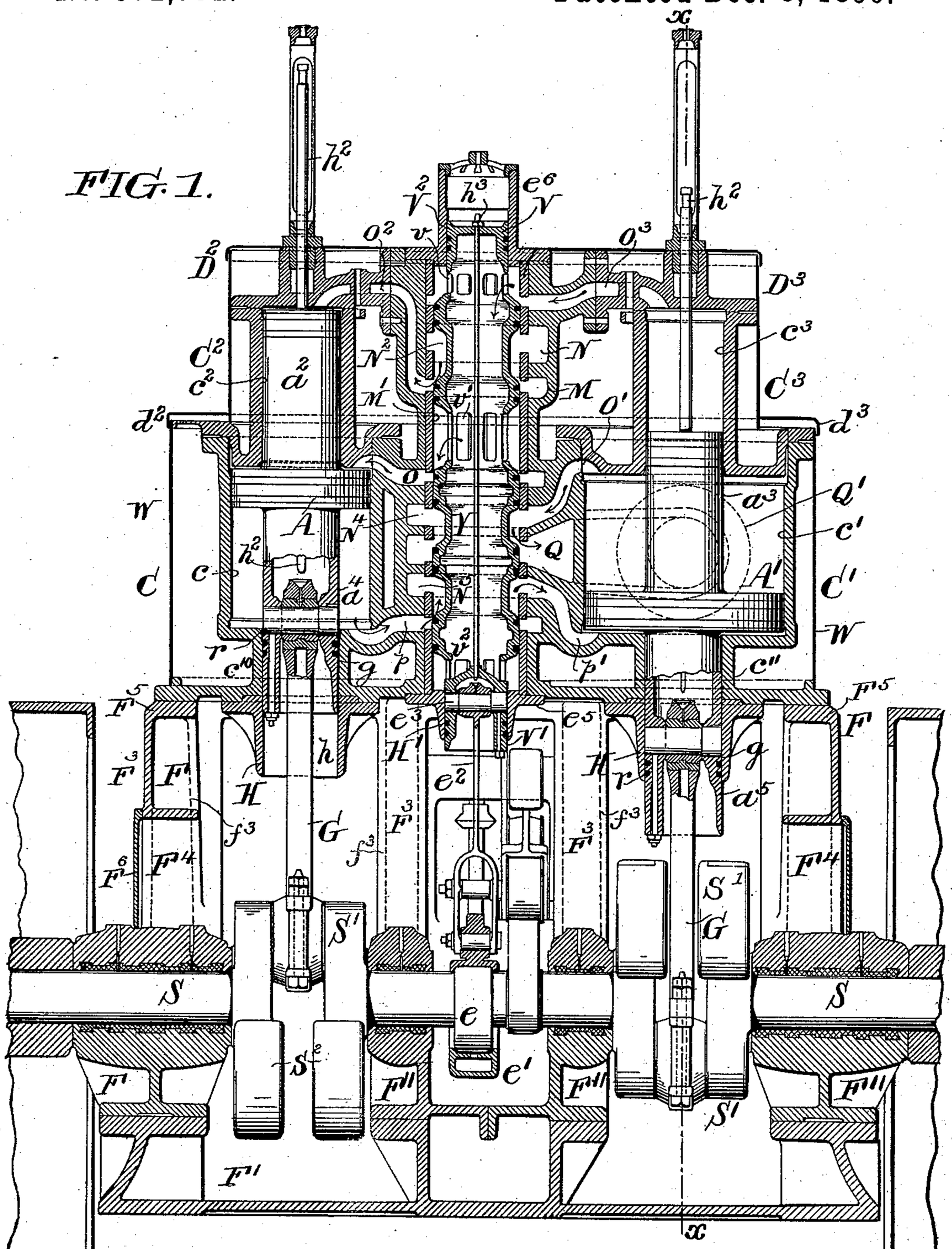
(No Model.) 3 Sheets—Sheet 1.

G. S. STRONG.

STEAM ENGINE.

No. 572,732. Patented Dec. 8, 1896.

FIG. 1.



WITNESSES:
Henry Drury
Henry J. Pack

INVENTOR:
George S. Strong
by his att'y.
Francis J. Chambers

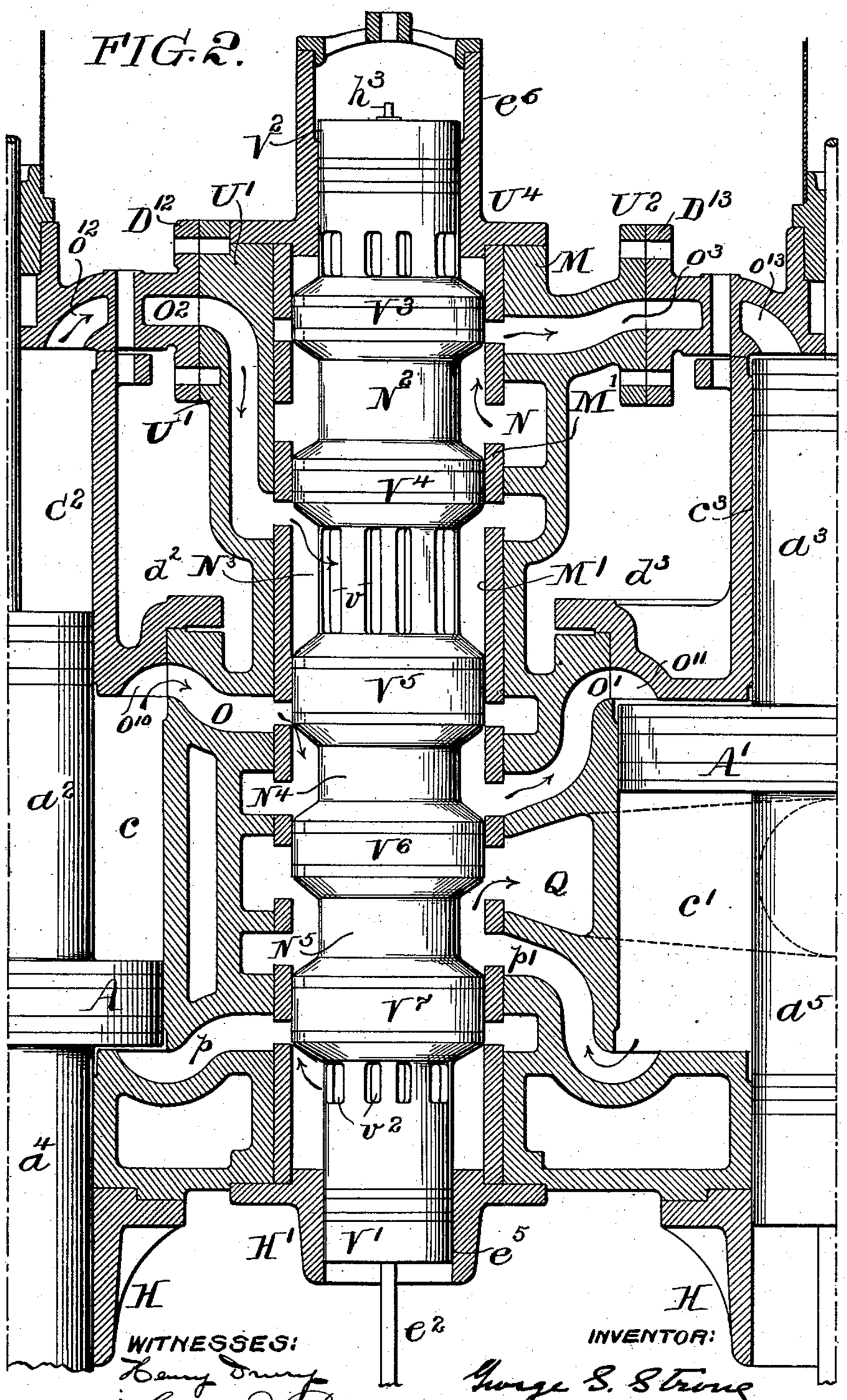
(No Model.) 3 Sheets—Sheet 2.

G. S. STRONG.

STEAM ENGINE.

No. 572,732. Patented Dec. 8, 1896.

FIG. 2.



WITNESSES:

Henry Orth

Henry J Pack

INVENTOR:

George S. Strong

by his atty

Francis J. Clarke

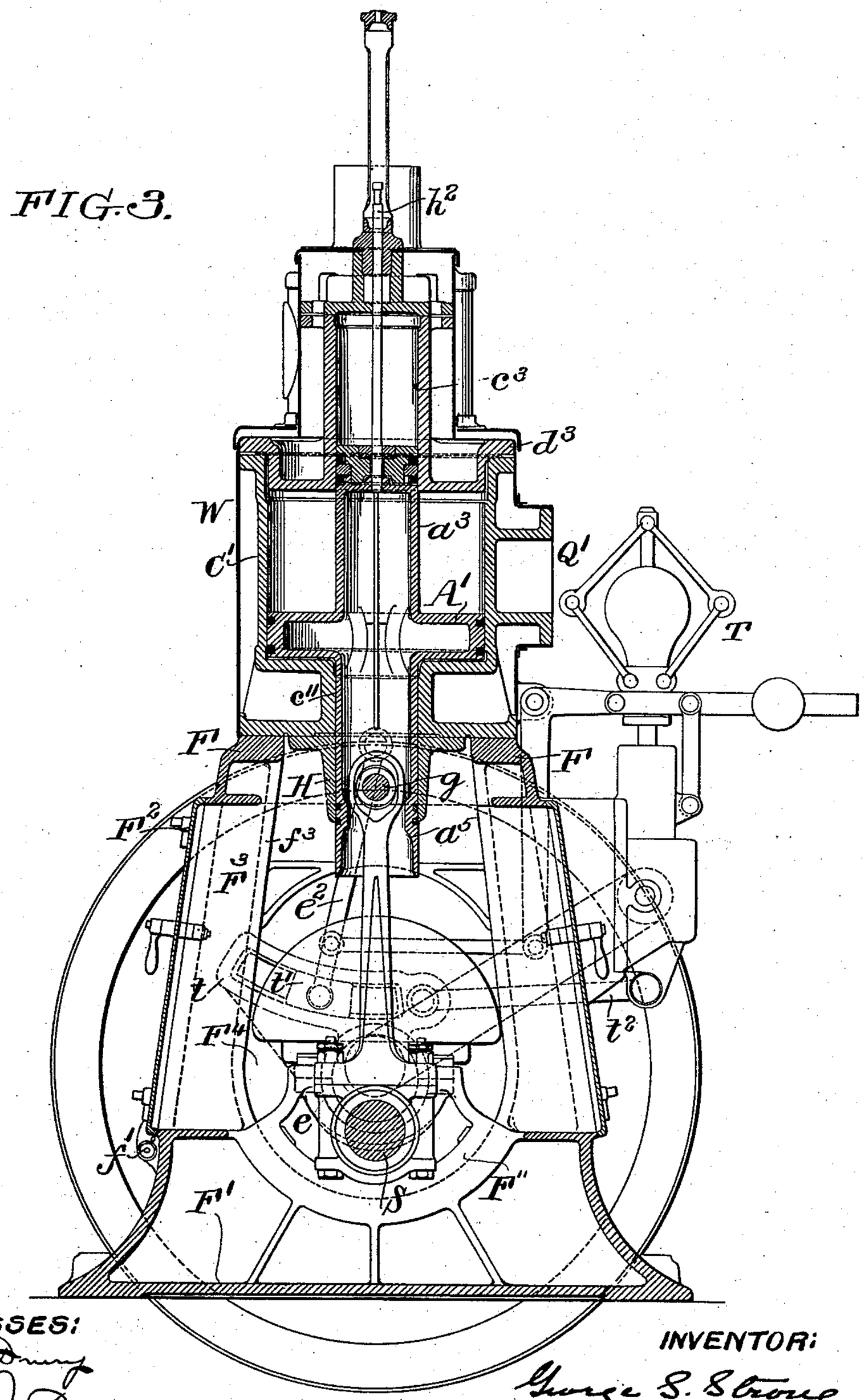
(No Model.) 3 Sheets—Sheet 3.

G. S. STRONG.

STEAM ENGINE.

No. 572,732. Patented Dec. 8, 1896.

FIG. 3.



WITNESSES:
Henry Drury
Henry J. Pack

INVENTOR:
George S. Strong
by his atty
Francis T. Chambers

UNITED STATES PATENT OFFICE.

GEORGE S. STRONG, OF NEW YORK, N. Y., ASSIGNOR TO THE BALANCED LOCOMOTIVE AND ENGINEERING COMPANY, OF SAME PLACE.

STEAM-ENGINE.

SPECIFICATION forming part of Letters Patent No. 572,732, dated December 8, 1896.

Application filed November 19, 1894. Serial No. 529,260. (No model.)

To all whom it may concern:

Be it known that I, GEORGE S. STRONG, a citizen of the United States, residing in the city, county, and State of New York, have invented a new and useful Improvement in Steam-Engines, of which the following is a true and exact description, reference being had to the accompanying drawings, which form a part thereof.

The invention relates to compound steam-engines, though many of my improvements are applicable to engines where the steam is not expanded in a low-pressure cylinder after being used once at a high pressure, and has for its general object to improve and simplify the construction of this class of machinery.

My invention will be best understood as expained in connection with the accompanying drawings, in which—

Figure 1 is a front view, in vertical section, of a compound engine embodying my invention. Fig. 2 is an enlarged view of the cylinders and the valve for governing the admission and exhaust of motive fluid thereto, showing the valve at the other extremity of its path from that which is shown in Fig. 1; and Fig. 3 is a vertical section on the line $x\,x$ of Fig. 1.

F is a frame on which is supported the shaft S of the machine, the bearings F^{11}, and also the cylinders and other operative parts of the engine.

C C′ is a casting, preferably formed in one piece, and forming cylinders c c' and a valve chamber or casing M. Cylinder-castings C^2 and C^3 are arranged over the cylinders c c', respectively, and are adapted to fit in and form the heads of said cylinders, the casting C^2 being provided with a flange d^2 and the casting C^3 with a flange d^3, whereby they may be bolted securely to the casting C C′. Cylinders c^2 c^3, preferably of the same size, are formed by the castings C^2 C^3.

A is a piston adapted to fit in the cylinder c and is provided with a trunk a^2, adapted to fit in the cylinder c^2, and also with a trunk a^4, preferably of the same size as the trunk a^2, adapted to project in the opposite direction from said trunk a^2 and serve as a cross-head. A piston A′, having a similar trunk a^5 adapted to serve as a cross-head, is arranged in cylinder c'.

As best shown in Fig. 1, pins g are fitted in the trunks a^4 a^5, on which are pivoted rods G G, which serve to connect the trunk extensions a^4 a^5, each with a crank S′ on the shaft S. It will therefore be seen that the trunk extensions a^4 and a^5 serve as the piston-rods of ordinary engines and also as cross-heads. To guide these cross-head trunks a^4 a^5, I provide sleeves H, which are secured to the cylinders either directly or to necks, as c^{10} c^{11}, formed on said cylinders. These sleeves are made removable, so that when the piston is at its lowest position, as shown to the right of Fig. 1, the cross-head pin can be conveniently removed for the purpose of disconnecting the rod G from the cross-head trunk by simply removing the sleeve. These sleeves H are of such a length that they prevent the springing out of the packing-rings r, arranged in grooves in the trunks a^4 a^5, even when these trunks are in their lowermost position.

The trunks a^2 a^3 are, as has been said, preferably of the same size, and the trunks a^4 a^5 are also the same size as the upwardly-projecting trunks. The upwardly-projecting trunks are adapted to serve as high-pressure pistons and the piston A as an intermediate-pressure piston, receiving its supply of steam from the exhaust of the cylinders c^2 c^3, and the piston A′ is driven by the exhaust-steam from the cylinder c and serves as a low-pressure piston. The areas on both sides of the piston A A′ are the same, since the trunks a^2 a^4 and a^3 a^5 are of the same area, and these pistons are double-acting, while the high-pressure pistons are single-acting.

N is the live-steam entrance-port, from which steam flows through passages o^2 o^3 into the high-pressure cylinders. o p are steam-conduits leading to the top and bottom of the cylinder c, and o' p' similar conduits leading to the top and bottom of the cylinder c'.

V is a single valve which controls the passage of steam to and from all the cylinders, and is very conveniently operated from an eccentric e on the main shaft S by means of a strap e' and a connecting-rod e^2, which is secured to the valve by means of a pin e^3. This

valve I preferably so construct that any tendency of the valve to move, due to the weight of its operating connections as well as its own weight, if arranged vertically, will be counterbalanced by the pressure of steam, and to this end I form guides, preferably cylindrical, as shown at e^5 e^6, and provide pistons V′ V², secured to the valve, which fit in the guides. As shown, these pistons are formed integral with the body of the valve. The piston V² is made sufficiently larger than the piston V′, so that the steam-pressure will support the weight of the valve and its connections instead of supporting them, as is usual, on the eccentric. Instead of supporting the valve by means of the live steam I prefer to do so by the exhaust from the high-pressure cylinders, and to this end I form the valve tubular, and form openings v v', whereby the steam escaping from the high-pressure cylinders exhausts into the chamber Y on the inside of the valve. The exhaust-steam exerts pressure on the pistons V² V′, and thereby tends to raise the valve, as has been explained.

As the valve V is rather long and the chamber Y inside of considerable size, this chamber forms a receiver for the exhaust-steam from the high-pressure cylinders, and it will be noted (see Figs. 1 and 2) that the ports o^2 o^3, which lead to the cylinders c^2 c^3, are uncovered to permit the steam to exhaust from these cylinders before the ports o p are uncovered to allow the steam to flow to the cylinder c. In the construction of this valve shown it consists of a number of pistons V³ V⁴, &c., which form passages N² N³, &c., between them, and has openings, as shown at v v' v^2, for the entrance and escape of steam to and from its interior chamber.

I preferably operate the valve indirectly from the eccentric e by means of the link t and block t'. T is a governor adapted to shift the block t' in the link t, so as to adjust the throw of the valve. W is a suitable casing, and h^2 h^3 oiling-tubes.

It will be noted, as best shown in Figs. 1 and 2, that the castings C² project somewhat into the cylinders c c', and in order to bring the steam in at the heads of these cylinders I form openings or passages o^{10} o^{11}, (see Fig. 2,) which form continuations of the conduits o o', as shown. The heads D² D³ of the cylinders c^2 c^3 I also provide with passages o^{12} o^{13}, which are continuations of the conduits o^2 o^3, and I provide these heads with flanges D¹² D¹³, which are adapted, when the cylinder-castings are in position, to abut against flanges U′ U² on the valve-casing M, whereby the heads may be secured to the valve-casing.

It will be noted in my construction that by unbolting the flanges U² D¹³ and U′ D¹² and by unbolting flanges d^2 d^3 the high-pressure cylinders can be entirely removed without disturbing the valve-casing or the intermediate or low-pressure cylinders, and also that by removing the sleeve H′, which forms the cylinder e^5 at the lower part of the valve, removing the pin e^3, and taking off the cap U⁴ on the top of the valve-casing the valve can be withdrawn without disturbing any of the cylinders when it is desired to remove the valve or the bushing M′.

The frame of the machine I preferably form with a base, as F′, on which the bearings F¹¹ are supported, and a plate, as F⁵, on which the cylinders are secured. To connect these two parts firmly, I arrange columns F³, which I preferably make hollow, so as to gain stiffness with as little weight as is necessary. I have indicated the hollow character of the columns by dotted lines at f^3, Fig. 1.

The open spaces between the columns I preferably close by means of plates F², pivoted at f', and at the ends, where a space F⁴ is provided in the frame of sufficient size to admit the shaft and cranks, I provide end plates F⁶.

In order to balance the engine, I make the piston A′, which of course is larger than the piston A, of the same weight as this piston. This reduction of weight may conveniently be effected by coring out the larger piston.

The cranks S′ S′, to which the connecting-rods G G are secured, are arranged at an angle to each other. In the construction shown, where two pistons are employed side by side, the cranks would of course be arranged at an angle of one hundred and eighty degrees one to the other, and therefore the two pistons A A′ balance each other and the weights S² have simply to counterbalance part of the weight of the connecting-rods G G and the cranks S′.

This construction of course is applicable not only to an engine similar to the particular one shown, but also to any compound engine where different-sized pistons operate on the same shaft, and consists, broadly, in making such different-sized pistons of the same weight and connecting them to cranks set at a proper angle to each other.

It will be noted that by my construction a very evenly-running engine is produced, the two pistons mutually counterbalance each other, and the weight of the valve is substantially sustained by steam-pressure; also, it will be noted that one of the cross-head trunks emerges from its inclosing cylinder just as fast as the other trunk recedes into its cylinder, and as these trunks are of equal size there will be no pulsations such as are often occasioned by the rapid movement of a piston-rod into and out of the cylinder.

In operation high-pressure steam enters at N, and in the position of the valve shown in Fig. 1 it flows through conduit o^2 into the top of the cylinder c^2 and acts on the piston formed by the trunk a^2, which is just starting on its downward stroke, at the same time steam is escaping from the cylinder c^3 through the passage o^3 and openings v into the interior chamber Y of the valve. From the receiver formed by this interior chamber of the valve steam escapes through openings v' and pas-

sage *o* into the upper part of the cylinder *c*, where it is acting to drive down the piston A, acting in the same direction as the high-pressure steam on the top of the trunk a^2. Steam is escaping from the lower part of the cylinder *c* through the passage *p*, across the space N^5, formed between the pistons V^6 V^7 of the valve, and through the passage *p'* into the lower part of the cylinder *c'*, thus raising the piston A'. Steam at the same time is escaping from the upper part of the cylinder *c'* through the passage *o'* and out through the exhaust-passage *q*.

The pistons A A' and their trunk extensions make their stroke, the piston A moving to the bottom of its cylinder and the piston A' rising to the top of the cylinder *c'*, as shown in Fig. 2. The valve V at that time has changed its position, as shown in said figure, and the high-pressure steam from the entrance N is passing into the top of cylinder c^3. Steam is exhausting from the top of cylinder c^2 into the interior of the valve through apertures *v'* and escapes from the interior of the valve through apertures v^2 and passage *p* into the bottom of cylinder *c*. Steam is exhausting from the upper part of cylinder *c*, across passage N^4, through passage *o* into the top of cylinder *c'*, and the steam from the bottom of said cylinder is exhausting through passage Q to the final exhaust Q. (Best shown in Fig. 3.)

While I prefer to use the whole engine, as shown, it is evident that some parts of my engine may advantageously be used in other connections than those which are specifically shown.

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

1. In a compound engine two pistons A A' of different sizes adapted to serve as intermediate and low-pressure pistons, trunks a^2 a^3 of substantially the same size projecting one from the piston A and the other from the piston A' and adapted to serve as high-pressure pistons, trunks a^4 a^5 of the same size as the trunks a^2 a^3 projecting in the other direction and adapted to serve as cross-heads, suitable cylinders for said pistons and means for admitting steam to and permitting its exhaust from the various cylinders.

2. In a compound engine, two pistons A A' of different sizes adapted to serve as intermediate and low-pressure pistons, trunks a^2 a^3 of substantially the same size projecting, one from the piston A and the other from the piston A' and adapted to serve as high-pressure pistons, trunks a^4 a^5 of the same size as the trunks a^2 a^3 projecting in the other direction and adapted to serve as cross-heads, suitable cylinders for said pistons, ports for steam leading to the cylinders and a single valve for covering and uncovering these ports to govern the admission and exhaust of steam to and from the cylinders.

3. The combination in a compound steam-engine of two high-pressure single-acting pistons, a double-acting intermediate piston arranged tandem with one of said high-pressure pistons, a double-acting low-pressure piston arranged tandem with the other high-pressure piston, a tubular valve having a passage N^2 adapted to connect a live-steam port N alternately with steam-conduits o^2 o^3 leading respectively to one end of the cylinders c^2 c^3 which inclose the high pressure pistons, an opening or openings for admitting the steam exhausted from these cylinders c^2 c^3 into the tubular interior of the valve, openings for permitting the escape of steam from the interior of the valve alternately into the top and bottom of the double-acting intermediate cylinder, and passages N^4 N^5 for conducting the steam exhausted from the intermediate cylinder alternately into the top and bottom of the low-pressure cylinder and for permitting its final exhaust.

4. In a compound engine, two cylinders *c* c^2 arranged tandem, two cylinders *c'* c^3 also arranged tandem, double-acting pistons A A' adapted to reciprocate in the cylinders *c* *c'* respectively, a single-acting trunk-piston a^2 secured to the piston A and operating in the cylinder c^2, a trunk secured to the piston A' and operating in the cylinder c^3, and means for admitting live steam to the cylinders c^2 c^3 conducting the steam once expanded in these cylinders to the cylinder *c* and from this cylinder after the second expansion to the cylinder *c'*.

GEORGE S. STRONG.

Witnesses:
HENRY J. PACK,
EDW. F. AYRES.