(No Model.)

2 Sheets—Sheet 1.

F. W. DEAN.

COMPOUND ENGINE.

No. 459,779. Patented Sept. 22, 1891.

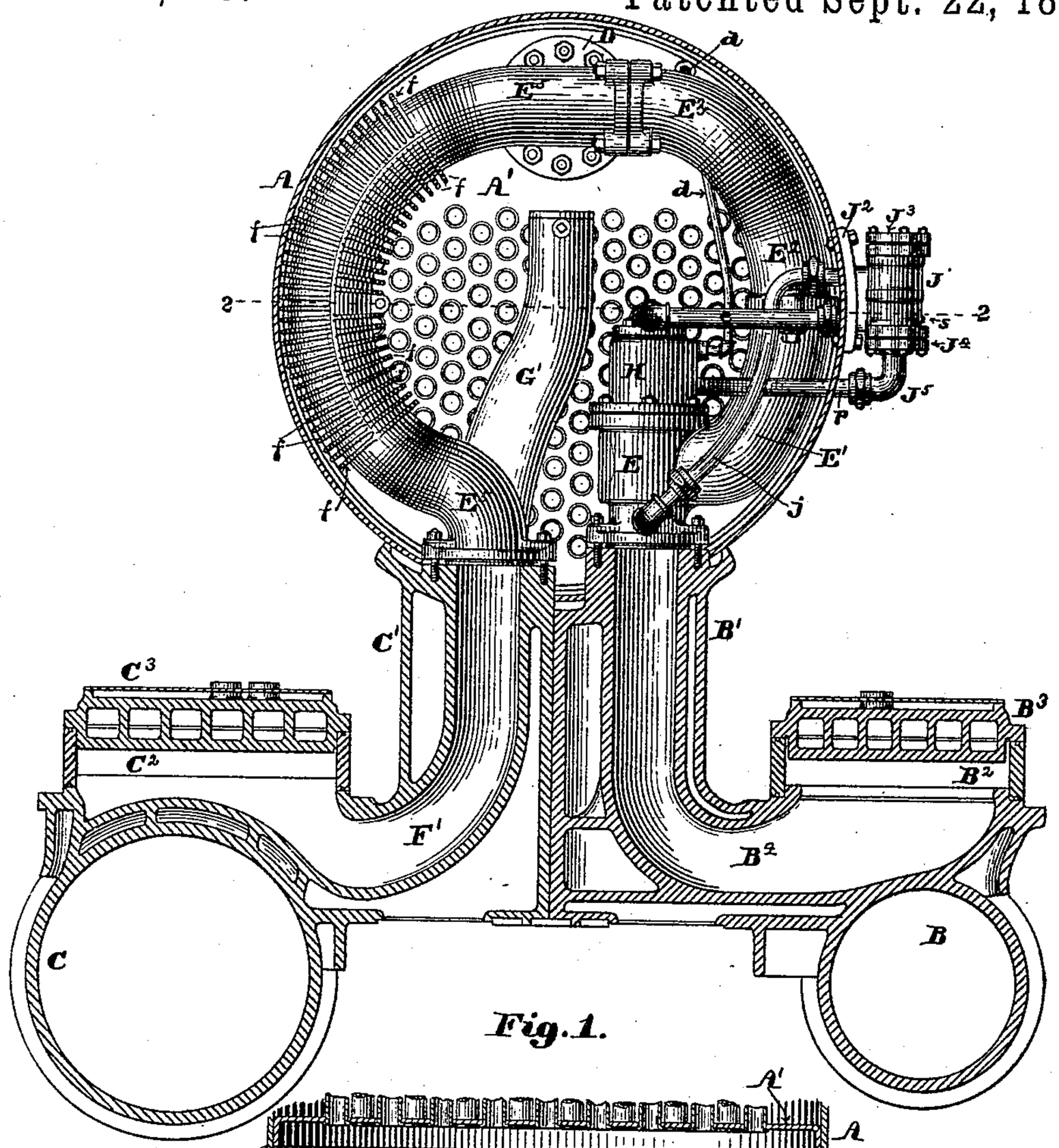

Fig. 1.

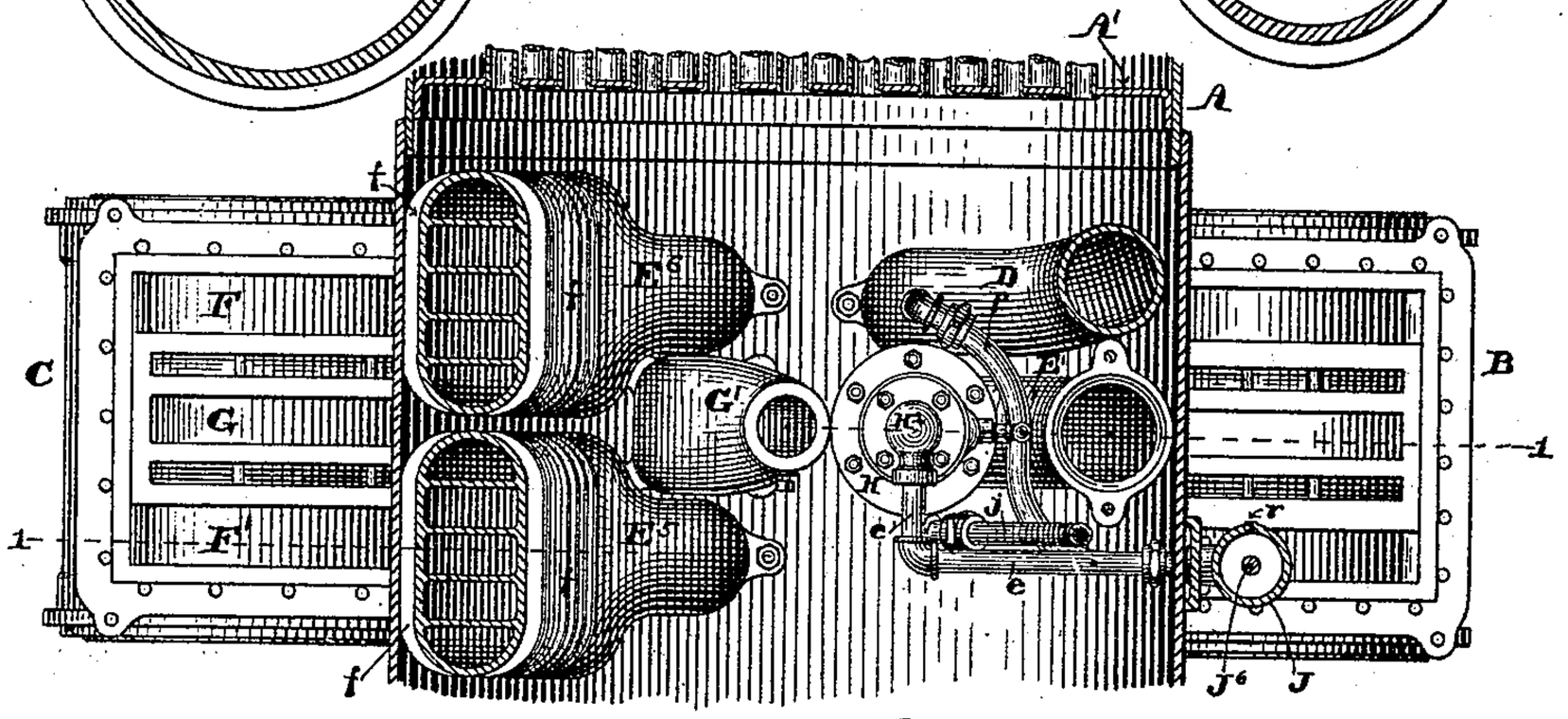

Fig. 2.

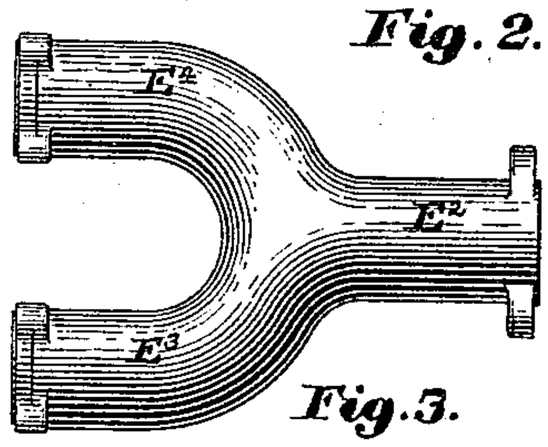

Fig. 3.

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(No Model.) 2 Sheets—Sheet 2.

F. W. DEAN.

COMPOUND ENGINE.

No. 459,779. Patented Sept. 22, 1891.

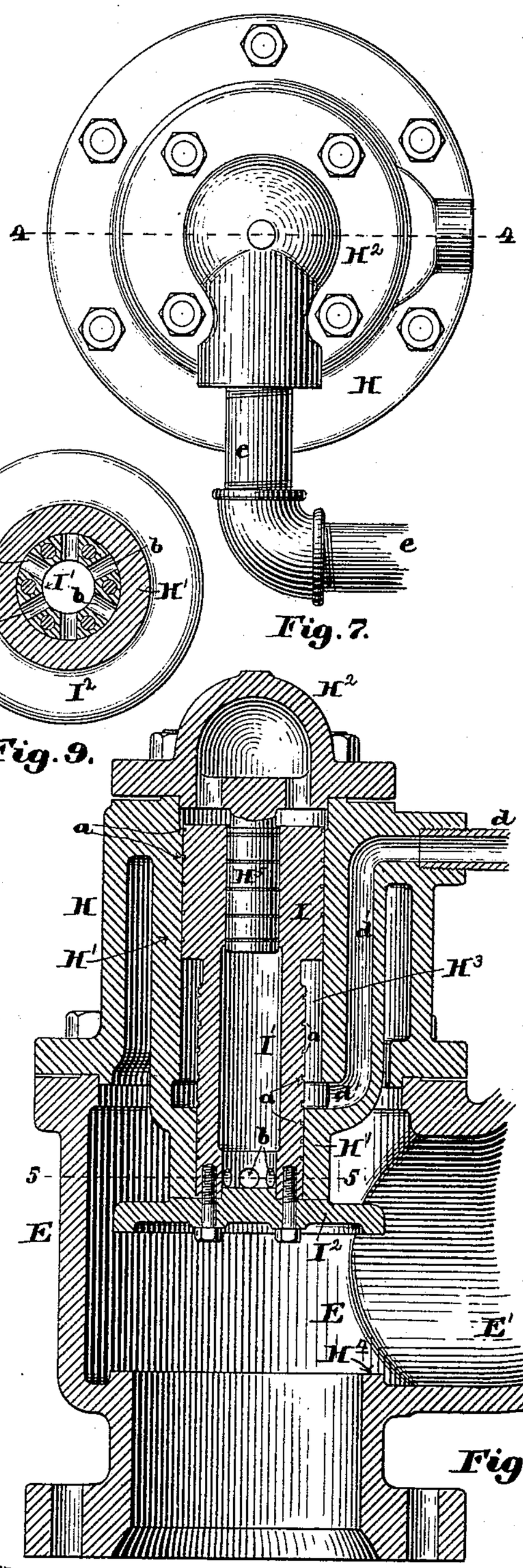

Fig. 9.

Fig. 7.

Fig. 8.

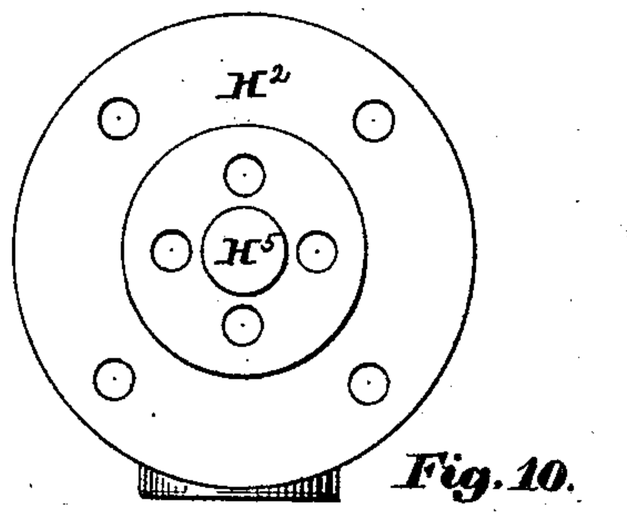

Fig. 10.

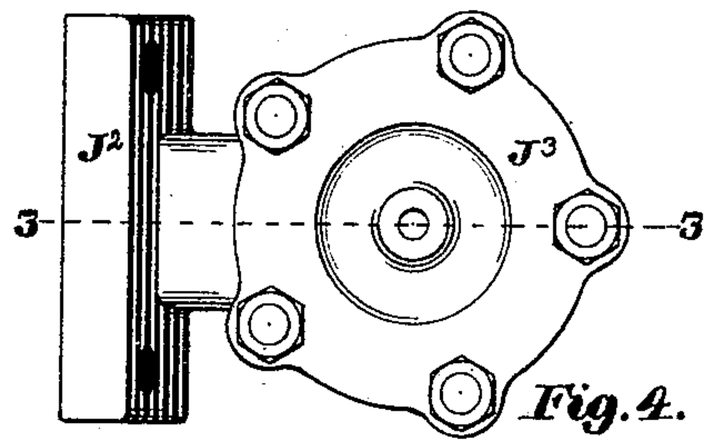

Fig. 4.

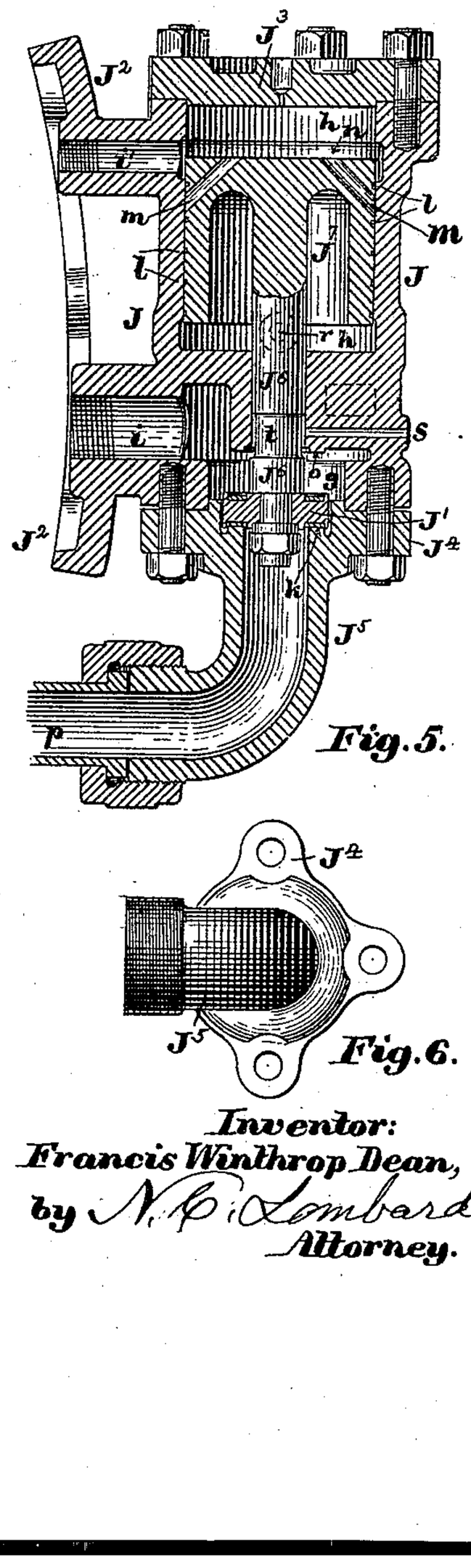

Fig. 5.

Fig. 6.

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UNITED STATES PATENT OFFICE.

FRANCIS W. DEAN, OF CAMBRIDGE, MASSACHUSETTS.

COMPOUND ENGINE.

SPECIFICATION forming part of Letters Patent No. 459,779, dated September 22, 1891.

Application filed May 29, 1891. Serial No. 394,501. (No model.)

To all whom it may concern:

Be it known that I, FRANCIS W. DEAN, of Cambridge, in the county of Middlesex and State of Massachusetts, have invented certain new and useful Improvements in Compound Engines, of which the following, taken in connection with the accompanying drawings, is a specification.

My invention relates to compound engines of that class in which, in starting, live steam is simultaneously admitted to both cylinders in order to obtain greater pressure at starting, and also to obviate the difficulty sometimes met of having to apply manual power to start the engine when steam is admitted first to the high-pressure cylinder only and the high-pressure crank happens to be on one of its dead-centers.

My invention is an improvement upon the invention described in the Letters Patent, No. 433,164, granted to me July 29, 1890; and it consists in certain novel features of construction, arrangement, and combination of parts, which will be readily understood by reference to the description of the drawings and to the claims hereinafter given, and in which my invention is clearly pointed out.

Figure 1 of the drawings is a vertical transverse section through the smoke box of a locomotive-boiler and the two steam-cylinders of a compound engine illustrating my invention on line 1 1 on Fig. 2. Fig. 2 is a sectional plan of same, the cutting plane being on line 2 2 on Fig. 1, the steam-chest and covers being removed. Fig. 3 is a plan of the forked section of the pipe connecting the high and low pressure cylinders. Fig. 4 is a plan of the converting-valve casing. Fig. 5 is a vertical section on line 3 3 on Fig. 4. Fig. 6 is an inverted plan of the lower head of the converting-valve casing and the inlet-pipe for live steam. Fig. 7 is a plan of the intercepting-valve casing. Fig. 8 is a vertical section on line 4 4 on Fig. 7. Fig. 9 is a horizontal section on line 5 5 on Fig. 8 and showing the valve in plan, and Fig. 10 is an inverted plan of the upper head of the intercepting-valve casing.

In the drawings, my invention is illustrated as applied to a locomotive, only so much of said engine and its boiler being shown as is necessary to illustrate my invention, but the principal features of my invention are equally as applicable to stationary as to locomotive engines.

In the drawings, A represents the shell of the locomotive-boiler, and A′ the tube-sheet at the rear of the smoke-box.

B is the high-pressure cylinder, B′ its saddle, B^2 its steam-chest, and B^3 the steam-chest cover.

C is the low-pressure cylinder, C′ its saddle, C^2 its steam-chest, and C^3 the steam-chest cover.

D is the steam-supply pipe through which live steam passes from the steam-dome to the steam-chest of the high-pressure cylinder.

B^4 is the exhaust-passage of the high-pressure cylinder, to the upper end of which is connected the casing E, which is provided with the curved pipe E′. The upper end of the pipe E′ has secured thereto the single arm E^2 of the forked curved section, the ends of the two arms E^3 and E^4 of its fork having secured thereto the two enlarged receiver-pipes E^5 and E^6, respectively, the lower ends of which communicate, respectively, with the supply-passages F and F′, leading to the interior of the low-pressure steam-chest C^2, as shown in Figs. 1 and 2.

G is the exhaust-passage of the low-pressure cylinder, communicating at its upper end with the exhaust-pipe G′, of usual construction.

So far the construction is the same as shown and described in my previously-cited Letters Patent, except the casing or chamber E in the pipe, through which the steam exhausted from the high-pressure cylinder passes to reach the low-pressure cylinder, which casing is made with an open top, to which is bolted the casing H, provided with the inner pendent tubular hub H′, which extends into the chamber E, and has its upper end closed by the dome-like cap H^2. The hub H′ is bored out to form a cylinder having two different diameters, the upper portion H^3 being the larger and having fitted thereto the piston I, made tubular and provided with the hollow stem I′, which fits the smaller bore of the hub H′, and has secured to its lower end the intercepting-valve disk I^2, adapted to fit the seat H^4 in the casing E and close the ex-

haust-passage from the high-pressure cylinder. The piston I and its stem I′ are each provided with peripheral packing-grooves *a a*, and the stem I′ has formed therein just above the valve I^2 a series of radial holes *b b*, (see Figs. 8 and 9,) through which any steam that enters the interior of the stem I′ will escape into the chamber E, and pass thence to the receivers and the low-pressure steam-chest when the valve I^2 is closed upon its seat. The normal position of the intercepting-valve I^2 is raised or open, as shown in Fig. 8, which position is maintained by live steam at boiler-pressure acting upon the annular lower end of the piston I, which steam direct from the boiler enters the annular space surrounding the stem I′ through the pipe *d* and the passage *d′*, cast in the hub H′, as shown in Fig. 8.

The interior of the dome-like cap H^2 is connected by the pipe *e* to the interior of the converting-valve casing J, above the valve J′, as shown in Figs. 1, 5, and 7. When the upward pressure of the live steam on the piston I is overcome by the pressure on the top of said piston I caused by the steam which has passed the converting-valve, the piston I descends and closes the intercepting-valve I^2 upon its seat H^4; but the steam above the piston I cannot enter the receiver until the piston has descended far enough to withdraw the plug H^5, formed in one piece with and pendent from the cap H^2 from the central bore of said piston, when the steam enters the chamber of the hollow piston and stem, and after acting upon the increased area due to the bottom of said chamber to force the valve for the balance of its movement with still greater force, escapes through the holes *b b* into the chamber E. This delay of the steam in entering the chamber E or receiver is important, for it otherwise might enter the high-pressure-exhaust passage before the intercepting-valve is closed and thus block the high-pressure piston, which is just what the intercepting-valve is intended to prevent.

The object of requiring considerable steam-pressure on the top of the piston I before it will descend is to prevent steam entering the receiver, except when it is wanted—that is, when the high-pressure crank is in a disadvantageous position for starting. If the engine does not start promptly by the action of the steam entering the high-pressure cylinder, the steam will accumulate above the intercepting-valve piston, press down said valve till the steam can enter the receivers through the holes *b b* and start the engine by acting upon the low-pressure piston, or the engineer, by opening the throttle wide enough, can make sure at will that the intercepting-valve will close and let steam into the receiver.

The areas for upward and downward pressures on the intercepting-valve can be so proportioned with reference to each other that any desired result may be accomplished. The intercepting-valve can thus be made to always or occasionally act—that is, it may be made to act sensitively or sluggishly, as may be desired.

The enlarged central portions of the receiver-pipes E^5 and E^6 are surrounded, or nearly so, with a series of outwardly-projecting ribs *f f* for the purpose of increasing the surface area of said receivers exposed to the hot gases in the smoke-box and thereby raising the temperature of the steam contained therein, and thus increasing the effectiveness of the low-pressure cylinder.

The intercepting-valve piston bearing is steam jacketed in order to prevent the hot gases in the smoke-box from having a destructive effect upon the oil with which the piston and valve-stem are lubricated.

The converting-valve casing J is secured by means of the flange J^2 and suitable bolts or rivets to the exterior of the smoke-box a little in advance of the intercepting-valve casing, as shown in Figs. 1 and 2, and has formed in its lower end the valve-chamber *g* and in its upper end the cylindrical chamber *h*, the upper end of which is closed by the head J^3, and said casing is provided with an orifice *i*, into which the pipe *e* is screwed, and also with the orifice *i′*, which communicates through the pipe *j* with the high-pressure exhaust-passage below the intercepting-valve I^2, as shown in Fig. 1. The lower side of the converting-valve chamber is closed by the head J^4, having cast therewith the elbow-pipe J^5 and the valve-seat *k*, as shown in Figs. 5 and 6. The converting-valve J′ is secured to the lower end of the stem J^6, formed in one piece with or connected to the piston J^7, fitted to and movable vertically in the chamber *h* and having formed in its periphery a series of annular packing-grooves *l l* and provided with the oblique perforations *m*, as shown in Fig. 5. The orifice *i′* opens into the chamber *h* about one-fifth (more or less) of the length of said chamber from its upper end, and said chamber *h* has formed therein at that point the annular enlargement *n*, with which the lower ends of the oblique orifices *m* coincide when the converting-valve and the piston J^7 are in their raised positions. The portion of the chamber *h* that is above the enlargement *n* serves as a dash-pot to cushion the piston and prevent slamming. When the converting-valve is lifted by the pressure of steam beneath it, its upper surface comes in contact with the seat *o*, formed on the lower end of the bearing for the stem J^6, where it is maintained until the exhaust-steam from the high-pressure cylinder, passing through the pipe *j* and orifices *i′* and *m* to the upper side of the piston J^7, overcomes the upward pressure on said valve when it will be forced down upon the seat *k*. The converting-valve J′ is raised by the action of live steam, which passes from the steam-supply pipe D through the pipes *p* and J^5, as shown in Figs. 1 and 2.

The casing J is provided with a vent-hole *r*, which communicates with the interior of

the chamber *h*, as shown in Fig. 2 and in dotted lines in Fig. 5, and said casing is also provided with a second vent-hole *s*, which communicates at its inner end with the interior of the bearing for the stem J^6, as shown in Fig. 5.

The stem J^6 has a portion of its length reduced in diameter, as at *t*, so that when the converting-valve is closed upon its seat *k* the steam that is in the chamber above the piston of the intercepting-valve will escape through the pipe *e*, chamber *g*, and vent-orifice *s* to the atmosphere. When the high-pressure cylinder makes its first exhaust, the converting-valve is depressed by a portion of the exhaust-steam passing to the upper side of the piston J^7, as before described, which shuts off the supply of live steam to the upper side of the intercepting-valve piston, and simultaneously opens the intercepting-valve supply pipe to the atmosphere, thus relieving the intercepting-valve piston of downward pressure, and enabling the boiler-pressure acting on the annular area of the lower end of said piston to raise and open the intercepting-valve. The size of the atmospheric communication can be so proportioned as to prevent the piston slamming in its upward movement, and the size of the pipe supplying live steam to the annular space below said piston can be such that the valve cannot slam in its downward motion, as it has to force this steam back into the boiler.

The escape of the steam into the atmosphere from the intercepting-valve-supply pipe becomes a tell-tale to the operator, and shows whether the valves are operating, and if steam escapes when the engine is running compound it shows that a leakage is occurring either in the converting or intercepting valve, or in both, from which one can always judge of the condition of those parts collectively, and thus easily locate the leakage in detail. As the intercepting-valve is held open at all times when steam is up, whether the engine is working or not, it can be made to operate vertically, which has never heretofore been accomplished. This adds much to its durability, as its weight does not wear the piston and stem. As the steam always keeps it up, it can never jar when the engine is running without steam or close and batter itself or close when the engine is reversed when running by the pumping of air or steam and air back into the receiver by the low-pressure cylinder. Any steam escaping from the vent-hole *r* shows leakage of the piston J^7.

The construction insures the opening of the converting-valve before the pressure of exhaust-steam in the high-pressure exhaust-passage accumulates above the receiver-pressure, and thus relieves the high-pressure piston of the early back-pressure. The intercepting-valve opens in advance of an accumulated back-pressure on the high-pressure cylinder to any desired degree. The covering of the holes *b b* in the lower end of the tubular stem of the intercepting-valve, as said stem and its valve rises, traps steam within the plunger, and thus prevents a final slam. The opening of the throttle-valve causes steam to pass the under side of and lift the converting-valve and then pass to the upper side of the intercepting-valve piston.

In operating compound engines it may happen that when it is desired to start the engine the high-pressure crank is on one of its dead-centers, and steam acting upon the high-pressure piston will not start the engine, in which case it becomes necessary to admit live steam to the low-pressure engine, which, acting upon the low-pressure piston in the regular way, will tend to move it and start the engine; but, unfortunately, it is liable, unless prevented, to flow back through the receivers and high-pressure exhaust-passage to that side of the high-pressure piston that will retard or prevent its motion. Hence the necessity of using a valve in the high-pressure exhaust-passage to intercept and prevent such backward flow of the auxiliary steam. If the low-pressure crank should happen to be on one of its dead-centers, so that the engine must be started by the high-pressure piston, this back-pressure might, in the absence of an intercepting-valve, or in case the intercepting-valve was too slow in closing, block the high-pressure piston and prevent the engine starting, for the auxiliary supply of steam in nearly all compound engines using intercepting-valves enters the receivers and the low-pressure steam-chest whenever the throttle-valve is open. Now in order to prevent this auxiliary supply of steam from flowing back to the high-pressure piston it is necessary that the intercepting-valve should close in advance of the admission of the auxiliary supply of steam, thus permitting the high-pressure piston to move without resistance of back-pressure, whether said piston is moved by the direct pressure of steam thereon or by power exerted thereon by its crank set in motion by movement of the low-pressure piston.

By the construction herein described and illustrated in the drawings this desirable end is accomplished.

What I claim as new, and desire to secure by Letters Patent of the United States, is—

1. In combination with the high and low pressure cylinders of a compound engine, their steam-chests and steam-passages, a forked pipe communicating with the exhaust-passage of the high-pressure cylinder at the end of its single portion and at its forked end to the low-pressure cylinder and provided near its connection to the high-pressure cylinder with a suitable annular valve-seat and an opening above said seat, a valve-supporting casing secured to said pipe and closing said opening, a hollow inner casing or hub bored out to two different diameters, a hollow piston and stem fitted to the two bores of said hub, a valve secured to the lower end of

said stem in position to co-operate with said seat to intercept the auxiliary steam admitted to the receivers and prevent it passing to the high-pressure cylinder, a pipe or passage for admitting live steam to the annular space below said piston to force said piston and valve upward, a stationary piston or plug fitted to the bore of said hollow intercepting-valve piston, and a pipe for admitting live steam to the chamber above said valve-piston, substantially as and for the purposes described.

2. The combination of the exhaust-pipe from the high-pressure cylinder provided with the valve-seat H^4, the casing H, having the inner pendent hollow hub H′, the hollow cap H^2, provided with the pendent cylindrical plug H^5, the hollow or tubular piston I and stem I′, the radial holes *b b* in the lower end of the stem I′, the pipe and passage *d* and *d′*, communicating with the boiler direct, and a pipe or passage connecting the interior of the steam-supply pipe with the chamber above the piston I.

3. The combination, with the high and low pressure cylinders of a compound engine, a pipe connecting the exhaust-passage of the high-pressure cylinder with the steam-chest of the low-pressure cylinder, and an intercepting-valve in the exhaust-pipe, of the high-pressure cylinder, a converting-valve casing provided with a valve-chamber and a piston-carrying chamber, and an upper and lower valve-seat, a valve secured to the lower end of a valve-stem, a piston provided with an oblique perforation and attached to the upper end of said stem and movable vertically in the piston-chamber, a live-steam-supply pipe communicating with the under side of said valve, a pipe or passage connecting the valve-chamber above the valve with the chamber above the intercepting-valve piston, and a pipe or passage connecting the high-pressure exhaust-passage below the intercepting-valve seat with the piston-chamber of the converting-valve below the top of the piston when in its highest position, whereby the upper portion of the piston-chamber is made to serve as a dash-pot, substantially as described.

4. The combination, with the high and low pressure cylinders of a compound engine, and a pipe connecting the exhaust-passage of the high-pressure cylinder with the steam-chest of the low-pressure cylinder, of the intercepting-valve I^2, its seat H^4, the hollow stem I′, and piston I, the steam-passage *d d′*, the converting-valve J′, the valve-seats *k* and *o*, the valve-stem J^6, provided with the peripheral groove or reduction *t*, the casing J, provided with the vent-hole *s*, the pipe *e*, connecting the converting-valve chamber with the chamber above the intercepting-valve piston, a pipe for supplying live steam to the under side of the converting-valve, and a pipe connecting the high-pressure exhaust-passage below the intercepting-valve seat with the interior of the chamber containing the converting-valve piston.

5. The combination, with the high and low pressure cylinders of a compound engine, a pipe connecting the exhaust-passage of the high-pressure cylinder with the steam-chest of the low-pressure cylinder, and an intercepting-valve in said pipe, of the converting-valve casing J, provided with the chambers *g* and *h* and the seats *k* and *o*, the piston J^7, the stem J^6, the valve J′, the pipe *e*, connecting the converting-valve chamber with the chamber above the intercepting-valve piston, the pipe *j*, leading from the high-pressure exhaust-passage below the intercepting-valve to the chamber *h*, the pipe *p*, leading from the steam-supply pipe to the under side of the converting-valve, and the vent-orifice *r*, extending from the interior of the chamber *h* to the open air.

In testimony whereof I have signed my name to this specification, in the presence of two subscribing witnesses, on this 27th day of May, A. D. 1891.

FRANCIS W. DEAN.

Witnesses:
N. C. LOMBARD,
WALTER E. LOMBARD.