No. 720,343. PATENTED FEB. 10, 1903.

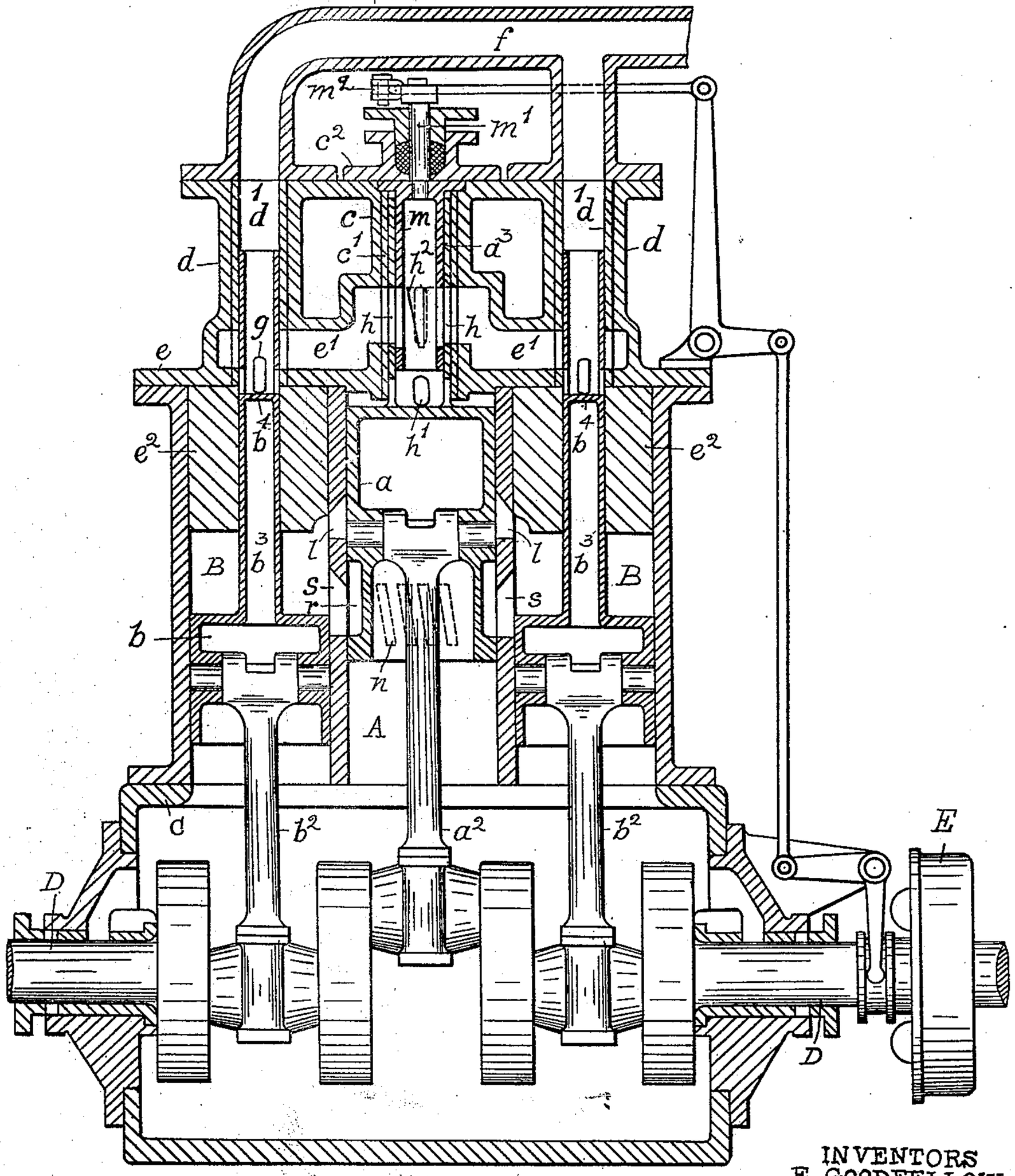
F., G. & R. GOODFELLOW.

COMPOUND EXPANSION FLUID ENGINE.

APPLICATION FILED JULY 14, 1902.

NO MODEL. 2 SHEETS—SHEET 1.

Fig. 1.



WITNESSES
Anna R. McCole
L. C. Hicks

INVENTORS
F. GOODFELLOW
G. GOODFELLOW
R. GOODFELLOW
By their Atty
Edward P. Thompson

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NO MODEL. 2 SHEETS—SHEET 2.

Fig. 2.

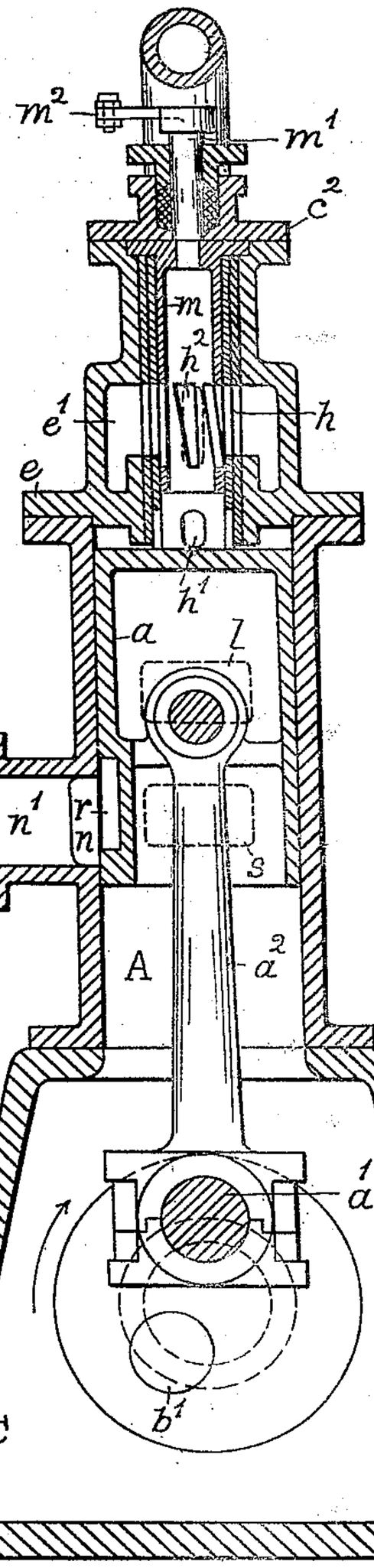


Fig. 3.

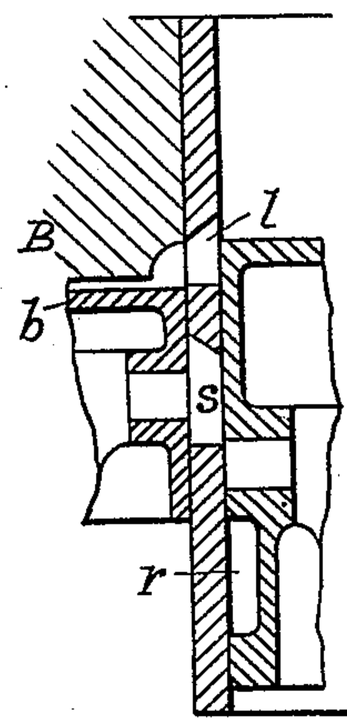
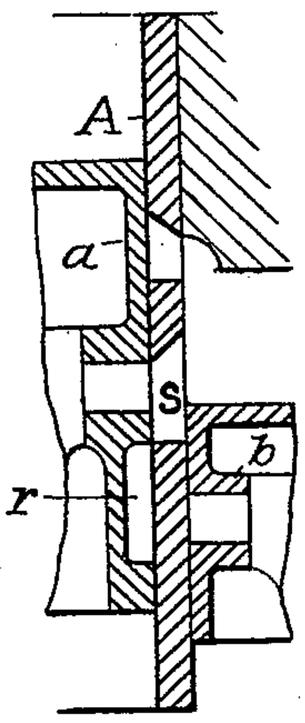
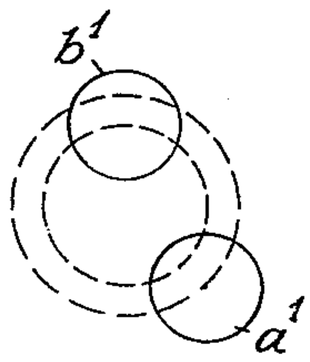
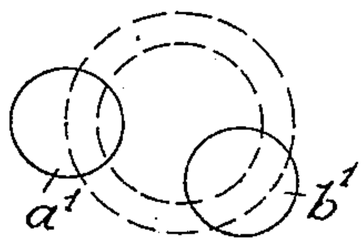


Fig. 4.







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Anna R. McCole

S. E. Hicks

INVENTORS

F. GOODFELLOW
G. GOODFELLOW
R. GOODFELLOW

By their Attorney
Edward P. Thompson

UNITED STATES PATENT OFFICE.

FRANK GOODFELLOW, GEORGE GOODFELLOW, AND ROBERT GOODFELLOW,
OF HYDE, ENGLAND.

COMPOUND EXPANSION-FLUID ENGINE.

SPECIFICATION forming part of Letters Patent No. 720,343, dated February 10, 1903.

Application filed July 14, 1902. Serial No. 115,511. (No model.)

To all whom it may concern:

Be it known that we, FRANK GOODFELLOW, GEORGE GOODFELLOW, and ROBERT GOODFELLOW, subjects of the King of Great Britain, and residents of Hyde, in the county of Chester, England, have invented new and useful Improvements in Compound Expansive-Fluid Engines, of which the following is a specification.

This invention relates to inverted compound single-acting engines worked by steam or other gaseous fluid in which the distribution of the steam or fluid is effected by the pistons themselves and piston or tubular valves connected to them; and it consists in the hereinafter-described improved construction and arrangements, the object of which is to simplify the construction of the engine and to obtain a better distribution of the steam or fluid pressure and a better balancing of the power and weight in the several cylinders than in engines of that kind hitherto made.

The improved engine is represented on the annexed drawings.

Figure 1 shows a vertical longitudinal section, and Fig. 2 a vertical cross-section, of the engine; Fig. 3, a diagram of the positions of the cranks and pistons when the low-pressure pistons are at the top of their stroke, Fig. 4 being a diagram of the positions at the time the exhaust is opened.

The engine may be made with one or more low-pressure cylinders to one high-pressure cylinder; but preferably we use two low-pressure cylinders B of the same diameter, one on each side of the high-pressure cylinder A. The stroke of the low-pressure pistons b is made less than that of the high-pressure piston a, the cranks b', connected to the former by the connecting-rods b^2, being made shorter than the crank a', connected to the piston a by the connecting-rod a^2, and the cranks b are set at an angle to the crank a so that the latter is in advance of the former by about one hundred and thirty-five degrees. The connecting-rods a^2 and b^2 and the pistons a and b are also of different lengths, so that the top of the piston a when at the end of its outward or downward stroke is about on the same level as the top of the piston b when at the end of its inward or upward stroke. The three cylinders are preferably all of the same length cast in one with only the thickness of the cylinder-wall between them, so as to obtain the shortest possible ports for the passage of the steam from one cylinder to another, and they are covered by one cover e, to which blocks e^2 are fixed to reduce the internal length of the cylinders B. The cylinders are mounted upon a closed case C, containing the bearings for the crank-shaft D in the manner usual for inverted single-acting high-speed engines.

A hollow trunk or piston-valve a^3 is formed on or attached to the piston a, which moves in the pipe or cylinder c, which may be fitted with a liner c'. Each of the pistons b has a similar trunk b^3 attached to it, moving in a pipe or cylinder d with liners d'. These several pipes are preferably cast with the cylinder-cover e, which serves for the three cylinders, and communicate with each other at the cover side by means of an enlarged passage e'. The trunks are all open at the top. The pipes d are connected to the steam-supply pipe f. The pipe c is closed at the top by a cover c^2. In the position of the parts shown on the drawings the piston a is at the end of its inward stroke and the cranks in the positions Fig. 2. As the cranks move farther around in the direction of the arrow the pistons b move upward, and the ports g, made in the sides of the trunks b^3, emerge from the cover e. Steam then passes from the pipe f through the trunks b^3, which are closed below the ports by cross-walls b^4, and through the ports g into the passage e', and enters the trunk a^3 through ports h, made in the side of this trunk. These ports may be prolonged to the piston a, or other separate ports h' are arranged in the side of the trunk just above the pitson, so that steam passes through them into the cylinder A and propels the piston a downward. Steam will continue to be admitted till the upper ends of the ports h enter the cover e, after which the steam will work expansively till the piston uncovers the ports l, leading from the cylinder A to the cylinders B. As the piston makes its return stroke the port h remains closed to the steam-passage e' till the crank a' reaches the position

corresponding to the closing position on its upstroke. The ports *g* are closed at that time and steam is compressed in the cylinder A, the trunk a^3, and the passage *e'* till the end of the inward stroke. As this space is very large, the compression will only be moderate.

By making the ports *h* shorter at the top end steam can be cut off earlier. The expansion can be varied by means of the arrangement shown on Figs. 1 and 2. A sleeve *m* is arranged inside the pipe or cylinder *c*, which is attached to a spindle *m'*, passing through a stuffing-box arranged in the cover *c'*. The sleeve *m* is held in its longitudinal direction by any convenient means, but can be turned by means of a handle m^2, fixed upon the spindle *m'*. The handle is connected to the engine-governor E. In the sleeve *m* a triangular opening or port h^2 is arranged opposite each of the ports *h*, so that the steam has to pass through them to the cylinder A. By turning the sleeve the inclined edges of the port h^2 are brought nearer to or farther away from the top end of the ports *h*, so that these are closed, and steam is thus cut off earlier or later. As the piston *a* approaches the end of its outward stroke it uncovers the ports *o*, formed in the walls of the cylinders A and B. The pistons *b* are then near to the end of their inward stroke, and the steam in the cylinder A expands into the cylinders B. As stated before, the lengths of the pistons *a* and *b* and the connecting-rods a^2 and b^2 are such that the top of the piston *a* is level with the top of the pistons *b* when the piston *a* is at the end of its outward stroke and the pistons *b* at the end of their inward stroke, as shown on the diagram Fig. 3. By this arrangement a very short steam-passage is obtained, as will be evident from the drawings, and any water condensed in the cylinder A runs off into the cylinders B. Steam is expanded from the cylinder A into the cylinders B till the upper edge of the piston *a* closes the ports *l*. As shown on the drawings, these ports are longer inside the cylinder A than in the cylinders B, and by lengthening the ports inside the cylinder A the admission of steam from the high-pressure cylinder to the low-pressure cylinders may be prolonged. After the ports *l* have been closed by the piston *a* the steam expands in the low-pressure cylinders till the exhaust-ports *s* are opened. At the time, however, when the pistons *b* uncover the upper end of these ports they are closed on the other side by the piston *a*, which then is near to the end of its outward stroke, and the expansion in the cylinders B continues. As shown on the drawings, near to its lower end the piston *a* is reduced in diameter, forming a horseshoe-shaped recess *r*, which through openings *n* in the wall of the cylinder A communicates with the exhaust-pipe *n'*. The upper edge of this recess will uncover the bottom edge of the port when the piston *a* is approaching the middle of its stroke, and it and the crank *a* are in the positions shown on Fig. 4 when the cranks *b* are in the position shown and the pistons B near the end of their outward stroke. Exhaust thus only takes place when the pistons *b* have nearly reached the end of their stroke and continues till the upward movement of the pistons *b* closes the ports *s*, which to prolong the period of exhaust and reduce compression are made longer inside the cylinders B than in the cylinder A. As soon as the piston *a* uncovers the exhaust-ports *s* any condensed water that may be in the cylinders B will run out into the annular recess *r* and as the piston *a* rises will be discharged through the openings *n* into the exhaust-pipe *n'*.

Instead of there being two cylinders B there may be only one of larger diameter; but the arrangement shown and above described is preferred as producing a better balancing of the weights and pressures acting on the crank-shaft.

Instead of steam compressed air or other expansive gas may be used for driving the engine.

We claim as our invention—

1. In a single-acting expansive engine, the combination of two equal low-pressure cylinders, a high-pressure cylinder between the latter cylinders, pistons in the cylinders, connecting-rods connected thereto, a shaft, cranks on the shaft connected respectively to said connecting-rods, the two cranks connected to the low-pressure pistons being in line and shorter than the crank for the high-pressure piston, whose crank is placed at an angle of about one hundred and thirty-five degrees relatively to the other two cranks, and means for distributing live steam to the high-pressure cylinders, and exhaust-steam from the high-pressure to the low-pressure cylinders.

2. In a single-acting expansive engine, the combination of low-pressure cylinders, a high-pressure cylinder, all the said cylinders being cast in one with only the thickness of the cylinder-wall between them, which wall has ports, a piston in each cylinder, and a connecting-rod connected thereto, a shaft having as many cranks as there are connecting-rods which rods are respectively connected to said cranks, said ports being longer on the side where the steam enters than on the opposite side.

3. In a single-acting expansive engine, the combination of low-pressure cylinders, a high-pressure cylinder located with only the thickness of cylinder-wall between the same and the low-pressure cylinders, a piston in each cylinder, a connecting-rod connected thereto, a shaft, cranks on the shaft connected respectively to said connecting-rods, and ports in said wall, said ports being longer on the side where the steam enters than on the opposite side.

4. In a single-acting expansive engine, the combination of two low-pressure cylinders, a high-pressure cylinder between the latter cylinders, a piston in each cylinder, a connect-

ing-rod connected thereto, a shaft, three cranks on the shaft, and connected respectively to said connecting-rod the two cranks connected to the low-pressure piston being in line, and placed at an angle in advance of the high-pressure piston-crank, and a single wall between the high-pressure and low-pressure cylinders, and provided with ports for the passage of steam between the cylinders.

5. In a single-acting expansive engine, the combination of two equal low-pressure cylinders, a high-pressure cylinder communicating therewith through ports, means for distributing live steam to the high-pressure cylinder, pistons in the cylinders, a shaft, a connecting-rod connecting each piston to each crank, the two cranks connected to the low-pressure pistons being in line and shorter than the crank connected to the high-pressure piston, which latter crank is placed at an angle to the other cranks, the crank-piston and connecting-rod of the high-pressure cylinder being longer than those of the low-pressure cylinders to such an extent that the top of the low-pressure piston at the end of its upward stroke is about level with the top of the high-pressure piston at the end of its downward stroke.

6. In an expansive engine, the combination of a low-pressure piston, a cylinder containing the same, a hollow trunk on said piston and open at the top, a pipe in which said trunk moves having ports opening into a passage, a fluid-pipe in communication with the above-named pipe, a high-pressure piston, a cylinder containing the same and having ports for exhausting the steam into the low-pressure cylinder, a hollow trunk on the high-pressure piston, a pipe in which said last trunk moves, closed on the top by a cover, ports in said pipe opening into said passage, ports in said trunks adapted to allow the expansive fluid to flow at the beginning of the stroke of the high-pressure piston from the supply-pipe through the low-pressure trunk, the passage and the high-pressure trunk into the high-pressure cylinder.

7. In an inverted compound expansive engine, the combination of a high-pressure cylinder, a piston therein, a hollow trunk thereon open at the top, a pipe closed at the top in which said trunk moves and having ports communicating with a passage in communication with the source of a supply of the expansive fluid, ports in said trunk adapted to allow the said fluid to pass into the cylinder, a sleeve open at the bottom suspended inside said trunk and having triangular ports adapted to close the ports in the trunk more or less when the sleeve is turned, a spindle fixed to said sleeve passing through the top of said pipe and a lever on said spindle adapted to be turned by the governor of the engine.

8. In an inverted compound single-acting elastic-fluid engine the combination of two low-pressure cylinders and a high-pressure cylinder between them, ports opening at the top of the low-pressure cylinders into the high-pressure cylinder, exhaust-ports in the lower part of the low-pressure cylinders, and opening into the high-pressure cylinder, a recess in the piston of the high-pressure cylinder adapted to receive the exhaust-steam, and an exhaust-pipe in communication with said recess.

9. In an inverted compound single-acting elastic-fluid engine the combination of two low-pressure cylinders and a high-pressure cylinder between them, the cylinders communicating with each other by ports at the top of the low-pressure cylinders and at the lower parts thereof, pistons in said cylinders connected by rods to three cranks on one shaft, the crank connected to the high-pressure piston being longer than and set at an angle to the cranks connected to the low-pressure pistons, which cranks are set on the same line, a hollow trunk open at the top on each piston, pipes on the cylinder-covers in which the trunks slide, the two pipes containing the low-pressure trunks being in communication with the fluid-supply pipe, the other pipe being closed by a cover, a passage between the pipes connecting the same, ports in the trunks adapted to allow, at the commencement of the downstroke of the high-pressure piston, the fluid to pass through the low-pressure trunks and the high-pressure trunk into the high-pressure cylinder, a recess in the high-pressure piston adapted to receive the exhaust-steam from the low-pressure cylinders and communicating with an exhaust-pipe, substantially as and for the purpose set forth.

10. In a single-acting expansive engine, the combination of two equal low-pressure cylinders, a high-pressure cylinder communicating therewith through ports, means for distributing live steam to the high-pressure cylinder, pistons in the cylinders, a shaft, a connecting-rod connecting each piston to each crank, the two cranks connected to the low-pressure pistons being in line and shorter than the crank connected to the high-pressure piston, which latter crank is placed at an angle to the other cranks, the crank-piston and connecting-rod of the high-pressure cylinder being longer than those of the low-pressure cylinders.

11. In an inverted compound single-acting elastic-fluid engine the combination of two low-pressure cylinders and a high-pressure cylinder between them, the cylinders communicating with each other by ports at the top of the low-pressure cylinders and at the lower parts thereof, pistons in said cylinders connected by rods to three cranks on one shaft, the crank connected to the high-pressure piston being longer than and set at an angle to the cranks connected to the low-pressure pistons, which cranks are set on the same line, a hollow trunk open at the top on each piston, pipes on the cylinder-covers in which the trunks slide, the two pipes containing the

low-pressure trunks being in communication with the fluid-supply pipe, the other pipe being closed by a cover, a passage between the pipes connecting the same, ports in the trunks adapted to allow, at the commencement of the downstroke of the high-pressure piston, the fluid to pass through the low-pressure trunks and the high-pressure trunk into the high-pressure cylinder, a recess in the high-pressure piston adapted to receive the exhaust-steam from the low-pressure cylinders and communicating with an exhaust-pipe, substantially as and for the purposes set forth.

In testimony whereof we have hereunto set our hands in the presence of two witnesses.

FRANK GOODFELLOW.
GEORGE GOODFELLOW.
ROBT. GOODFELLOW.

Witnesses:
CARL BOLLÉ,
RIDLEY JAMES URQUHART.