(No Model.) 3 Sheets—Sheet 1.

T. MAIN.

BALANCED COMPOUND ENGINE.

No. 354,644. Patented Dec. 21, 1886.

Fig. 1.

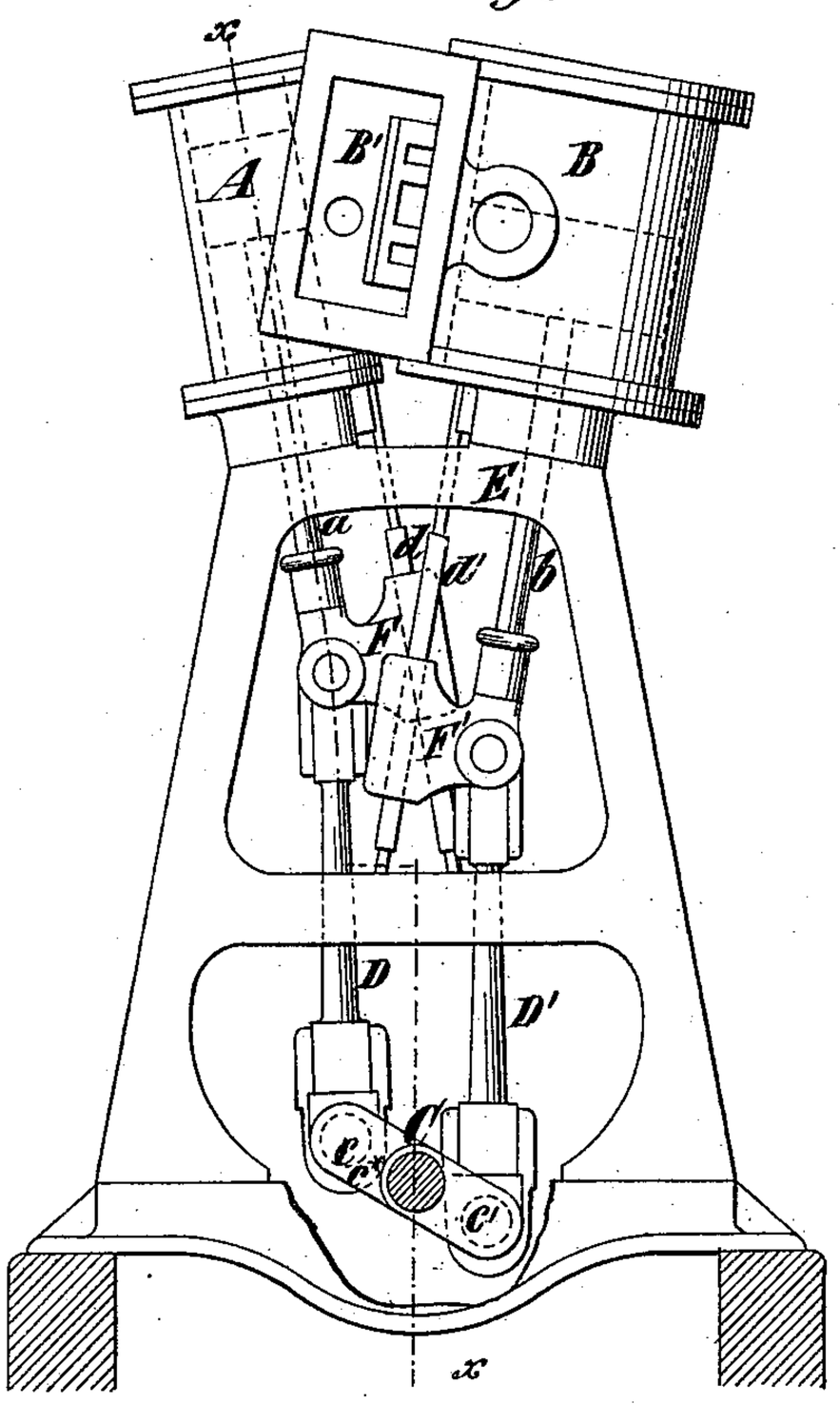


Fig. 2.

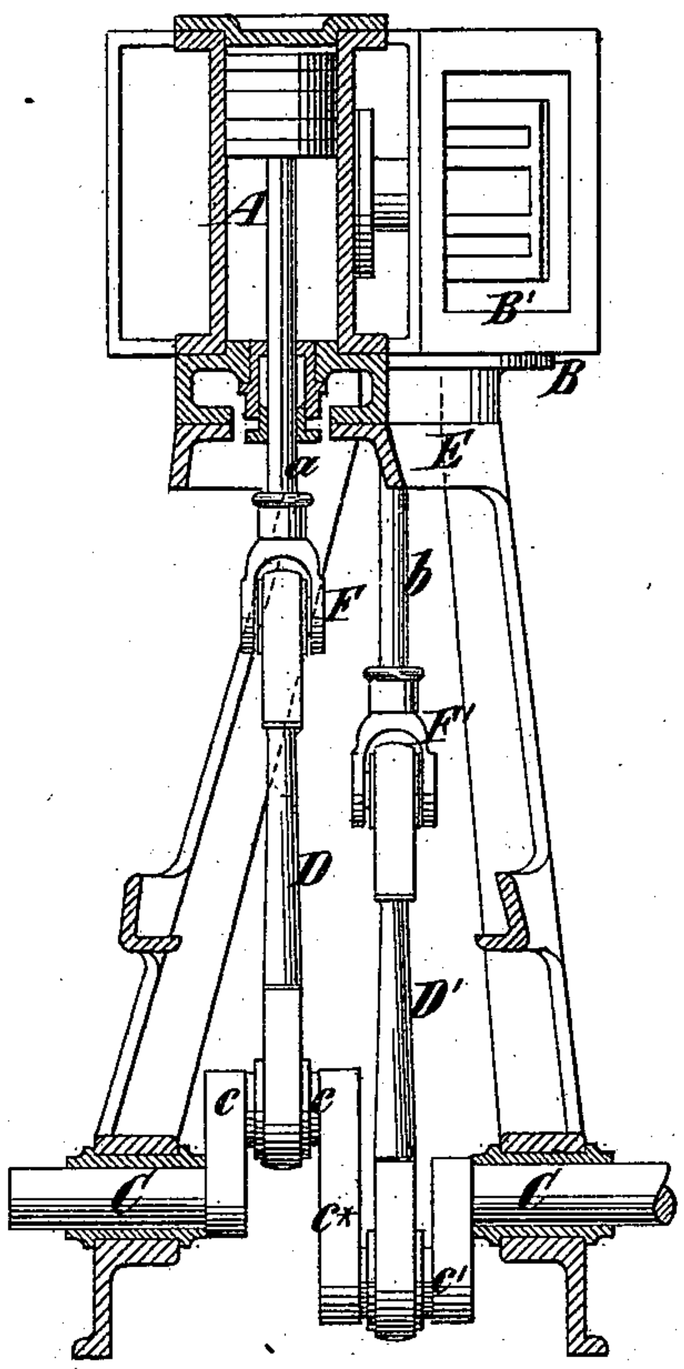


Fig. 3.

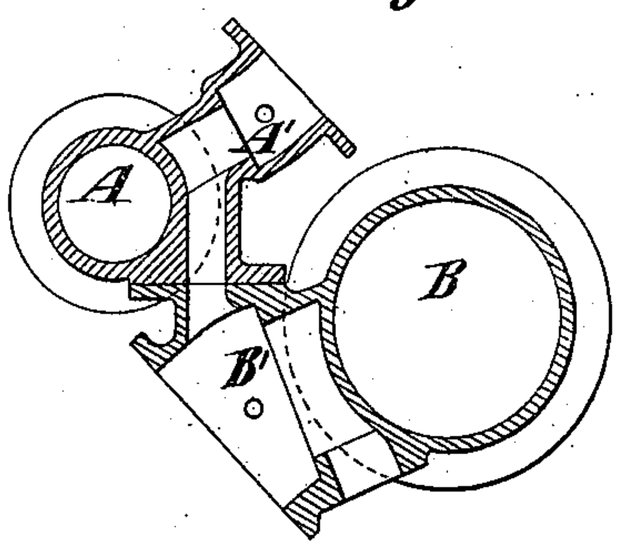
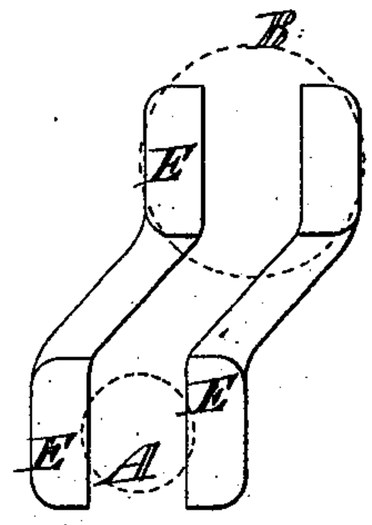


Fig. 4.



Witnesses.
Emil Herter.
C. L. Sundgren

Inventor:
Thomas Main
by his Attys
Brown & Hall

(No Model.) 3 Sheets—Sheet 2.

T. MAIN.

BALANCED COMPOUND ENGINE.

No. 354,644. Patented Dec. 21, 1886.

Fig. 5.

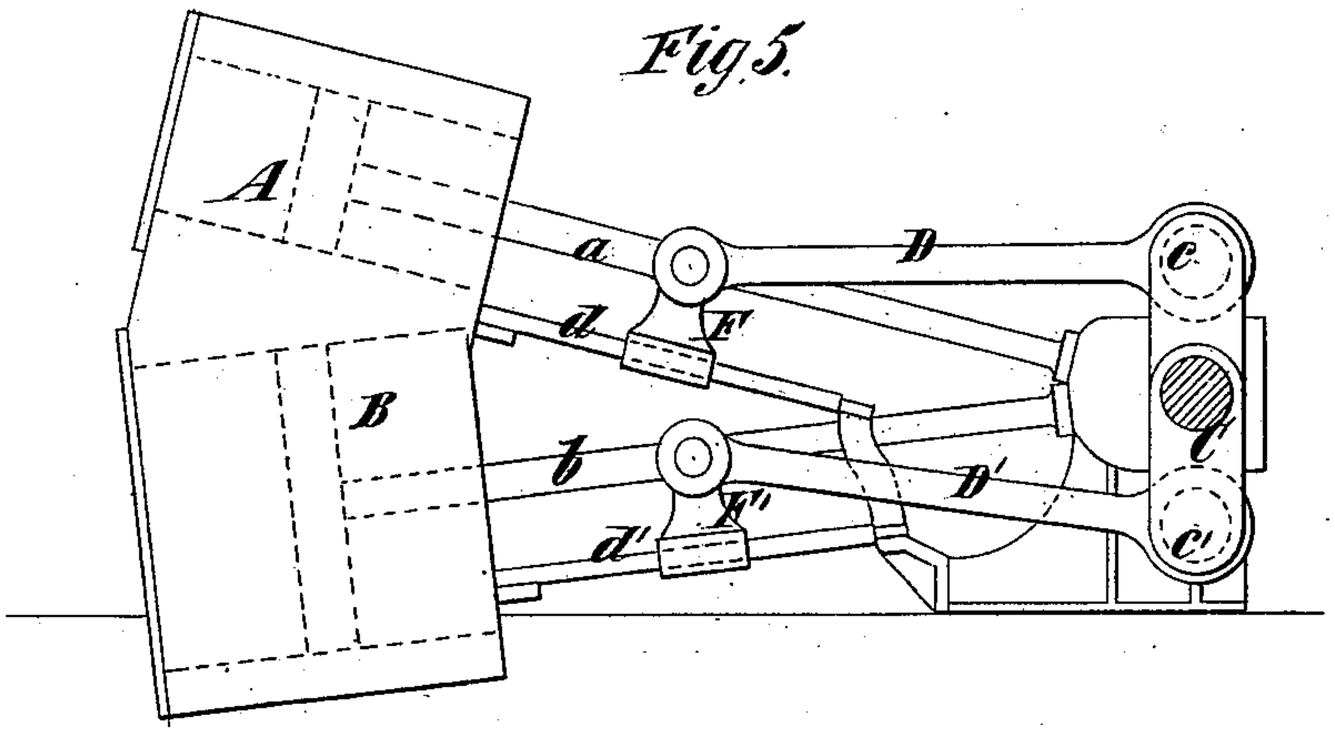


Fig. 6.

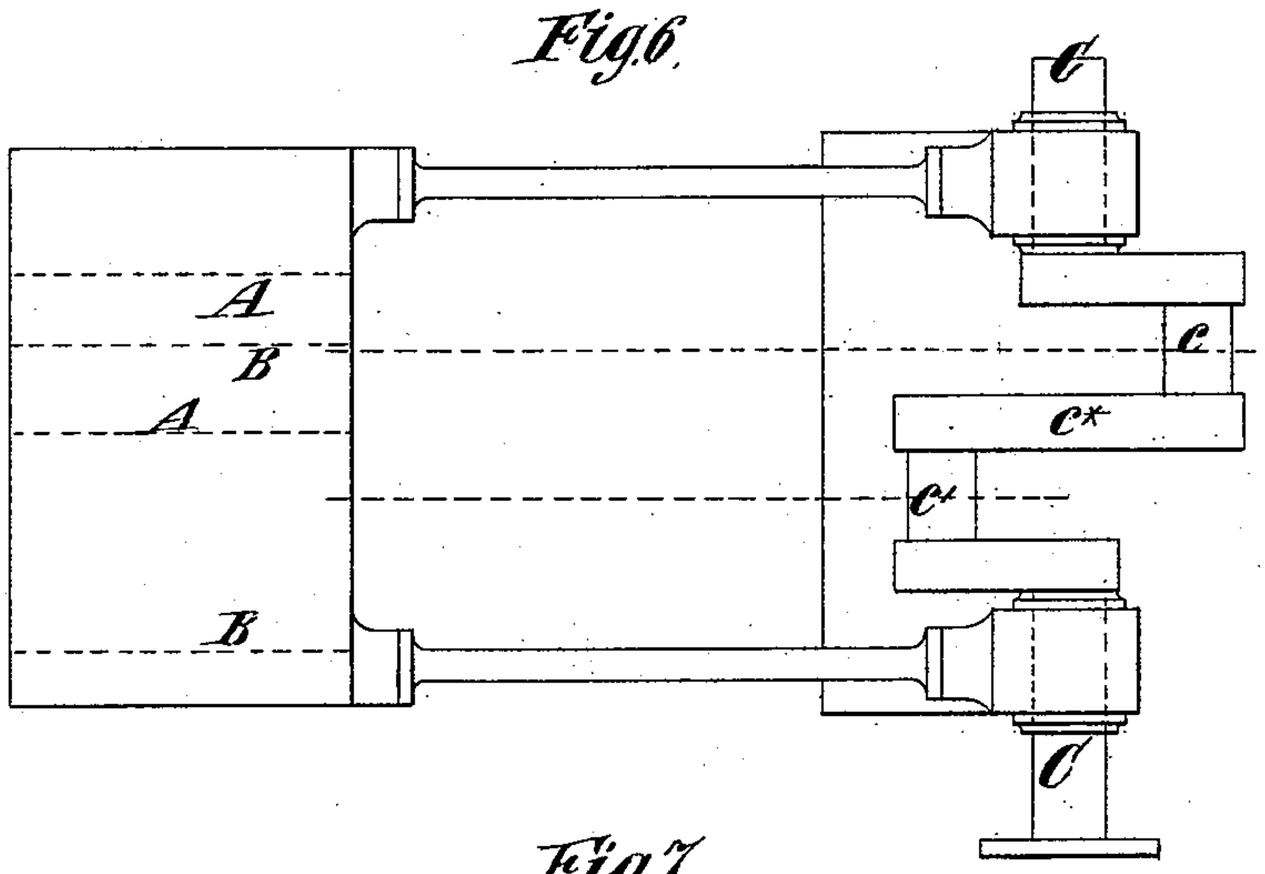
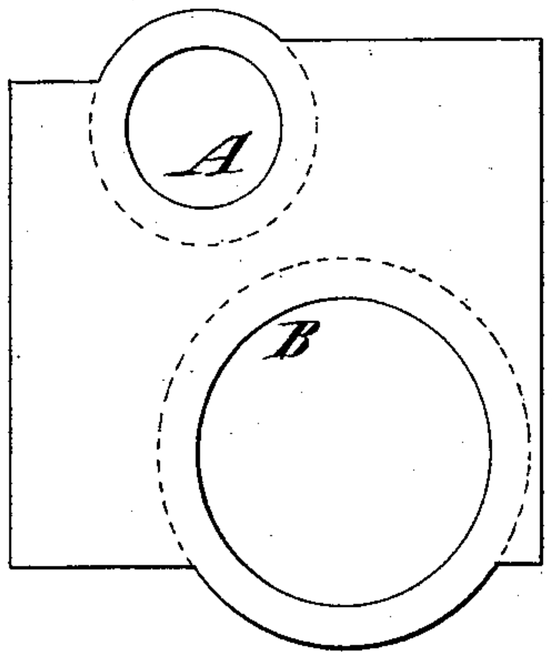


Fig. 7.



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(No Model.) 3 Sheets—Sheet 3.

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BALANCED COMPOUND ENGINE.

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Fig. 8.

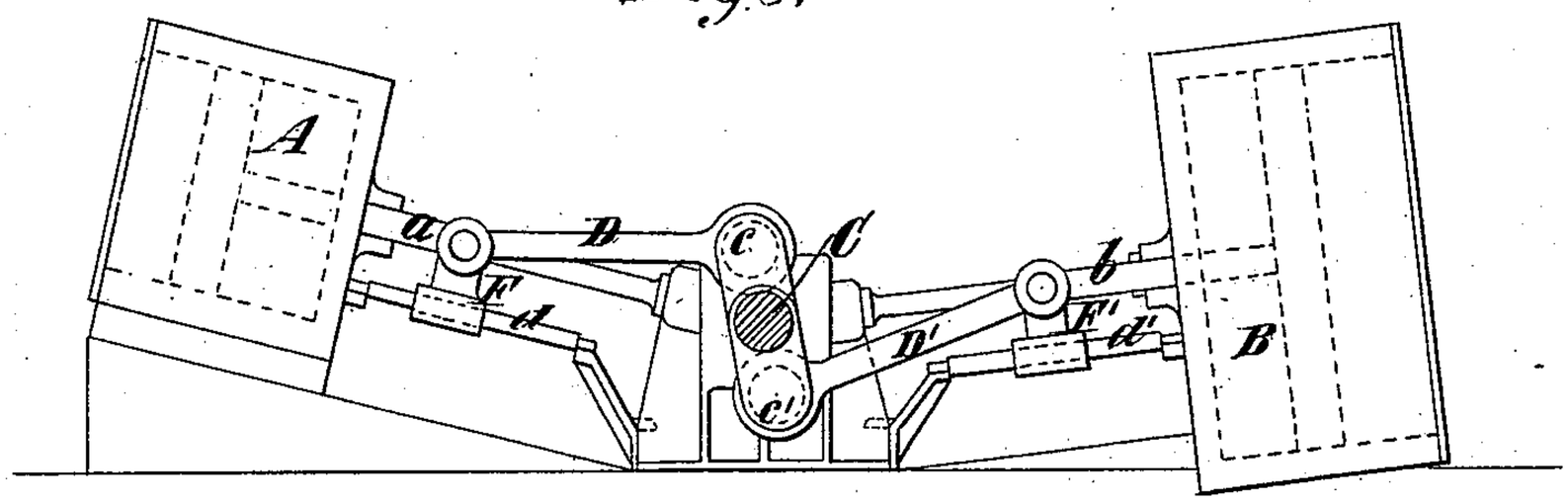
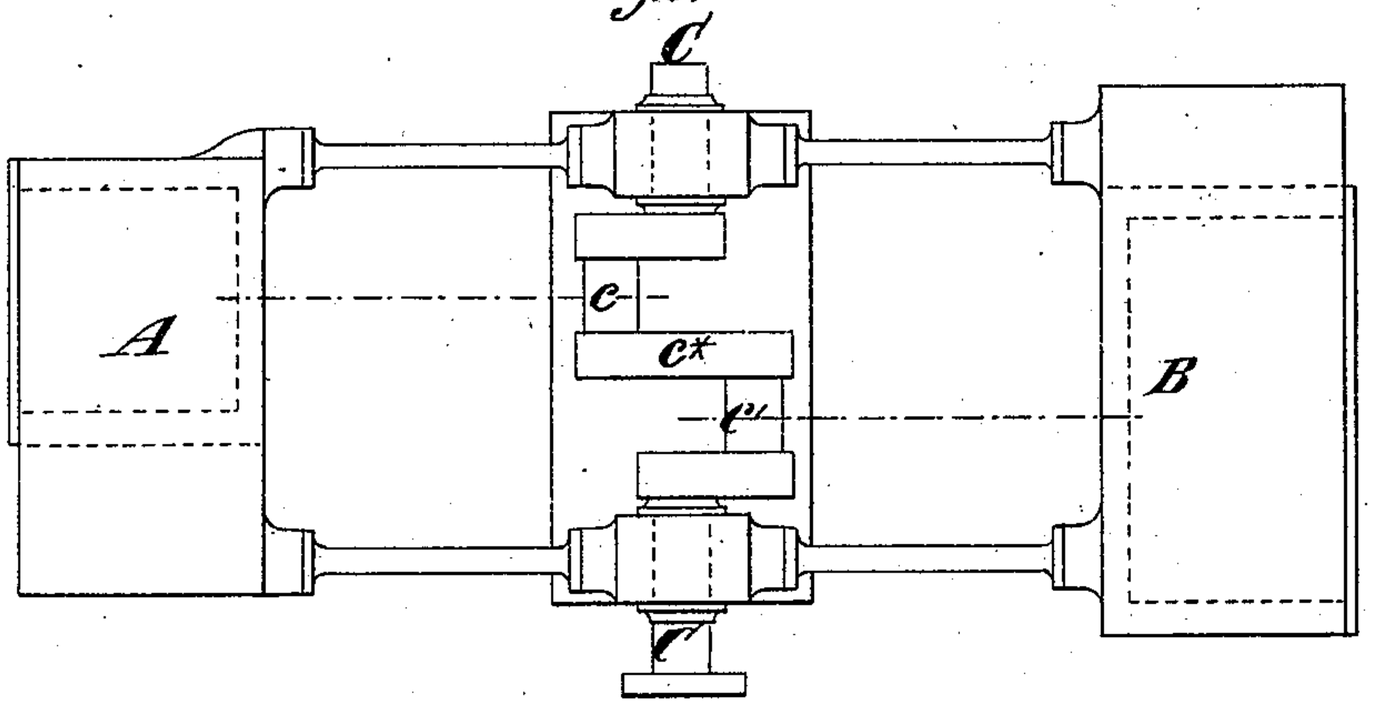


Fig. 9.



Witnesses.
Emil Herter.
C. L. Sundgren

Inventor:
Thomas Main
by his attys
Brown & Hall

UNITED STATES PATENT OFFICE.

THOMAS MAIN, OF NEW YORK, N. Y.

BALANCED COMPOUND ENGINE.

SPECIFICATION forming part of Letters Patent No. 354,644, dated December 21, 1886.

Application filed March 1, 1886. Serial No. 193,567. (No model.)

To all whom it may concern:

Be it known that I, THOMAS MAIN, of the city and county of New York, in the State of New York, have invented a new and useful Improvement in Balanced Compound Engines, of which the following is a specification.

My invention relates to double-acting engines having balanced crank-shafts, the two cranks being arranged at opposite points and balancing each other; and the invention consists in the novel combination, with a balanced crank-shaft having auger-handle cranks, the crank-pins being separated only by a single member or arm which extends transversely to the axis of the shaft, of double-acting high and low pressure cylinders, the pistons of which are connected with the opposite cranks, and each of which is arranged at an angle of about twenty degrees (20°) relatively to an axial line through the other cylinder. By this combination the moving parts are balanced and vibration obviated, and the working-pressures are always balanced, thereby reducing the friction of the crank-shaft journals and their tendency to heat.

By this invention I enable compound engines to be run at an increased speed, and so obtain the required power with smaller engines at a reduced weight and cost, and with less cylinder-condensation.

In the accompanying drawings, Figure 1 is an elevation of a vertical compound engine embodying my invention in a plane at right angles to the crank-shaft. Fig. 2 is a sectional elevation on the plane of the dotted line *x x*, Fig. 1. Fig. 3 is a horizontal section through the two cylinders and their valve-chests. Fig. 4 is a plan of the upper portion of the frame and a dotted outline of the cylinders, showing their position thereon. Fig. 5 is a side elevation, and Fig. 6 a plan, of an approximately-horizontal engine, also embodying my invention; and Fig. 7 is an end view of the cylinder structure, showing the position of the two cylinders relatively to each other. Figs. 8 and 9 are respectively a side elevation and plan of a compound engine embodying a modification of my invention.

Similar letters of reference designate corresponding parts in all the figures.

In the drawings I have omitted all parts not necessary to a clear understanding of the invention, in order that it may be more clearly understood.

Referring first to Figs. 1, 2, 3, and 4, A B designate, respectively, the high and low pressure cylinders of a compound engine, which are arranged radially to a balanced crank-shaft, C, and each of which stands at an angle of about twenty degrees (20°,) more or less, relatively to an axial line drawn through the other cylinder. The crank-shaft C has two cranks, *c c'*, placed opposite each other, and the connecting-rods D D' are placed as near together, side by side, as the crank-pins and the center member, *c**, between the cranks will allow. This arrangement of the cranks and connecting-rods entails the lapping of the cylinders A B, one on another, as shown best in Fig. 3, and the framing E of the engine is offset so as to support the cylinders in these positions, as shown in Fig. 4. The steam-chests A' B' are presented on opposite sides of the cylinders, as shown in Fig. 3. The placing of the cylinders at about the angle shown with each other prevents them from interfering when the cranks and connecting-rods are as near together as shown in Fig. 2. By the arrangement of the cranks and connecting-rods shown in Fig. 2 the working-pressures on the pistons may be exerted as nearly as possible in a straight line, and the arrangement of the cylinders at an angle is utilized in preventing dead-centers, while the balancing is not affected.

F F' designate the cross-heads, with which are connected the piston-rods *a b* and the connecting-rods D D', and which are fitted to suitable guides, *d d'*, in the usual manner. The cranks *c c'*, the connecting-rods D D', the cross-heads F F', and the piston-rods *a b* will exactly balance and the pistons will almost balance, and there will, therefore, be no vibration in the engine when running at a high speed. The working-pressures on the pistons will always act in opposite directions, and consequently the opposing forces will meet in the crank-shaft and be very little felt on the journals. They will simply control the shaft and support the weight of the moving parts, and the engine may be run at a high speed without heating of journals. The most severe action will be felt on the crank-pins, and this may be provided for by using phosphor-bronze

boxes and good lubricators. Such an engine as is shown in Figs. 1, 2, 3, and 4 may be used either for marine or stationary work.

In Figs. 5, 6, and 7 I have represented an approximately-horizontal engine for twin-screw steamships, and which may be arranged below the water-line. The same description of the arrangement of the cylinders A B and the connecting-rods and cranks applies as well to these figures as to Figs. 1, 2, and 3, and the same letters of reference are used to designate the parts.

In Figs. 8 and 9 I have represented another form of engine embodying the elements of my invention, and which may be employed for single-screw steamships. In this case the high and low pressure cylinders A B are arranged on opposite sides of the crank-shaft, but here also each cylinder is set at an angle of about twenty degrees (20°) relatively to an axial line drawn through the other cylinder. In these Figs. 8 and 9 the same letters of reference are used to designate the parts as are used for the before-described figures.

The essential object which I have sought to obtain by my invention is to provide a compound engine which may be run at a very high speed without vibration. This object can only be obtained by balancing the pressure upon the crank-pins, and also upon the crank-shaft journals. The advantages of a high-speed compound engine are very great. By the use of a small, light, and comparatively inexpensive machine a high power may be obtained very much more economically, because the loss by condensation will be very greatly reduced. To secure these results the cylinders and pistons of the engine must be double acting, and the pistons must move throughout substantially the whole of their stroke in directions reverse to each other, so that while the pressure from one piston is transmitted downward to the crank-pin and shaft-bearings the pressure from the other piston will exert an upward pull on the crank-pin and shaft-bearings, thus almost perfectly balancing the pressure upon the crank-shaft bearings and crank-pins; hence if the two cylinders and pistons of my engine were single acting the desired results would not be secured, because the pressure on the crank-pins and crank-shaft journals would always be downward, or in one direction, and the friction on the shaft-bearings would be excessive. To secure all the advantages of my invention the cylinders and pistons must be double acting, and the cranks must be set at opposite points and be of equal length to balance each other.

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

The combination, with a balanced crank-shaft having auger-handle cranks, the two crank-pins being separated only by a transverse member or arm, *c**, of double-acting high and low pressure cylinders, the pistons of which are connected with the opposite cranks, and each of which is arranged at an angle of about twenty degrees (20°) relatively to an axial line through the other cylinder, substantially as and for the purpose herein described.

THOMAS MAIN.

Witnesses:
FREDK. HAYNES,
EMIL HERTER.