exhaust-outlet of the said cylinder *c*. During the time that the piston of the primary cylinder uncovers the exhaust-outlet of the said cylinder and again returns and covers the said outlet the piston of the cylinder *c* has returned to its starting position, as shown in Fig. III, and the valve is still closed, and the piston of the intermediate cylinder *b* is ready to uncover the exhaust-outlet of the said cylinder *b*. Hence it will be observed that at all times during the rotation of the engine-shaft at least one of the pistons is under pressure.

The fluid under pressure admitted to the cylinders *b* and *c* works only expansively in the said cylinders.

The intermediate cylinder *b* and the latter's piston are as much larger diametrically or in transverse area than the primary cylinder and the latter's piston as is required to render the work capable of being done by the cylinder *b* equal, or approximately equal, to the work done by the primary cylinder, and similarly the cylinder *c* and the latter's piston are as much larger diametrically or in transverse area as the intermediate cylinder *b* and the latter's piston as is required to render the said cylinder *c* capable of doing as much, or approximately as much, work as the cylinder *b*, and hence a uniform or approximately uniform torque on the engine-shaft obtains at all times during the operation of the engine.

The essential and characteristic feature of the engine hereinbefore described is the maintenance at all times of an uninterrupted communication between the exhaust-belt of the primary cylinder and the fluid-pressure-receiving port of a secondary cylinder, and only the primary cylinder is provided with valve mechanism.

The passage-way *o* leading from the exhaust-outlet of the primary cylinder *a* to the inlet of the cylinder *b* is formed in the shell or casing of the crank-case and the said cylinders. The shell of the crank-case between the said cylinders is arranged concentrically of the engine-shaft, and hence the central portion of the said passage-way *o* that is formed within the said portion of the crank-case is arranged concentrically of the engine-shaft, and opposite end portions of the passage-way *o* are formed upon the different cylinders *a* and *b*, respectively. Similarly the passage-way *r* leading from the exhaust-outlet of the cylinder *b* to the inlet of the cylinder *c* is formed in the shell or casing of the crank-case and the said cylinders and has its central portion arranged concentrically of the engine-shaft between the said cylinders *b* and *c*, and opposite end portions of the passage-way *r* are formed upon the different cylinders *b* and *c*, respectively. The cylinders, the crank-case, and the walls of the passage-ways *o* and *r* are formed, therefore, in one and the same casting, and the arrangement and construction of the parts hereinbefore described are meritorious on account of their simplicity, symmetry, durability, and convenience.

By my improved construction, hereinbefore described, it will be observed that in my improved engine the piston of each cylinder controls only the exhaust-port of the said cylinder and does not control the pressure-receiving inlet of the cylinder and that the engine can, in fact, be operated without any admission-valve. It will be observed that in my engine the arrangement of the parts is such that the path of the fluid under pressure from the pressure-receiving inlet of the primary or first cylinder *a* to the exhaust-port of the third cylinder *c* is substantially straight—that is, there is no diversion of the said fluid between the said inlet and the said exhaust-port, and consequently the loss of power is reduced to a minimum.

What I claim is—

1. In an expansion-engine, the combination, with the engine-shaft, a primary cylinder having a fluid-pressure inlet and an exhaust-port arranged a suitable distance from the said inlet between the inlet and the shaft, a trunk-piston arranged within the said cylinder and operatively connected with the shaft, and means for controlling the supply of fluid-pressure to the said cylinder, of a secondary cylinder having a fluid-pressure inlet and an exhaust-port a suitable distance from the said inlet between the inlet and the aforesaid shaft, a trunk-piston arranged within the secondary cylinder and operatively connected with the shaft, and an uninterrupted passage-way between the exhaust-port of the primary cylinder and the inlet of the secondary cylinder, and the aforesaid cylinders being arranged radially about the shaft and the arrangement of the parts being furthermore such that the piston of each cylinder shall control only the exhaust-port of the said cylinder and not the pressure-inlet of the cylinder, substantially as shown, for the purpose specified.

2. An expansion-engine, comprising the engine-shaft, three cylinders arranged the one between the others and provided each with a fluid-pressure inlet and an exhaust-port arranged a suitable distance from the inlet and between the inlet and the shaft, trunk-pistons arranged to operate within the cylinders and operatively connected with the shaft, a pas-

sage-way connecting the pressure-inlet of the intermediate cylinder with the exhaust-port of one of the outer cylinders, another passage-way connecting the exhaust-port of the intermediate cylinder with the pressure-inlet of the remaining outer cylinder, and the arrangement of the parts being such that, when the piston of the first-mentioned outer cylinder is at its starting-point and fluid under pressure is admitted to the said cylinder, the piston of the intermediate cylinder shall be returning to its said position and shall have just covered the exhaust-port of the said cylinder, and the piston of the other outer cylinder shall be ready to uncover the exhaust-port of the said last-mentioned outer cylinder, substantially as shown, for the purpose specified.

3. An expansion-engine, comprising the following: the engine-shaft, three cylinders, *a*, *b* and *c*, arranged at equal intervals circumferentially of and radially to the shaft and provided, respectively, with a fluid-pressure inlet at the outer end and an exhaust-port a suitable distance from the inlet between the inlet and the shaft; trunk-pistons arranged to operate within the cylinders and operatively connected with the shaft; a case inclosing or surrounding the piston-connected portion of the shaft; a passage-way *o* connecting the exhaust-port of the cylinder *a* with the inlet of the cylinder *b* and having its central portion formed in the shaft-surrounding case and having opposite end portions thereof formed in or upon the different cylinders *a* and *b*, respectively, and a passage-way *r* connecting the exhaust-port of the cylinder *b* with the inlet of the cylinder *c* and having its central portion formed in the aforesaid case and having opposite end portions thereof formed upon the different cylinders *b* and *c*, respectively, all arranged and operating substantially as shown, for the purpose specified.

4. An expansion-engine comprising the following: a crank-shaft; a crank-case containing the crank-bearing portion of the shaft; the three cylinders, *a*, *b* and *c*, arranged at equal intervals circumferentially of and radially to the shaft and provided, respectively, with a fluid-pressure inlet at the outer end, and having an exhaust-outlet a suitable distance from the inlet; trunk-pistons arranged to operate within the cylinders and operatively connected with the engine-shaft; the passage-way *o* having its central portion connecting the exhaust-outlet of the cylinder *a* with the inlet of the cylinder *b* and having its central portion formed in the crank-case and having opposite end portions thereof formed in or upon the different cylinders *a* and *b*, respectively, and the passage-way *r* connecting the exhaust-outlet of the cylinder *b* with the inlet of the cylinder *c* and having its central portion formed in the crank-case and having opposite end portions thereof formed upon the different cylinders *b* and *c*, respectively, all arranged and operating substantially as shown, for the purpose specified.

Signed by me at Cleveland, Ohio, this 18th day of December, 1899.

GEORGE ARNOLD.

Witnesses:
C. H. DORER,
A. H. PARRATT.