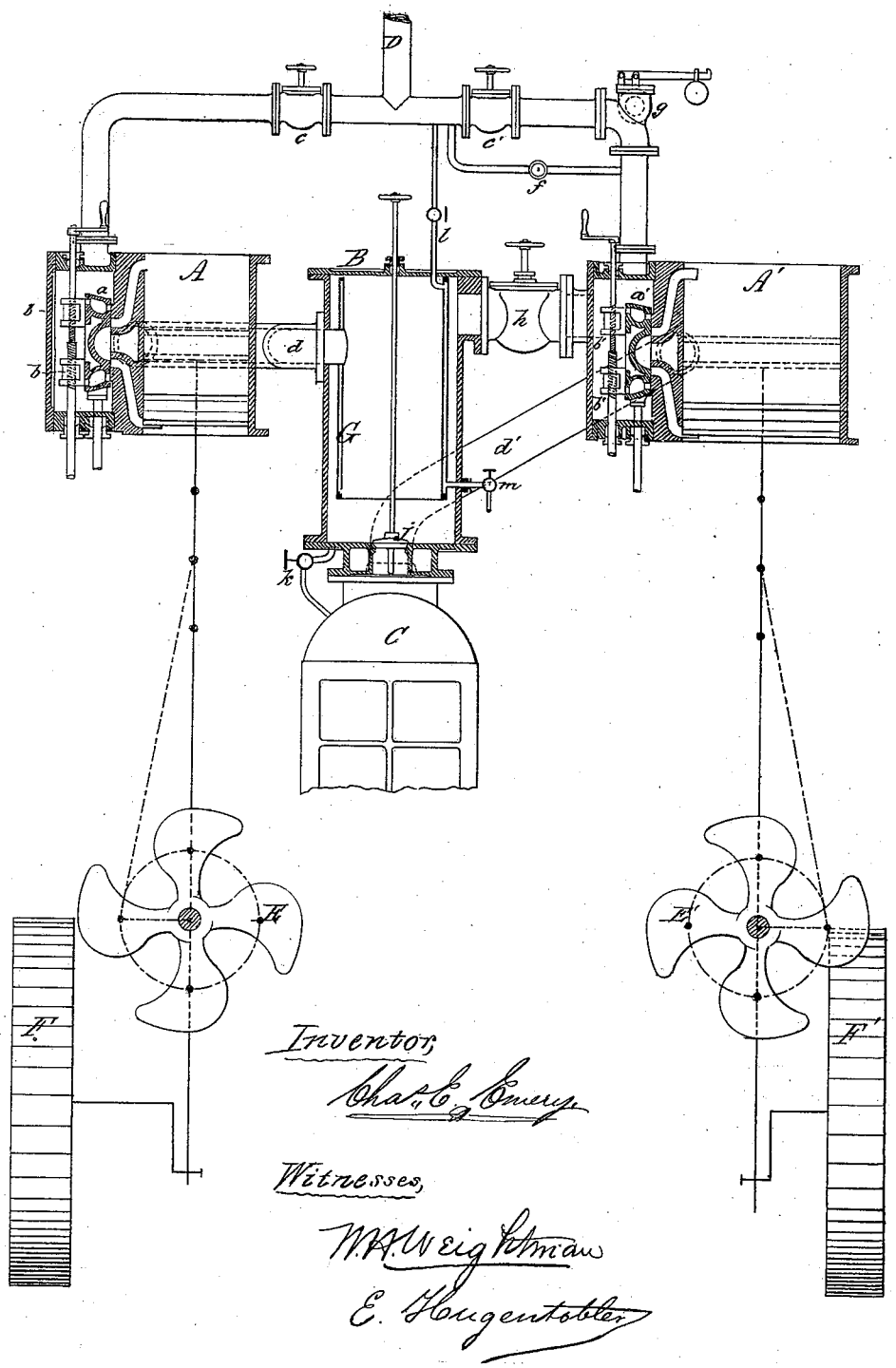
C. E. EMERY.

COMPOUND ENGINE.

No. 181,780. Patented Sept. 5, 1876.



Inventor,
Chas. E. Emery

Witnesses,
W. A. Weightman
E. Hougentobler

UNITED STATES PATENT OFFICE.

CHARLES E. EMERY, OF BROOKLYN, NEW YORK.

IMPROVEMENT IN COMPOUND ENGINES.

Specification forming part of Letters Patent No. **181,780**, dated September 5, 1876; application filed December 12, 1873.

To all whom it may concern:

Be it known that I, CHARLES E. EMERY, of the city of Brooklyn, Kings county, New York, (office No. 7 Warren street, New York city,) have made a new and useful Improvement in Compound Engines; and I do hereby declare that the following is a full, clear, and exact description thereof, reference being had to the accompanying drawings, making part of this specification.

The invention relates more particularly to an application of the compound engine to vessels provided with independent propellers—as, for instance, twin screws or independent side wheels—and is applicable in general to two or more engines located in the same vicinity, and capable of being independently loaded.

Heretofore, to apply the compound principle to vessels with independent propellers, it has been necessary to have a complete compound engine, with its two or more cylinders, attached to each independent propeller. I use only two single engines of different sizes, each of which is connected to one of the propellers, and valves are so arranged that either or both engines may be operated by live steam direct from the boiler, and be exhausted into the atmosphere or condenser, or, at will, the exhaust steam from the smaller may be diverted to a reservoir, and used as the supply for the larger cylinder, thereby making the two combined a compound engine. The engines are, in practice, used independently when maneuvering in harbor, thereby insuring the usual advantages of independent propellers, and, when regularly under way, the compound system is used with as great advantage as in any compound engine, and yet no more working parts are required than in any other independent propeller system—that is, for each propeller there is but a single engine with its proper attachments.

I have discovered that the distribution of the power between the two engines, when working as a compound engine, can be regulated within wide limits by varying the pressure in the intermediate reservoir or chamber, which can be done readily by adjusting the point of cut-off in the larger of the two cylinders, the regulation being assisted also, in some cases, by the use of a cut-off on the smaller cylinder. I use also, in the same connection, means by which steam may be admitted to or withdrawn from the intermediate chamber to change the pressure therein, and regulate the relative speeds of the engines, which may be used to obtain small variations with a fixed cut-off on large cylinder set approximately, or when an adjustable cut-off fails to correct the speed in the desired degree—as, for instance, under the unusual circumstances of a continued reduction of vacuum or a leaky piston or valve.

The invention will be so well understood from the foregoing general description that it will be necessary only to describe one manner of putting the same in practice, and the various incidental details found convenient or necessary for the purpose.

The drawing represents one view, partly in skeleton style and partly in longitudinal section, vertical or horizontal, according to the kind of engine, the general arrangement of the parts above referred to, with sufficient of detail to enable one skilled in the art to apply the invention readily in practice.

A designates the smaller cylinder, which is to be provided with all the usual attachments to make a complete engine of any type. The piston of the same is to be connected to operate, by crank and shafting in the usual way, one of a pair of twin-screw propellers, E, for instance, or one of a pair of paddle-wheels, F, or is to be connected to an independent load of any kind.

The main valve of this cylinder A is designated by *a*, and, as shown, is an ordinary slide, with steam-ports carried through its ends and regulated by cut-off plates *b b*, sliding on the back and adjustable by right and left hand screws on the stem. Any other kind of valve and cut-off may be used, and in many cases a lap slide-valve, operated by a link, will answer this purpose.

The larger cylinder is designated A′. With the exception of size, this cylinder may be constructed in every respect similar to the smaller one, A. It is also to be connected to the other of the independent propellers above referred to, and may have a similar kind of valve and cut-off. The two cylinders A and A′ are

shown constructed in a similar way, and, for the convenience of reference, the corresponding parts of the two are similarly lettered, with the addition, in each instance, of a prime mark to each part of the large engine, which has a corresponding part in the smaller. For instance, the cut-off plates of smaller cylinder are marked *b* and of the larger *b'*. The valve-gear and details of main connections may be the same for each engine; but, not being peculiar, are not shown. The steam-connections are different for the two cylinders, as hereinafter described.

D represents the main steam-pipe, which divides into two branches leading to the respective cylinders, the admission of steam to the smaller and larger, respectively, being regulated by valves *c* and *c'*. With *c'* closed and *c* opened steam may be admitted to, and put in motion, the smaller engine, the exhaust from the same passing through pipe *d* into the intermediate chamber B. From this chamber it may, by opening a valve, *h*, be admitted to and operate the larger engine, the intermediate chamber B serving as a reservoir to keep the pressure substantially uniform. The exhaust steam of the larger engine is conducted to the condenser C, or the atmosphere, by an exhaust-pipe, *d'*. By closing the valve *h* and opening a valve, *j*, communicating from intermediate chamber B or exhaust-pipe *d* to the condenser C, or the atmosphere, the smaller engine becomes entirely independent of the other, and may be stopped, backed, or maneuvered in the customary way in vessels with independent propellers. So, also, by using live steam through valve *c'*, the large cylinder may be similarly maneuvered, independent of the other, a safety-valve, *g*, being connected to the same, and set to lift at such pressure as to prevent undue strain on the working parts of the engine. An ordinary pressure-regulating valve may, also, if desired, be placed between the valve *c'* and the steam-chest, to keep the pressure therein reduced in an inverse ratio to the increased size of cylinder. I have found it convenient, however, to admit steam for maneuvering purposes through a smaller pipe and valve, *f*, and to use the larger valve only when high independent speed is required, the smaller engine disabled, &c.

When the two independently-loaded engine are operating together as a compound engines, the speeds which the single engines will have in relation to each other, when the load for each is practically the same, as on a steamer, is, in my system of working, regulated principally by the amount of pressure in the intermediate chamber. If the intermediate pressure be increased, the back pressure in cylinder of small engine, and the working pressure in cylinder of large engine will be correspondingly increased, so the effective pressure in the smaller cylinder, will be diminished, and that in the larger increased; hence the smaller engine will run slower, and the larger engine faster, than before. On the contrary, if the pressure in intermediate chamber be diminished, the back pressure in smaller cylinder and working pressure in larger cylinder will be correspondingly diminished, and consequently the speed of smaller engine will be increased, and that of the larger diminished. With other parts properly proportioned and adjusted, as hereinafter explained, the intermediate pressure, and consequently the relative speeds of the engines, may be regulated within proper limits by simply setting or adjusting the cut-off on the larger cylinder. This may be explained as follows: If we suppose the supply of steam to the smaller cylinder to remain constant, the quantity or weight of steam delivered by that cylinder per stroke will remain constant, and, in this method of working, in all cases equal to the weight of steam received by and discharged from the larger cylinder.

By Mariotte's law of the expansion of gases, which is nearly correct in respect to the expansion of steam, the pressures are inversely as the volumes. So, in order that the same weight of steam may be discharged from the larger cylinder that is delivered to it from the smaller, the pressure at the termination of the stroke of the larger must, for equal speeds of engines, be less than that in the smaller in the inverse proportion of the increased size. For instance, if the total terminal pressure in the smaller cylinder were thirty pounds, the terminal pressure in the larger cylinder, if of three times the capacity, would be one-third as much, or ten pounds. If the engines were running at different speeds, the terminal pressure in the larger would be greater or less in proportion to the increase or decrease of speed of that engine in relation to the speed of the other engine. If the steam followed at full stroke in larger cylinder, the pressure would be reduced by expansion but little from the beginning to the end of the stroke, the large volume of intermediate chamber tending to keep the pressure uniform; but if the steam were cut off in the larger cylinder, at, say, one third of the stroke, that engine would only take out of intermediate chamber one-third of the quantity of steam that it did before; consequently, with a constant supply from smaller cylinder, the steam would accumulate in chamber until the total pressure was trebled, when the larger cylinder at one-third of the stroke would receive the same weight of steam as was delivered by the smaller. It is evident that if under these conditions the cut-off took place later in the stroke of larger engine, that engine would receive more steam than before, and quickly reduce the intermediate pressure till equilibrium became established again.

As previously explained, the raising and lowering of intermediate pressure would vary the relative speed of the two engines, and it becomes evident that the cut-off on larger cylinder is efficient for this purpose. By so proportioning the sizes of cylinders and origi-

nal steam-pressures that the speeds of engines will be the same by calculation, with a moderate cut-off in the larger cylinder, it is evident that that cut-off may be set or adjusted so that the pressure in the chamber will be such that the two engines will make substantially the same speed in practice. In cases of equal resistances equal work will be performed in the two cylinders at the same speeds, but evidently either the relative speed or work, or both, may also be varied within wide limits, if desired, by adjustments of the cut-off on larger cylinder. When parts are proportioned, and adjustments made nearly right to insure the desired distribution of power between the two engines, the intermediate pressure may be varied so as to vary the relative speed or work of the engines by admitting steam to or allowing some steam to escape from the intermediate chamber. It may be observed, also, that in making a substantially equal distribution of the work between two independent engines of different sizes acting together as a compound engine, for equal weights of steam used in the smaller cylinder the greater amount of work will be done in that cylinder the more it is expanded in the same; hence in many cases it may be necessary to use a cut-off on that cylinder in order that that on the larger may increase or diminish the intermediate pressure to accomplish the regulation of speed or distribution of work to the degree desirable.

In illustration of the mode of operation above set forth, let us suppose the capacity of the two cylinders to be as one to two, that the steam is cut off in the larger at half-stroke, and that the supply is sufficient to fill the larger cylinder with steam at eight pounds pressure above absolute zero, the back pressure in same being four pounds. By the usual rules, cutting off at half-stroke in larger cylinder the initial pressure will be sixteen pounds, and the total mean pressure 13.44 pounds, or 9.44 pounds effective—exactly the same as if the steam were supplied direct from a boiler. The smaller cylinder should have an effective mean pressure of double that in the larger, so the total mean pressure in the smaller should be 18.88 pounds plus the back pressure, which would equal fully sixteen pounds, or in all 34.88; but were the small cylinder supplied throughout with steam at that pressure, it would entirely fill the large cylinder with steam of half that pressure, or 17.44 pounds, whereas we base our calculations on a terminal pressure therein of only eight pounds. We must, therefore, raise the steam-pressure, and expand sufficiently in the first cylinder to have a terminal pressure of about sixteen pounds, with a mean total pressure of 34.88 pounds. This would require a total initial pressure of about fifty pounds, expanded in small cylinder three times.

For different steam-pressures and proportions of cylinders, the cut-off in large cylinder would be varied to suit. For instance, with ninety pounds total pressure, cut off at one-fourth in the smaller cylinder, and with the latter four-tenths the capacity of the larger—which works well in practice—the cut-off in larger cylinder, on basis above set forth, should be between four and five tenths of the stroke. In practice, however, judging from experiment, it would probably require to be set at more than five-tenths, on account of re-evaporation at the lower pressures.

On account of condensation, re-evaporation, leakage, and other causes, the calculation would rarely give results exactly correct; but such calculations will furnish a guide as to proportions of parts, so that equal distribution of the power can be effected by the adjustments mentioned.

It is not necessary that the cut-offs be instantaneously adjustable. They may be fixed at points determined by trial or calculation to give, for instance, substantially equal speeds of the two engines; and, in extreme cases, regulation of power can be effected, when small cylinder does more work, by admitting a little live steam to the intermediate chamber or larger steam-chest through the main throttle-valve *c'*; or, better, through a smaller one, *f*; and, when larger cylinder does the more work, by wasting a little steam through the exhaust-valve *j*, or a smaller valve, *k*. The intermediate valve *h* is preferably made a check-valve, as shown in my patent of May 7, 1872.

With a view of drying or superheating the steam before it is used to perform more work in the second cylinder, I arrange a special heater, kept filled with live steam, or steam of greater temperature than that in the chamber. This heater may be of the ordinary tubular kind, like those used for heating feed-water, with the hotter steam on either side of the tubes, and the exhaust steam on the other; but I have shown in the drawings simply two concentric cylinders of boiler-iron, secured together at the ends, between which cylinders live steam is admitted by a suitable pipe, *l*, and the condensed water is conducted away by a suitable pipe, *m*.

By arrangement of passages the steam is caused to circulate on both sides of this heater. As adapted in the drawing, the heater is not carried to the bottom of the chamber, and steam is admitted from small cylinder, through pipe *d*, to the interior of the heater, and passes under and around it to the steam-pipe *h* of the larger cylinder. In practice, there is a little space over the top of the heater opposite pipe *h*, through which sufficient steam passes to cause a circulation in the top of both compartments.

The means of regulating the distribution of power between the cylinders of a compound engine are equally applicable when there are more than two cylinders, as the considerations hereinbefore expressed will apply as well to steam passing from a second to a third cylinder, or a third to a fourth, as from the first to the second.

The independent cylinders of different sizes may be employed also, to do any kind of work which is tolerably uniform, as well as to operate independent propellers. For instance, in a city water-works, two independent pumping-engines could be made with cylinders of different sizes, and operated on this plan as a compound engine; or, in case of accident to either, the other would be available as an ordinary engine for regular duty. In such cases it might be convenient also to arrange a clutch-coupling so that the two engines, when working together, might be connected at right angles, if desired.

I do not claim the use of a cut-off on the larger cylinder of two independently-loaded engines, one receiving steam from the other, if the arrangement be such that the operation of cut-off is not permitted to change the intermediate pressure and relative speed of the two engines. Neither do I claim the use of a cut-off on the larger cylinder of a compound engine when the working parts deriving motion from the two cylinders are mechanically connected, and must make the same time. Nor do I claim the use of valves to admit steam to or from intermediate chambers, when the engines are mechanically connected—for instance, as on the Washington duplex system, where one engine operates the valve of the other, so that the two engines must make the same number of strokes; but

What I do claim as my invention, and desire to secure by Letters Patent, is—

1. The method of regulating the relative speeds or powers of two independently-loaded engines, of different sizes, operating together, in connection with an intermediate chamber, as a compound engine, by means of a cut-off on the larger cylinder, substantially as specified.

2. The method of regulating the relative speeds or powers, with a given quantity of steam, of two independently-loaded engines, of different sizes, operating together, in connection with an intermediate chamber, as a compound engine, by means of cut-offs on both cylinders, substantially as specified.

3. The method of regulating the relative speeds or powers of two independently-loaded engines, of different sizes, operating together as a compound engine, but having no mechanical connections to keep the two in time, by varying the pressure in an intermediate chamber, substantially as and for the purposes specified.

4. An annular heater, G, combined with the intermediate chamber of a compound engine in such manner as to secure circulation of the steam on both sides of the heater, substantially as and for the purposes specified.

CHAS. E. EMERY.

Witnesses:
W. H. WEIGHTMAN,
E. HUGENTOBLER.