(No Model.) 2 Sheets—Sheet 1.

G. S. STRONG.

COMPOUND ENGINE.

No. 559,502. Patented May 5, 1896.

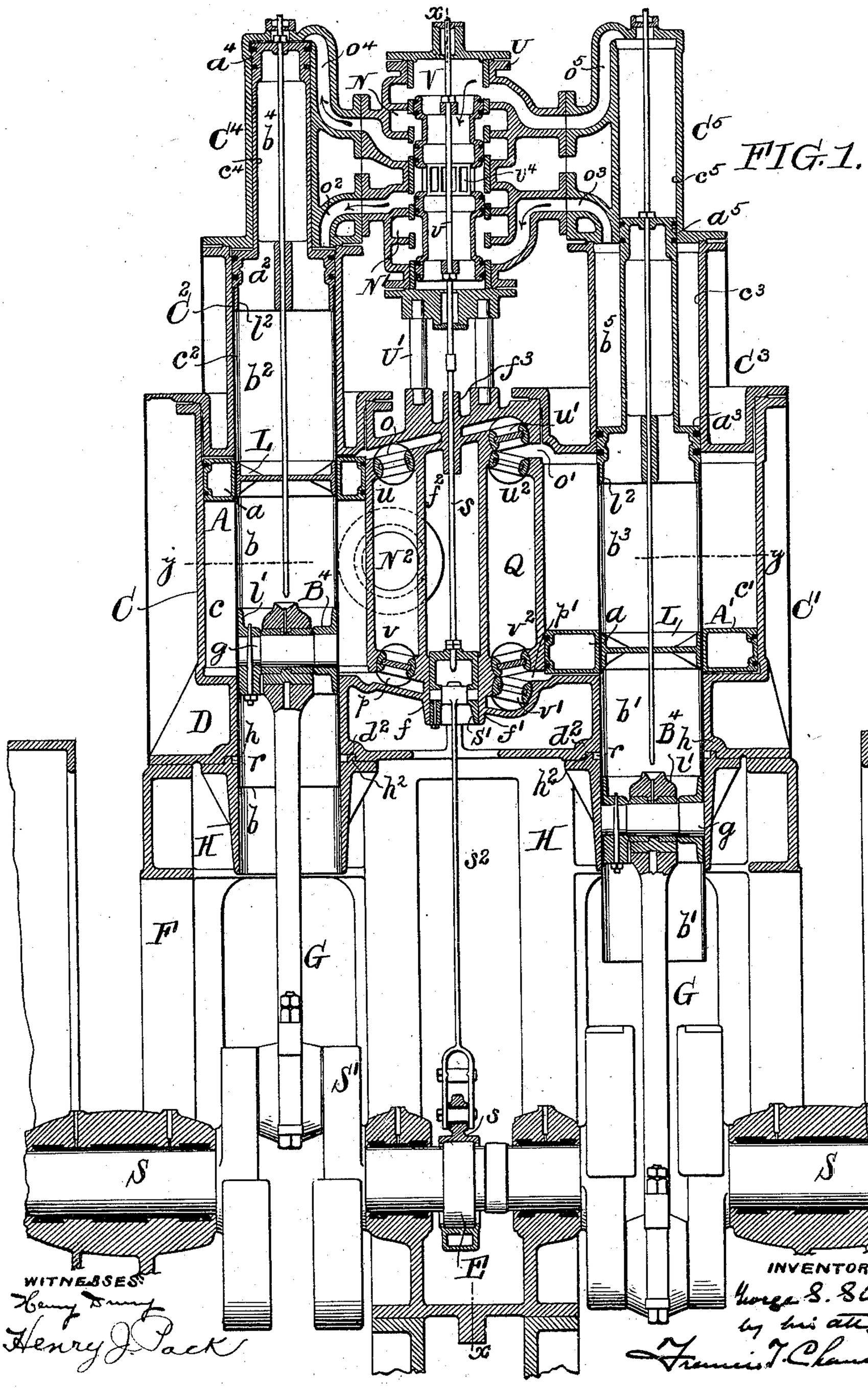

FIG. 1.

WITNESSES:
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INVENTOR:
George S. Strong
by his attys.
Francis T. Chambers

(No Model.) 2 Sheets—Sheet 2.

G. S. STRONG.

COMPOUND ENGINE.

No. 559,502. Patented May 5, 1896.

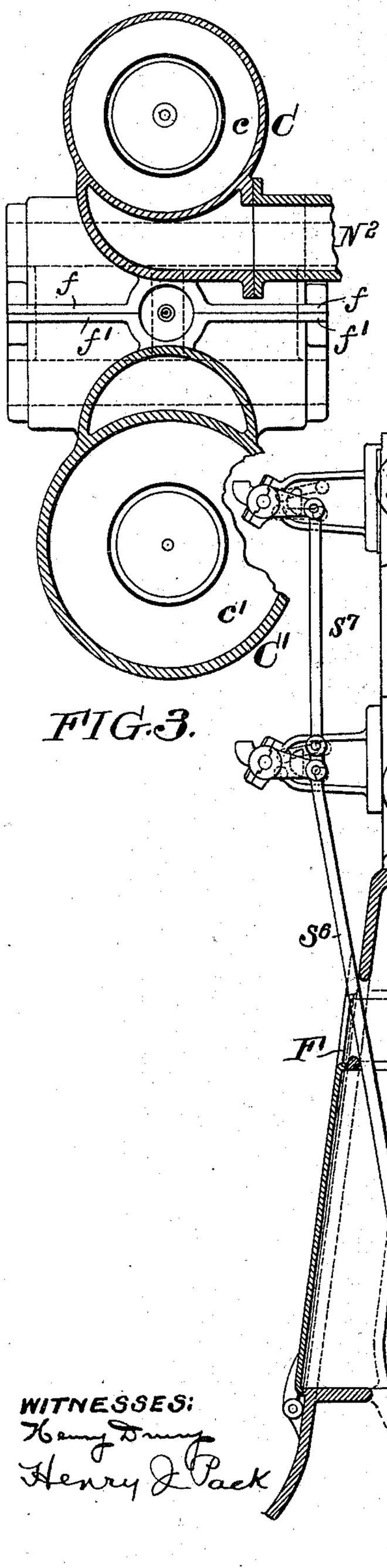

FIG. 3.

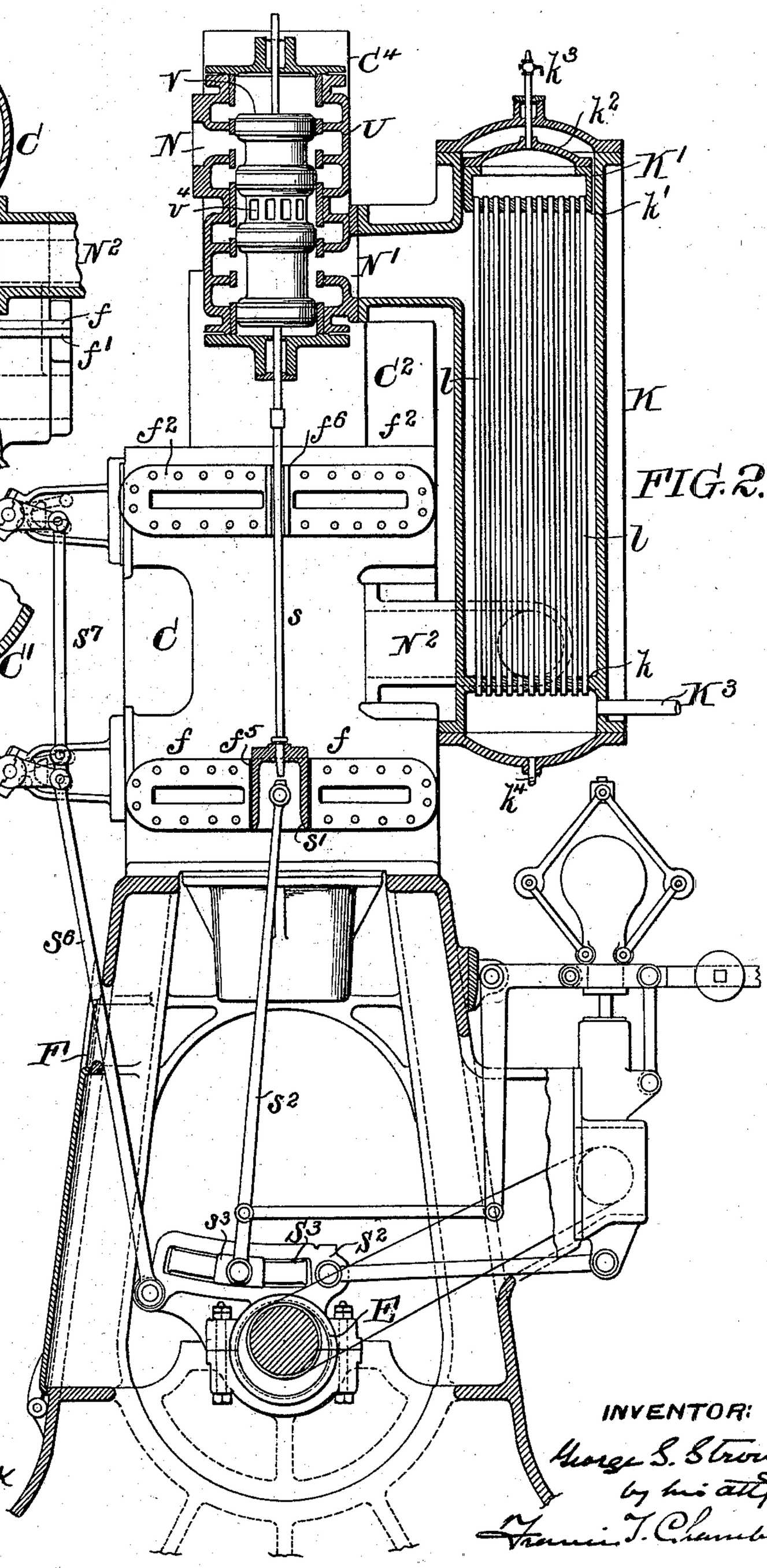

FIG. 2.

WITNESSES:
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UNITED STATES PATENT OFFICE.

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

COMPOUND ENGINE.

SPECIFICATION forming part of Letters Patent No. 559,502, dated May 5, 1896.

Application filed November 17, 1894. Serial No. 529,110. (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 certain new and useful Improvement in Compound Engines, of which the following is a true and exact description, reference being had to the accompanying drawings, which form a part thereof.

My invention relates to compound engines, and has for its object to improve and simplify the construction of such engines and render them more compact.

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

Figure 1 is a front view, in vertical section, of a quadruple expansion-engine embodying my improvements. Fig. 2 is a vertical section on the line $x\ x$ of Fig. 1, and Fig. 3 is a cross-section on the line $y\ y$ of Fig. 1.

F is a suitable frame on which are supported the crank-shaft S, the cylinders, and the other operative parts of an engine.

C is a casting having formed therein a cylinder c, suitable cores for valves $u\ v$, and is provided with a suitable flange, which is preferably formed in two parts $f\ f^2$.

C′ is a casting very similar in form to the casting C, having formed therein a cylinder c' of larger cross-section than the cylinder c, suitable cores for valves, and is provided with a flange adapted to abut against the flange on the casting C. This flange is also conveniently formed in two parts $f'\ f^3$. The faces of these flanges are planed off true, and when the castings are in position these flanges abut, as shown in Fig. 3, and the castings are bolted together. In the construction shown I also form recesses $f^5\ f^6$ in the flanges, which serve as guides for a valve-stem s. A casting C^2, having a cylinder c^2 formed therein, forms the head of the cylinder c, and a casting C^4, having a cylinder c^4 formed in it, forms the head of the cylinder c^2. Similar castings C^3 C^5, with cylinders $c^3\ c^5$, are similarly arranged over the cylinder c'. I preferably form the cylinders $c^4\ c^5$ of the same size, and also the cylinders $c^2\ c^3$, these last-named cylinders being larger than the cylinders $c^4\ c^5$.

A is a piston adapted to reciprocate in the cylinder c, and is provided with trunk extensions $b\ b^2$, preferably of the same size, the trunk b^2 extending into and forming with its head a^2 the piston in cylinder c^2, while the trunk b serves as a cross-head guided in neck D and sleeve H. From the end of the trunk b^2 another trunk b^4 extends into the cylinder c^4 and forms the piston in that cylinder. A similar piston A′, provided with similar trunks b^3, b', and b^5, is arranged in the parallel set of cylinders $c'\ c^3\ c^5$. The pistons in the cylinders $c^4\ c^5$ are preferably of the same size. So are the pistons in the cylinders $c^2\ c^3$, and these pistons are all single-acting. A single valve V, preferably a tubular piston-valve, as shown, is adapted to govern the admission of steam to and its exhaust from these cylinders $c^2\ c^3\ c^4\ c^5$, which, it will be observed, form of themselves a compound engine, and these four cylinders, arranged substantially as shown, form a very efficient single-acting engine, and may be used as such independent of the cylinders $c\ c'$, which form a second compound engine.

In the position of the valve N (shown in Fig. 1) steam at high pressure from the port N′ enters the cylinder c^4 through the port o^4. Steam at the same time is exhausting from the cylinder c^5 into the tubular valve V and through the openings v^4 and port o^2 into the cylinder c^2, and finally the steam from the cylinder c^3 is exhausting out of port o^3 and port N′. The steam is preferably exhausted from the upper cylinders into a receiver K, from which it is taken to be further expanded in the lower pressure-cylinders. This receiver K, I prefer to make also a reheater, and I therefore provide a tube-plate k, preferably in the lower part of the receiver K, in which the tubes are $l\ l$ secured. K′ is a closed box not connected with the casing of the reheater K, into which box the tubes $l\ l$ open. $k^2\ k^3$ are covers of the box K′ and the reheating-receiver K, respectively.

K is a pipe for the admission of superheated steam or other hot gas for reheating the partially-expanded steam in the reheater, and k^4 is a drip-pipe which may lead to a trap.

By my construction of the reheater it will be seen that no expansion which the tubes can be subjected to will have any effect on

the casing, as the box K′ is independent of this casing.

The space around the tubes *l l* forms part of the passage of the steam from the upper cylinders to the lower, and the steam, after being superheated, passes through the passage N^2 and is admitted alternately into the upper and lower ends of the cylinder *c* by means of valves *u v*. The steam after being expanded in the cylinder *c* passes through the passages *o p*, extending from the top and bottom of the cylinder *c*, respectively, and is admitted into the top and bottom of the cylinder *c′* by means of valves *u′ v′*, respectively, u^2 v^2 being exhaust-valves through which the steam flows to the final exhaust-passage O. The valves *u v*, &c., for the lower cylinders are substantially the same and are operated in substantially the same way as the valves described and claimed in my application, Serial No. 529,109, filed November 17, 1894, and I therefore do not claim the arrangement or mode of operating these in this application. While, as I have said, the single-acting cylinders c^2 c^3 c^4 c^5 can be used by themselves, I prefer to combine them with the double-acting cylinders *c* and *c′*, thus making a quadruple expansion-engine which is very compact and easily operated.

The piston A, I preferably form of an annular ring *a*, and form a cylinder *b* b^2 of thin metal, preferably steel boiler-plate, which cylinder is adapted to extend in both directions, forming trunks, as has been explained. This cylinder *b* b^2 I turn up on the outside so that it will fit the cylinder c^2 and the inside of the ring *a*. Then it is turned up on the inside and a spider L fitted therein. When in position, the spider L is secured to the ring *a*, as by rivets, securing all the parts together.

The piston-head a^2 has formed on it a flange l^2, which fits the upper end of the cylinder *b* b^2, and at the lower end I secure a plate *l′*, to which is secured the connecting-rod G by means of the pin *g*. This construction produces a very light piston and may of course be duplicated in the other set of pistons.

To guide the trunk extensions *b b′*, I provide necks D on the cylinders *c c′* and also sleeves H, conveniently centered by means of suitable flanges h^2, which are seated in grooves d^2 in the frame of the engine. The sleeves H have grooves *h*, in which are seated packing-rings *r*, which embrace the trunks *b b′*, and, as will be seen, the neck D and sleeve H form in effect a cylindrical cross-head guide for the trunk extension *b*.

The two connecting-rods G are connected to cranks S′ on the main shaft.

E is an eccentric, S^2 a link having a slot S^3, in which is arranged a block S, and serves by means of rod s^2 and stem *s* to operate the valve V, and by means of the rod S^6 to operate the valve *u v*, &c.

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

1. The combination in a compound engine of a casting C having a cylinder *c* formed therein and provided with flanges *f* f^2, with a casting C′ having a cylinder *c′* formed in it and provided with flanges *f′* f^3 corresponding to the flanges *f* f^2 on the casting C, said flanges having recesses f^5 f^6 adapted to form guides for a valve-rod *s*.

2. In a compound engine the combination with the double-acting cylinders *c c′* arranged side by side and having steam-ports adapted to admit steam at the top and bottom of said cylinders, of cylinders c^2 c^3 of decreasing areas arranged over the cylinders *c c′* respectively and having steam-ports o^2 o^3 for admitting steam to the top of the cylinders, and cylinders c^4 c^5 of decreasing diameters arranged over the cylinders c^2 c^3 having ports o^4 o^5 for admitting steam into the top of the cylinders c^4 c^5 all substantially as specified and so that the cylinders c^4 c^5 and c^2 c^3 can serve as single-acting and the cylinders *c c′* as double-acting cylinders.

3. The combination with the cylinders c^4 c^2 *c* arranged in line with each other of the cylinders c^5 c^3 *c′*, also arranged in line with each other, the cylinder c^4 being of the same size as the cylinder c^5 and the cylinder c^2 of the same size as the cylinder c^3, ports adapted to admit steam to the cylinders so that the cylinders *c c′* will act as double-acting and the other cylinders as single-acting cylinders and trunk-pistons for said single-acting cylinders.

4. In a compound engine a double-acting piston A having trunks *b* b^2 extending from it in opposite directions b^2 being a piston and *b* a cross-head and a trunk-piston a^4 extending from the trunk-piston b^2 in combination with a piston A′ having trunks *b′* b^3 extending from it on opposite sides b^3 being a piston, and *b′* a cross-head and a trunk b^5 extending from the trunk b^3 and suitable cylinders for said pistons.

5. In a compound engine a piston A having trunks *b* b^2 of equal size extending from it in opposite directions b^2 being a piston and *b* a cross-head and a trunk-piston a^4 extending from the trunk-piston b^2 in combination with a piston A′ having trunks *b′* b^3 of the same size as the trunks *b* b^2 extending from it on opposite sides b^3 being a piston and *b′* a cross-head and a trunk-piston b^5 extending from the trunk-piston b^3 suitable cylinders for said pistons and cylindrical cross-head guides for the trunks *b* and *b′*.

6. The combination with a double-acting piston A of a thin metal cylinder b^2 extending in one direction and serving as a trunk-piston and a similar cylinder *b* extending in the other direction and serving as a cross-head, a trunk-piston head a^2 secured to the cylinder b^2 a plate B^4 secured to the cylinder *b* and a connecting-rod G secured to the plate B^4.

7. The combination with an annular double-acting piston A, of a thin metal cylinder *b* b^2 extending through the annular piston A and forming trunk extensions on each side thereof,

a spider L inside the piston A and a piston-head a^2 having a flange l^2 fitting in the upper part b^2 of the cylinder.

8. The combination with cylinders c^2 c^4 and c^3 c^5 provided with suitable pistons and adapted to act as a compound engine, a valve for governing the flow of steam to and from said cylinders, a cylinder c in line with the cylinders c^2 c^4 a cylinder c' in line with the cylinders c^3 c^5 the cylinders c c' being adapted to act as a compound engine, and a receiver between the two sets of cylinders.

GEORGE S. STRONG.

Witnesses:
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EDW. F. AYRES.