(No Model.) 2 Sheets—Sheet 1.

C. C. WORTHINGTON.

DIRECT ACTING ENGINE.

No. 448,744. Patented Mar. 24, 1891.

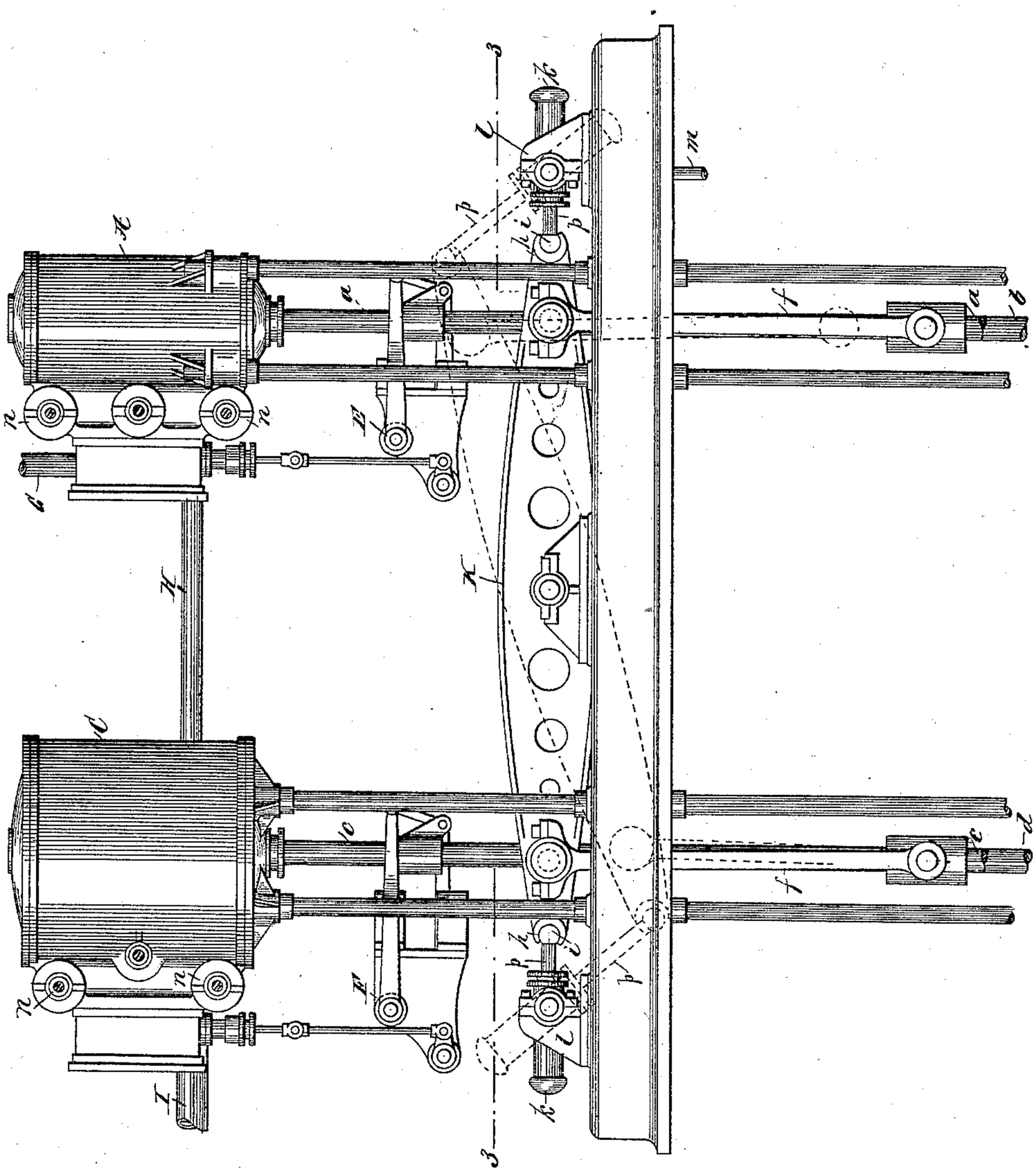


Fig. 1.

Attest:
Geo. H. Lotts.
G. M. Borst.

Inventor:
Charles C. Worthington
by Philipp, Phelps & Hovey
Attys.

(No Model.) 2 Sheets—Sheet 2.

C. C. WORTHINGTON.

DIRECT ACTING ENGINE.

No. 448,744. Patented Mar. 24, 1891.

Fig. 2.

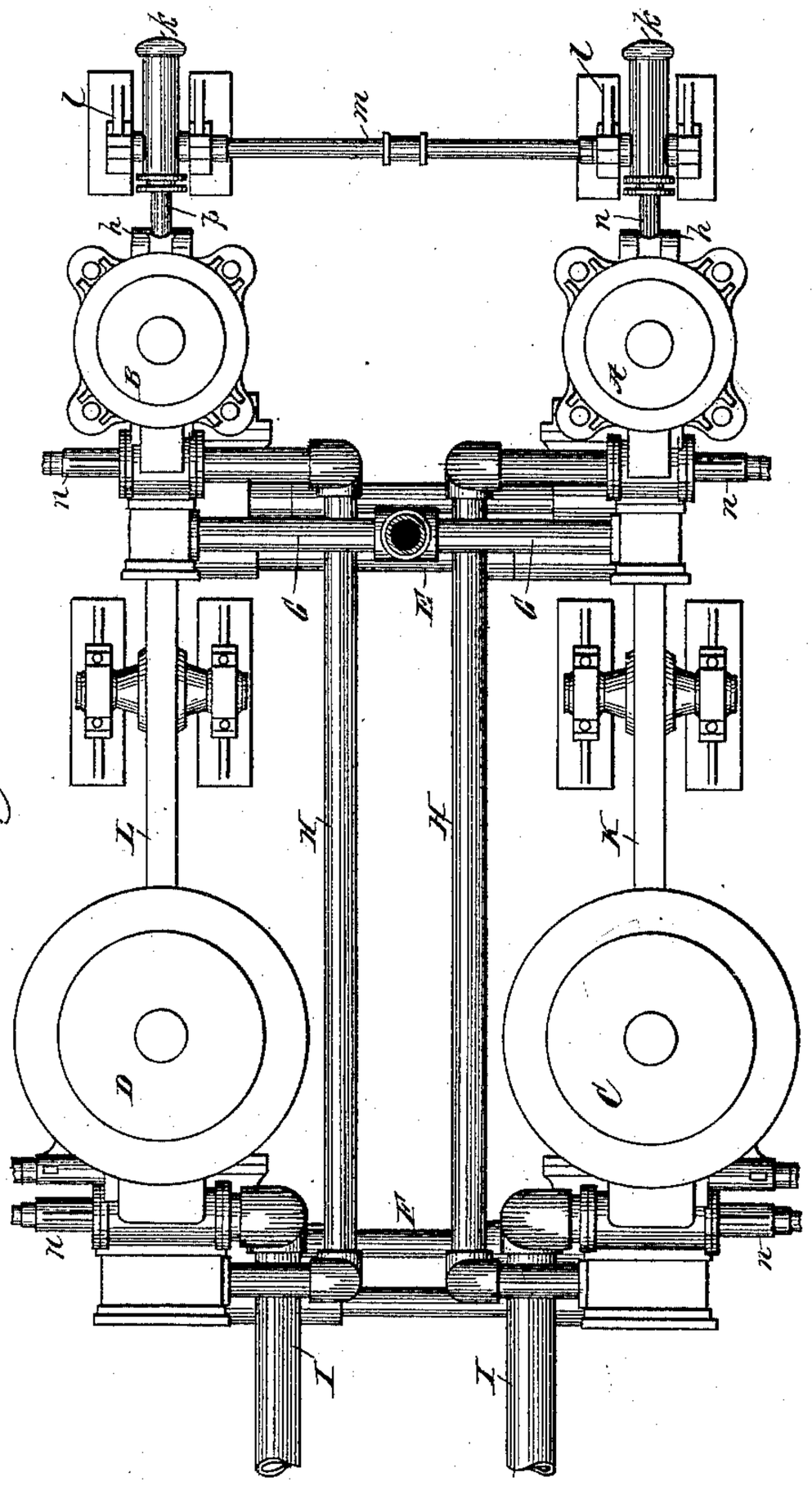
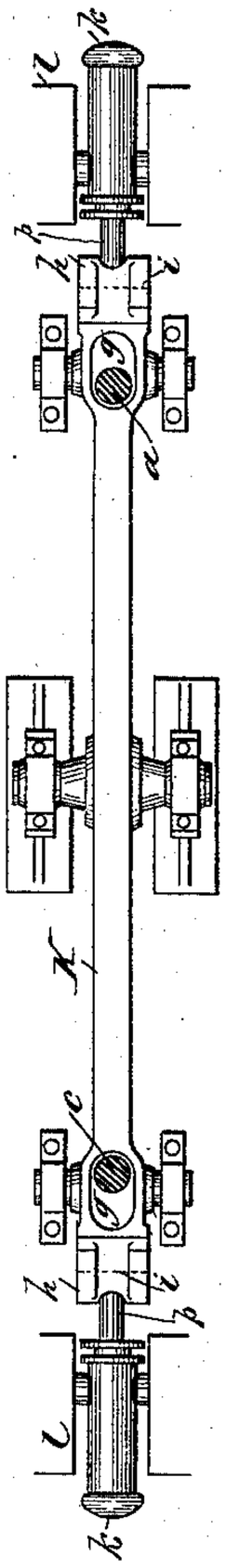


Fig. 3.



Attest:
Geo. H. Bolt.
G. M. Borst

Inventor:
Charles C. Worthington
by Philipp. Phelps & Hovey
Attys

UNITED STATES PATENT OFFICE.

CHARLES C. WORTHINGTON, OF IRVINGTON, NEW YORK.

DIRECT-ACTING ENGINE.

SPECIFICATION forming part of Letters Patent No. 448,744, dated March 24, 1891.

Application filed May 17, 1888. Serial No. 274,138. (No model.)

To all whom it may concern:

Be it known that I, CHARLES C. WORTHINGTON, a citizen of the United States, residing at Irvington, county of Westchester, and State of New York, have invented certain new and useful Improvements in Direct-Acting Engines, fully described and represented in the following specification and the accompanying drawings, forming a part of the same.

This invention relates to a vertically-arranged duplex engine, which is especially designed to permit of the use of steam expansively, and also to secure the balancing of the parts, so that the available power exerted by the steam-pistons will be the same or substantially the same upon the up and down strokes.

As a full understanding of the invention can be best given by an illustration and a detailed description of an organized engine embodying the same, all preliminary description of the invention will be omitted and a detailed description given, reference being had to the accompanying drawings, in which—

Figure 1 is a side elevation of an engine organized according to the present invention. Fig. 2 is a plan view of the same; and Fig. 3 is a horizontal section of one side of the engine, taken on the line 3 of Fig. 1.

Referring to said drawings, it is to be understood that the engine as therein shown consists, primarily, of two high-pressure steam-cylinders A B and two low-pressure steam-cylinders C D. The cylinders A C form one side of the duplex engine and the cylinders B D the other side, the two cylinders forming each side of the engine being arranged side by side in vertical position and being connected so as to use the steam upon the compound principle. The cylinders are provided with induction and exhaust valves of ordinary construction, and the piston-rods *a b* of the cylinders A B are provided with the usual connections E, by which the valve of each cylinder is operated from the piston-rod of the other in the manner common in duplex engines, the piston-rods *c d* being provided with similar connections F, by which the valves of those cylinders are operated in the same manner. The steam is supplied to the cylinders A B through induction-pipe G, and after performing its work in these cylinders is exhausted through pipes H and enters the low-pressure cylinders C D, where it acts at a reduced pressure and is then exhausted through pipes I to the condenser or to the open air, the same as is usual in compound engines. In those cases where the pistons of the two cylinders forming the compound engine act upon the same rod, which is the more common organization, the valves of the two cylinders are of course arranged so that the steam acts upon the pistons of the two cylinders in the same direction at the same time. In the present case, however, the valves of the two cylinders forming each side of the duplex engine are arranged so that the steam acts upon their pistons in opposite directions—that is to say, the valves are so arranged that when the steam is acting upon the upper side of the piston of the cylinder A to drive the piston downward the exhaust-steam from the cylinder A will act upon the under side of the piston of the cylinder C to drive that piston upward, and vice versa, and the valves of the cylinders B D are arranged in the same manner.

Fulcrumed upon the frame-work beneath the main steam-cylinders are a pair of rocking beams K L, which are respectively connected by links *f* with the piston-rods *a c* and *b d*. By this means the pistons of the cylinders A C and the parts connected therewith are caused to move in unison, one piston and its connected parts making the upstroke while the other piston and its connected parts are making the downstroke, thus causing the weight of the descending piston and its connected parts to be counterbalanced or substantially counterbalanced by the weight of the ascending piston and its connected parts, thus balancing the engine and causing the available power exerted upon the pistons to be the same upon the up and down strokes. The beams K L are provided with openings *g* for the passage of the piston-rods *a b c d*, as indicated in Fig. 3, and the links *f* are connected to bearings projecting from the sides of the beams, and also to corresponding bearings projecting from the sides of heads or collars secured to the piston-rods, as indicated in Fig. 1. The ends of the beams K L, which project beyond the piston-rods, are provided with bearings *h*, which receive heads *i*, formed upon the ends of the piston-rods *p* of two

pairs of oscillating compensating cylinders *k*, which are provided with trunnions supported in suitable bearings *l* upon the frame-work. These compensating cylinders are supplied with a motor-fluid under suitable pressure, which may be steam, air, or liquid, through pipes *m*, which communicate with one of the trunnions of each cylinder, and are arranged, substantially as described in my prior Letters Patent No. 292,525. The pressure for the motor-fluid supplied to the compensating cylinders may be derived in any of the various ways described in my prior Letters Patent Nos. 292,525, 309,676, 332,857, and 341,534. The compensating cylinders are so arranged with relation to the beams K L as to offer a gradually-decreasing resistance to the pistons of the main cylinders A C and B D during the first part of their strokes and a gradually-increasing assistance during the last parts of their strokes, in the same manner as fully described in my prior Letters Patent before referred to.

The operation of the engine thus organized is as follows: In describing this operation it will be assumed that the piston of the cylinder C has completed its downstroke and the piston of the cylinder A its upstroke, thereby bringing the compensating cylinders and the beam K to the position indicated by dotted lines in Fig. 1, and that the pistons of the cylinders A C are ready to commence their strokes in the opposite directions. It will be observed that when the beam K is in this position the angle of the rods *p* of the compensating cylinders *k* with relation to the beam K is such as to resist the downward movement of the piston of the cylinder A and the upward movement of the piston of the cylinder C. During the first part of the strokes of the pistons of these cylinders the power developed by the steam against their pistons will therefore be resisted by the power developed in the compensating cylinders; but as the pistons of the main steam-cylinders proceed upon their strokes this resistance will, owing to the constantly-changing angle at which the piston-rods of the compensating cylinders act upon the beam K, be gradually reduced until the pistons of the cylinders A C arrive at the middle of their strokes, as indicated by full lines in Fig. 1, at which time the piston-rods of the compensating cylinders will be brought into line and will therefore oppose each other but offer no resistance to the pistons of the main steam-cylinders. During the last part of the stroke of the pistons of the main steam-cylinders the operation will be reversed and the pistons of the compensating cylinders will offer a gradually-increasing assistance to the main steam-pistons, all as more fully set forth in my prior Letters Patent referred to. The operation of the compensating cylinders in connection with the steam-cylinders B D, forming the opposite side of the engine, will of course be exactly the same. This operation of the compensating cylinders permits the admission of steam to the cylinders A B C D to be cut off after the pistons of those cylinders have completed part of their stroke, thus allowing the remainder of the stroke to be made by the expansive force of the steam in the cylinders aided by the power exerted by the compensating cylinders. The engine will therefore be provided with suitable cut-off valves, as *n*, which may be operated in any suitable way—as, for example, in the manner described in my prior Letters Patent No. 342,669.

By the employment of the beams K L for connecting the piston-rods of the two cylinders forming each side of the engine and thus balancing the engine, and by causing the piston-rods of the compensating cylinders to act upon the ends of these beams instead of upon the piston-rods *a b c d*, it becomes feasible to employ but two of the compensating cylinders for each side of the engine, whereas, if the compensating cylinders were not arranged to act upon the beams it would be necessary to employ four of these cylinders for each side of the engine—two for each of the piston-rods—or else to provide the piston-rods with cross-heads and bearings to resist the thrust of the pistons of the compensating cylinders and prevent distortion of the rods. Another advantage resulting from the use of the rocking beams in connection with the compensating cylinders is due to the fact that the employment of the beams permits the piston-rods of the compensating cylinders to occupy a position more nearly parallel with the main piston-rods at the commencement and termination of the stroke of the engine, and thus offer a proportionately greater opposition and assistance to the main pistons. This permits the compensating cylinders to be reduced in size without reducing their effectiveness.

The invention, although herein shown as applied to a compound engine, is not limited in its application to an engine of this character, but is designed to and may be applied equally well to engines which do not use steam upon the compound principle and also to single as well as duplex engines. In some cases, also, but a single compensating cylinder may be employed for each of the rocking beams; but it will usually be preferable to employ two, as shown.

What I claim is—

1. The combination, with two main steam-cylinders, as A C, of a rocking beam connecting the piston-rods of the two cylinders, and a compensating cylinder or cylinders *k*, having a piston or pistons acting upon said beam and arranged to offer a gradually-decreasing resistance to the pistons of the main cylinders during the first part of their strokes and a gradually-increasing assistance during the last part of their strokes, substantially as described.

2. The combination, with two vertical main cylinders, as A C, of a rocking beam connecting the piston-rods of the two cylinders, and

a compensating cylinder and piston acting upon each end of the beam and arranged to offer a gradually-decreasing resistance to the pistons of the main cylinders during the first part of their strokes and a gradually-increasing assistance during the last part of their strokes, substantially as described.

3. The combination, with four vertical main steam-cylinders forming the two sides of a duplex engine, of rocking beams K L, connecting the piston-rods of the two cylinders forming each side of the engine, and compensating cylinders having pistons acting upon each of said beams and arranged to offer a gradually-decreasing resistance to the pistons of the main cylinders during the first part of their strokes and a gradually-increasing assistance during the last part of their strokes, substantially as described.

4. The combination, with two main steam-cylinders, as A C, of a rocking connection between the piston-rods of the two cylinders, whereby power exerted upon one piston-rod is transferred to the other, and a compensating cylinder or cylinders *k*, having a piston or pistons arranged to offer a gradually-decreasing resistance to the pistons of the main cylinders during the first part of their strokes and a gradually-increasing assistance during the last part of their strokes, substantially as described.

5. The combination, with two main steam-cylinders, as A C, of a rocking connection between the piston-rods of the two cylinders, whereby power exerted upon one piston-rod is transferred positively to the other, and a compensating cylinder or cylinders *k*, having a piston or pistons arranged to offer a gradually-decreasing resistance to the pistons of the main cylinders during the first part of their strokes and a gradually-increasing assistance during the last part of their strokes, substantially as described.

In testimony whereof I have hereto set my hand in the presence of two subscribing witnesses.

CHARLES C. WORTHINGTON.

Witnesses:

I. F. HOLLOWAY,

D. H. JOHNSON.