3 Sheets--Sheet 1.

CHARLES E. EMERY.

Improvement in Compound Steam-Engines.

No. 126,383.

Patented May 7, 1872.

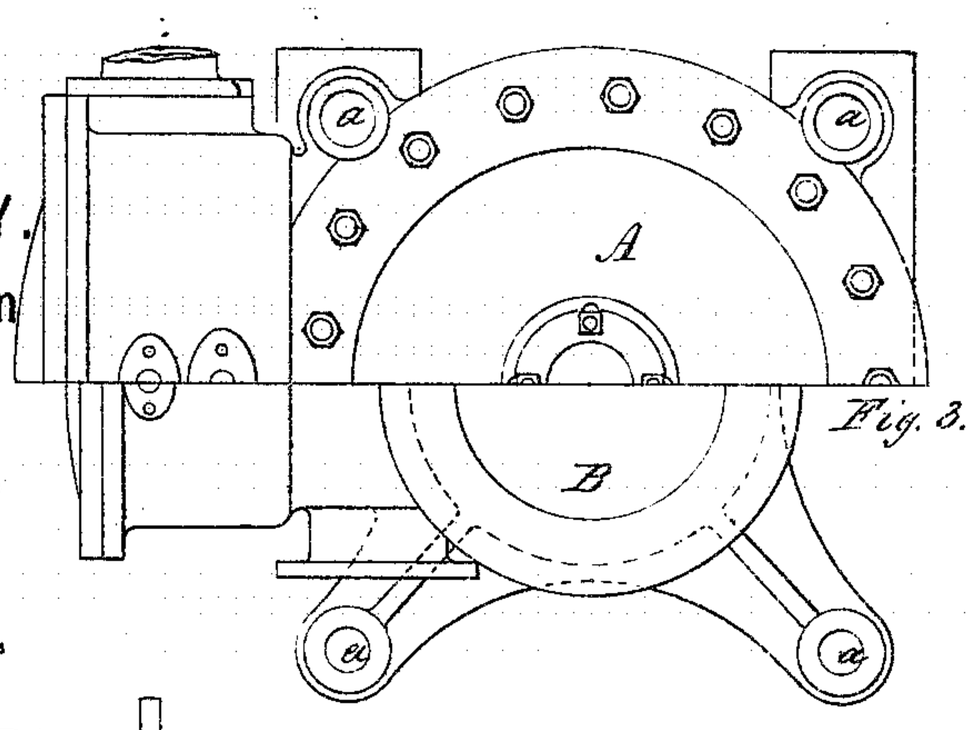

Fig. 3.

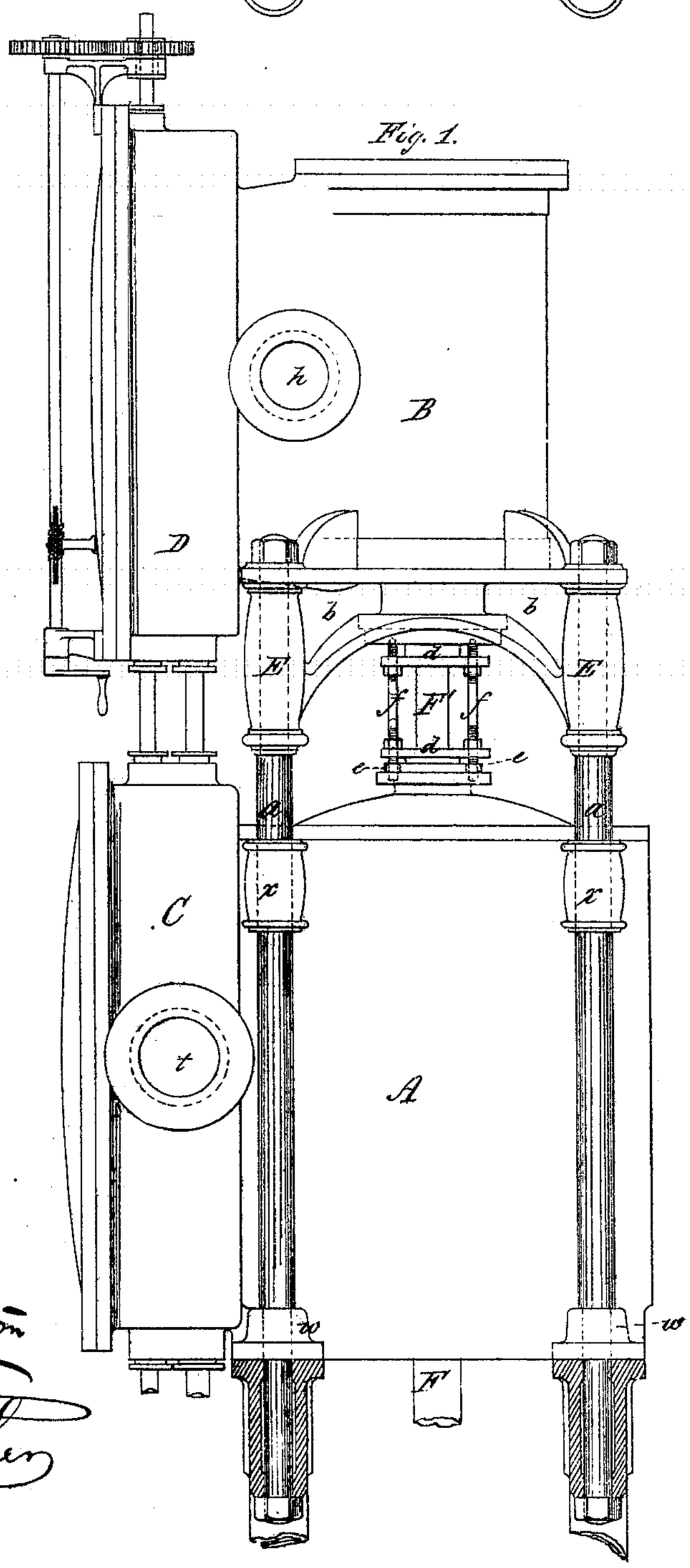

Fig. 1.

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Fig. 2.

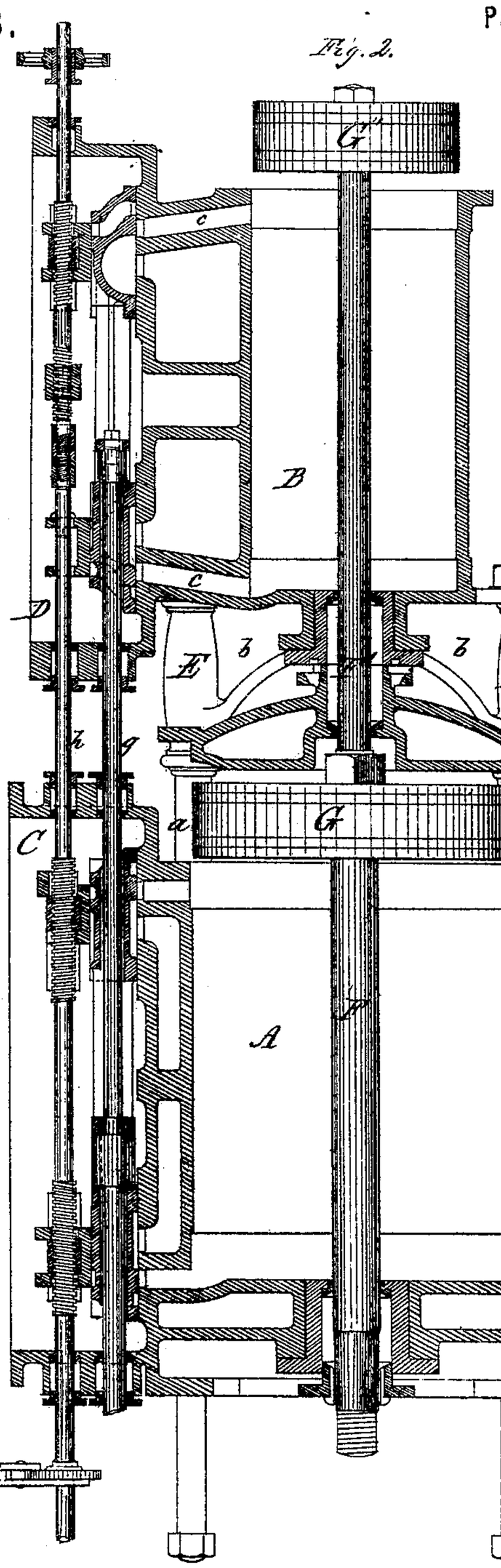


Fig. 4.

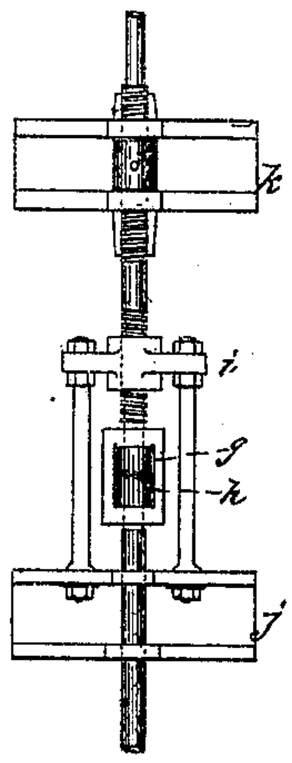
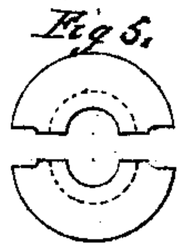


Fig 5.



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Improvement in Compound Steam-Engines.

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Fig. 7.

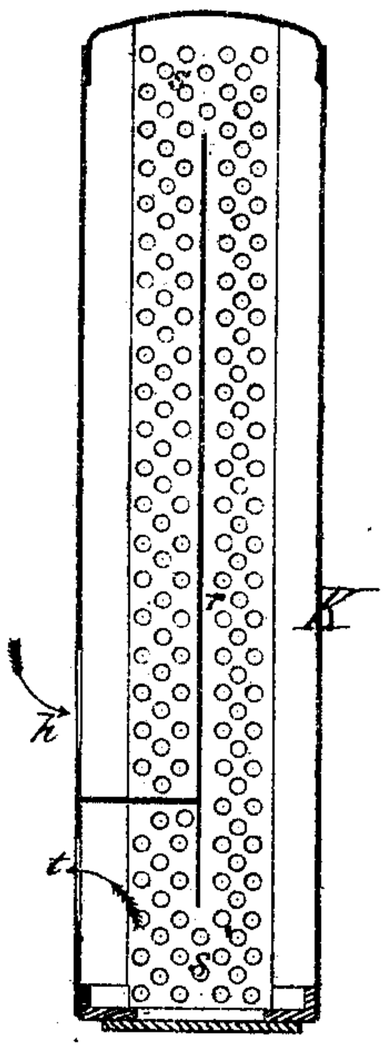
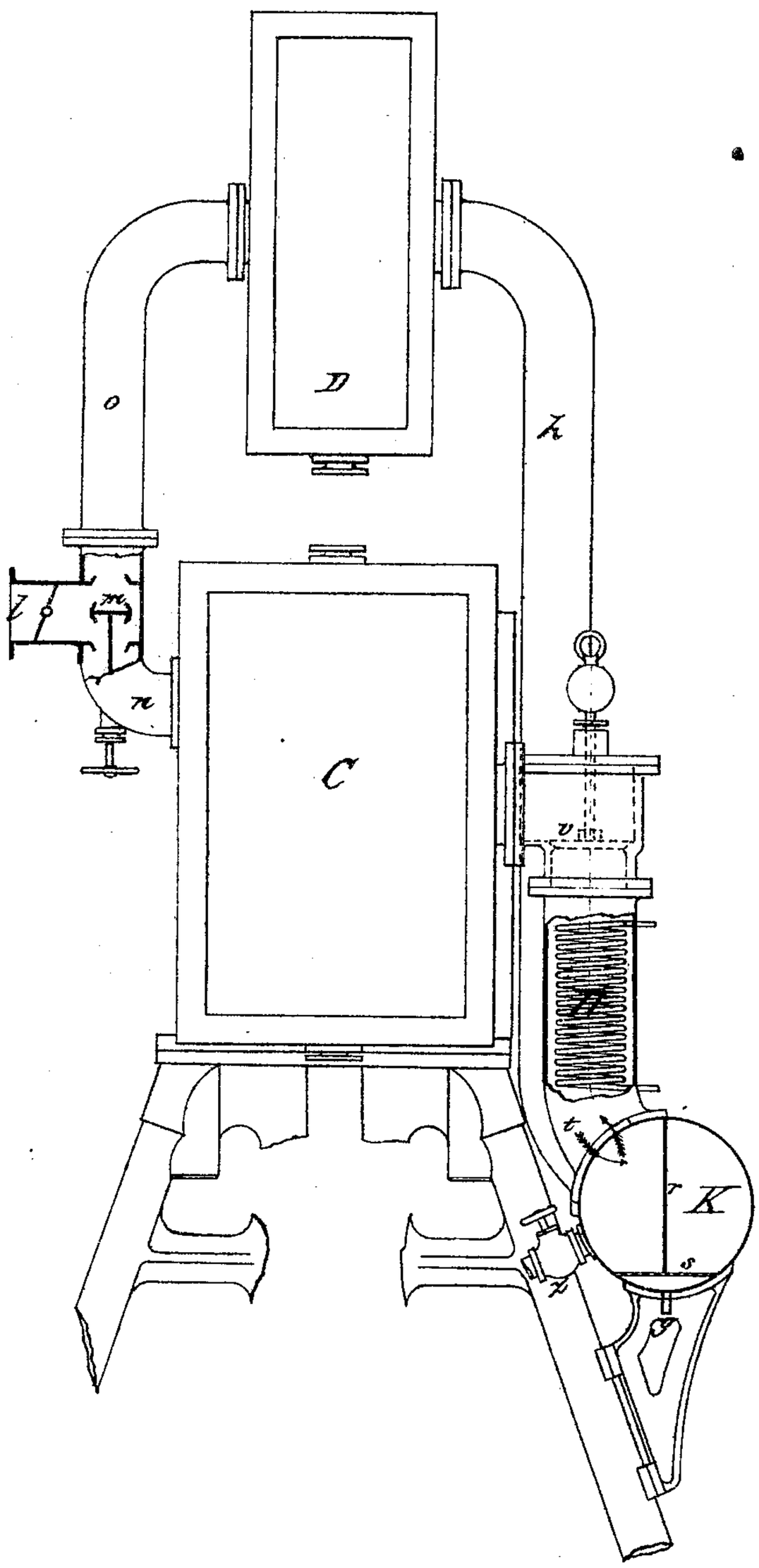


Fig. 6.



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UNITED STATES PATENT OFFICE.

CHARLES E. EMERY, OF NEW YORK, N. Y.

IMPROVEMENT IN COMPOUND STEAM-ENGINES.

Specification forming part of Letters Patent No. 126,383, dated May 7, 1872.

Be it known that I, CHARLES E. EMERY, engineer, doing business at No. 7 Warren street, in the city of New York, have invented certain new and useful Improvements in Compound Steam-Engines; and I do hereby declare that the following is a full, clear, and exact description of the same, reference being had to the accompanying drawing making a part of this specification.

My invention consists, first, of the combination, with the lower cylinder of a vertical compound engine, of a smaller cylinder provided with braced legs which extend outside the cylinder-head of the lower cylinder, and are supported upon said cylinder, or, through rods, upon the engine-framing, such combination holding the upper cylinder rigidly and permitting the lower cylinder-head to be raised in the ordinary way a sufficient distance to permit the examination of the piston and the adjustment of its parts; second, long studs extended between the intermediate stuffing-boxes of a steepled compound engine, with nuts on same to secure both glands, in combination with divided and slotted glands, all parts being arranged so that they can be readily removed to permit the lifting of the cover of the lower cylinder; third, the arrangement of both the main and the cut-off valve-seats of the upper and lower cylinders at the same, or nearly the same, distance from the center of cylinders, to permit the valves to be operated by simple direct connections from one to the other; fourth, the method of working the steam expansively in a compound engine, by cutting off the steam in the larger cylinder at such point that the fall of pressure in the passages during the time that said cylinder is receiving steam therefrom, is substantially restored during the time that the supply of steam to said cylinder is cut off by the compression into the passages of the steam remaining in the small cylinder, and thereby transferring the expansion from one cylinder to the other with far less loss of effect than has ever before been accomplished when the cylinders were separated from each other; fifth, a pipe or reservoir to connect the two cylinders of a compound engine when loss of effect from the use of the same is prevented in the manner above expressed; sixth, an independently-adjustable cut-off for the larger cylinder of a compound engine, to enable adjustment to be made, as desired, to secure maximum economy or facility in starting; seventh, the arrangement, in the passages connecting the two cylinders of a compound engine, of devices for drying the steam, first by gravity and afterward by the direct application of heat to produce economy of steam; eighth, the arrangement of a check-valve in the passage between the two cylinders of a compound engine to assist in starting and backing the engine.

In the drawing, Figure 1 represents a side elevation of the cylinders of a compound engine constructed in accordance with my improvements, with the connecting-pipes removed. Fig. 2 is a central vertical section of the same. Fig. 3 is a top view of half of each of the cylinders. Fig. 4 is a front view of the cut-off valves of the upper cylinder. Fig. 5 is a top view of the intermediate piston-rod stuffing-box glands. Fig. 6 is a front view of the steam-chests and pipes with portions shown in section. Fig. 7 is a central horizontal section of the intermediate reservoir.

The larger or low-pressure cylinder of the engine is designated A. It is supported upon suitable framings or housings, and its piston C is connected, through a suitable rod, F, to the working-parts of the engine in the usual manner. The high-pressure cylinder, designated B, is arranged above the other in the same line, and its piston G connects with the lower piston by a suitable rod, F. The upper cylinder is sufficiently elevated above the other to permit the arrangement of stuffing-boxes on the piston-rod F, where it passes through the proximate cylinder-heads. The cylinder B is provided at its lower end with a number of legs, E, (four are represented,) strongly braced to each other and to the cylinder or its bottom, which legs either rest upon lugs on the lower cylinder outside the cylinder-cover, or are attached to large bolts or bars secured to lugs on the lower cylinder, or which, as shown, extend down outside the lower cylinder and take hold of the framing of the engine, serving, if desired, to hold down the lower cylinder upon the frame by the shoulders on the rod above lugs *w* on the cylinder, and, at the same time, to support the upper cylinder. The rods *a a* pass through ears *x x* at the upper part of the lower cylinder, and thereby the lateral motion of the upper cylinder is prevented. The

rods *a a* are so extended and the feet E E and the braces *b b* so arranged that the lower cylinder-head can be freely lifted so that the piston may be examined. To still further facilitate the raising of the cylinder-cover without unduly separating the cylinders, the glands of both of the stuffing-boxes between the cylinders are held in place by studs *f f*, extended from one box to the other, and secured so that they may be readily removed. In the plan shown, a point, *m*, on each of the studs is jammed into a shallow hole on one stuffing-box by a nut, *e*, forced against the other stuffing-box. The holes through the flanges of the glands are slotted to the edges and the glands are split, so that by slacking the nuts *e* the studs and glands may be quickly removed, when the cover of lower cylinder may be raised until its stuffing-box comes in contact with the lower stuffing-box of the upper cylinder, and the lower piston can be readily reached, and, if necessary, lifted entirely out of the cylinder, the parts then assuming the position shown in Fig. 2.

The piston of a steam-engine is the most important detail of its construction. Any steam that leaks past a piston is in all cases (except in the high-pressure cylinder of a compound engine) absolutely wasted. The pistons, therefore, need frequent examination and careful attention. The simplest method of constructing a compound engine is to arrange the cylinders in the same line, but all previous methods of doing this were liable to mechanical objections. For instance, the small cylinder has been attached directly to the head of the large cylinder, in which case it was necessary to lift off the whole of the upper cylinder to examine the intermediate stuffing-box or the lower piston. Again, the two cylinders have been attached to external framing and separated from each other a sufficient distance to admit of proper stuffing-boxes on the two contiguous cylinder-heads, but this arrangement cannot, as ordinarily constructed, be applied conveniently to vertical engines. The cylinders of vertical compound engines have also been connected by a frame placed between or forming part of the two heads, which arrangement permits access to the stuffing-boxes on the piston-rod, but renders it necessary to get at the piston of the large cylinder through a man-hole in large engines, and by removing the upper cylinder of small engines. It has been proposed, also, to support the upper cylinder of a vertical compound engine by rods, but the suggestion has never been carried out in such manner as to prevent the rods from springing. My plan, previously described, overcomes all these objections, as the piston-rods can be readily packed; the lower piston readily examined and adjusted; and the stiffly-braced legs E E bring the lateral strain so near the guide-ears *x x* that the upper cylinder is rigidly supported.

To secure simplicity of construction when slide-valves are employed, the valve-face of the upper cylinder is carried out a sufficient distance to enable the main and cut-off valves of the two cylinders to be operated by a continuous rod, *g*, as is clearly shown in Fig. 2. By using separate main valves the cylinder-ports *c c* of the upper cylinder are no longer than though one short valve were arranged close to the cylinder.

The steam for operating the engines is received at *l*, Fig. 6, and, being regulated in the usual manner by a throttle-valve, passes usually through a pipe, *o*, to the steam-chest D of the upper cylinder, from which cylinder it is exhausted into a pipe, *h*, which leads directly to the lower steam-chest, or, preferably, as is shown, to a reservoir, K, and from the same, through a pipe, *t*, to the lower steam-chest C. The reservoir K is provided usually, as is shown also in Fig. 7, with a longitudinal partition, and also has a perforated plate near its bottom. The steam, entering at *h*, passes around the longitudinal partition to the pipe *t*, and, during the passage, the water it contains is separated from it in manner described in my patent on "separator for steam-engines," dated 8th March, 1870, which waterfalls through the perforated plate, and is withdrawn at a suitable opening, *y*.

Some difficulty has been experienced in starting and backing compound engines arranged with the pistons on the same rod, to prevent which the double valve *m*, Fig. 6, is provided, so that steam can be admitted when desired to the lower cylinder through a pipe, *n*, and the large engine be worked like any single engine, the other cylinder having steam on both sides of its piston. Preferably, however, to prevent working off at each stoppage the steam in the upper cylinder and reservoir *k*, the valve *m* may be operated to shut off the steam from the upper cylinder, and a check or equivalent valve, *v*, be provided to keep the pressure in the chest C out of the reservoir K. In most cases, however, I use the check-valve *v*, in the position indicated, and also provide a valve, *z*, to open communication from the reservoir K to the condenser, in which case I have two independent engines, either or both of which may be made serviceable by a proper adjustment of the valves. In starting it is convenient to keep the valve *m* in mid position to admit steam to both engines, the valve *v* being shut and *z* open, so that the steam from the upper cylinder will pass to the condenser; then, so soon as the valve *m* is operated to shut pipe *n*, and the valve *z* closed, the steam from the upper cylinder will lift the check-valve *v*, and the two engines operate on the compound system. The reservoir K may be placed in any convenient position, and is supported by the pipes attaching it to the cylinders, or by brackets on the cylinders, or the framing which sustains them, so that on shipboard the combination will move together as a whole and not strain the joints.

In most of the compound engines constructed previous to my invention the steam in the pas-

sages connecting the two cylinders is expanded to, or nearly to, the terminal pressure in the large cylinder, whence the energy of the steam from the smaller cylinder is at each stroke partially expended in elevating the pressure in the passages, and consequently the initial pressure in the large cylinder falls much below the terminal pressure in the small cylinder. It has been determined experimentally that any loss of initial pressure is attended with loss of economy; hence, to reduce this loss between the cylinders of a compound engine, engineers have studied to reduce the capacity of the connecting-passages to a minimum. I, on the contrary, can construct the passages of any desired capacity, and prevent the losses above mentioned by cutting off the steam in the larger cylinder at such point that the fall of pressure in the passages during the time that said cylinder is receiving steam therefrom is substantially restored, during the time the supply of steam to said cylinder is cut off, by the compression into the passages of the steam remaining in the small cylinder, and the energy of the exhaust steam from the said small cylinder, at the next stroke of its piston, is nearly all exerted in doing work instead of being expended in equalizing the pressure. The result is that the expansion is transferred from one cylinder to the other with far less loss of effect than has ever before been accomplished when the cylinders were separated from each other. In all compound engines there must be a difference between the back pressure in one cylinder and the effective pressure in the other sufficient to put the steam in motion at the required velocity, or usually about two pounds. The steam has been cut off at about half-stroke in the large cylinder, in cases where the two engines were connected at right angles, in order to prevent the said large cylinder from receiving steam after the other had completed its stroke, and in some cases the larger engines have been provided with lap-valves to insure smoothness of working, and possibly, also, the result last above mentioned; but in no instance, to my knowledge, has the entire loss of pressure in the passages at each stroke been restored by compression previous to my invention, nor have the advantages of such a method been pointed out. The proper point of cut-off to employ on the larger cylinder may be determined by calculation on the principles above expressed, or by the use of the indicator, either on the small cylinder or the intermediate passages. In the diagrams from the smaller cylinder there should be no fall in pressure between the terminal pressure due to expansion and the back pressure, except, perhaps, two or three pounds, or sufficient to overcome the friction of the engine. The method is applicable, whatever be the capacity of the passages between the two cylinders, and also when the pistons are connected to cranks set at any angle with each other instead of moving together, as is shown. This method makes it possible to separate the high and low pressure cylinders any desired distance without the loss in economy which would have resulted previously; and the chamber F, or enlarged connecting-pipe, may be made of any shape or dimensions that may be desired to act as a separator, a heater, or simply as a connection between the two cylinders. It is an advantage to have an independently-adjustable cut-off on the larger cylinder, so that it may be set to obtain maximum economy when the engine is in motion and altered to admit steam nearer full-stroke when it is desired to start or reverse the engine. This result can be obtained with a lap-valve for a cut-off when the link or other device operating the same is capable of adjustment independently of the cut-off valves of the smaller engine.

In Fig. 6 is shown a coil, H, arranged in the pipe *t*, connecting the reservoir K with the steam-chest C. This coil is heated by high-pressure steam from the boilers, and is intended to thoroughly dry the steam before it enters the large cylinder after all the water that will become separated by gravity has been deposited in the reservoir. The coil or its equivalent may be arranged in the steam-chest C or in one end of reservoir K, and the heat may be obtained directly from the fuel instead of from the steam, the distinctive feature being that the exhaust of the small cylinder is first dried as far as possible by gravity, and afterward by exposure to a higher temperature, before entering the large cylinder. It is evident that the cut-off on the large cylinder, and the essential principles involved in the arrangement of the passages from one cylinder to the other, may be employed for compound engines in which the cylinders are arranged in any desired manner, as, for instance, when their pistons are connected to different cranks on the same shaft set at any desired angle to each other.

What I claim as new, and desire to secure by Letters Patent, is—

1. The combination, with the lower cylinder of a vertical compound engine, of a smaller cylinder provided with braced legs which extend outside of the cylinder-head of the lower cylinder, and are supported upon said cylinder, or through rods upon the engine-framing, in such manner as to permit the raising of the lower cylinder-head, substantially as shown and described.

2. Long studs extended between the intermediate stuffing-boxes of a steepled compound engine, with nuts on same to secure both glands, in combination with divided glands having slotted flanges, all arranged and operated substantially as described.

3. The arrangement of both the main and the cut off valve-seats of the upper and lower cylinders, at the same or nearly the same distance from the center of cylinders, to permit the valves to be operated by direct connections from one to the other, substantially as shown and described.

4. The method of working steam expansively in a compound engine when the steam in the larger cylinder is cut off at such point that the fall of pressure in the passages during the time that said cylinder is receiving steam therefrom is substantially restored, during the time that the supply of steam to said cylinder is suppressed, by the compression into the passages of the steam remaining in the small cylinder, substantially in the manner and for the purposes specified.

5. An enlarged pipe or reservoir combined with and connecting the two cylinders of a compound engine when the reduction of pressure in said pipe or reservoir, during the time the larger cylinder is receiving steam, is substantially restored by compression in the manner set forth.

6. An independently-adjustable cut-off for the larger cylinder of a compound engine to enable adjustment to be made to secure maximum economy or facility of starting.

7. The arrangement, in the passages connecting the two cylinders of a compound engine, of devices for drying the steam, first by gravity and afterward by the direct application of heat, substantially as and for the purposes specified.

8. The arrangement of a check-valve in the passages between the two cylinders of a compound engine, substantially as and for the purposes specified.

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