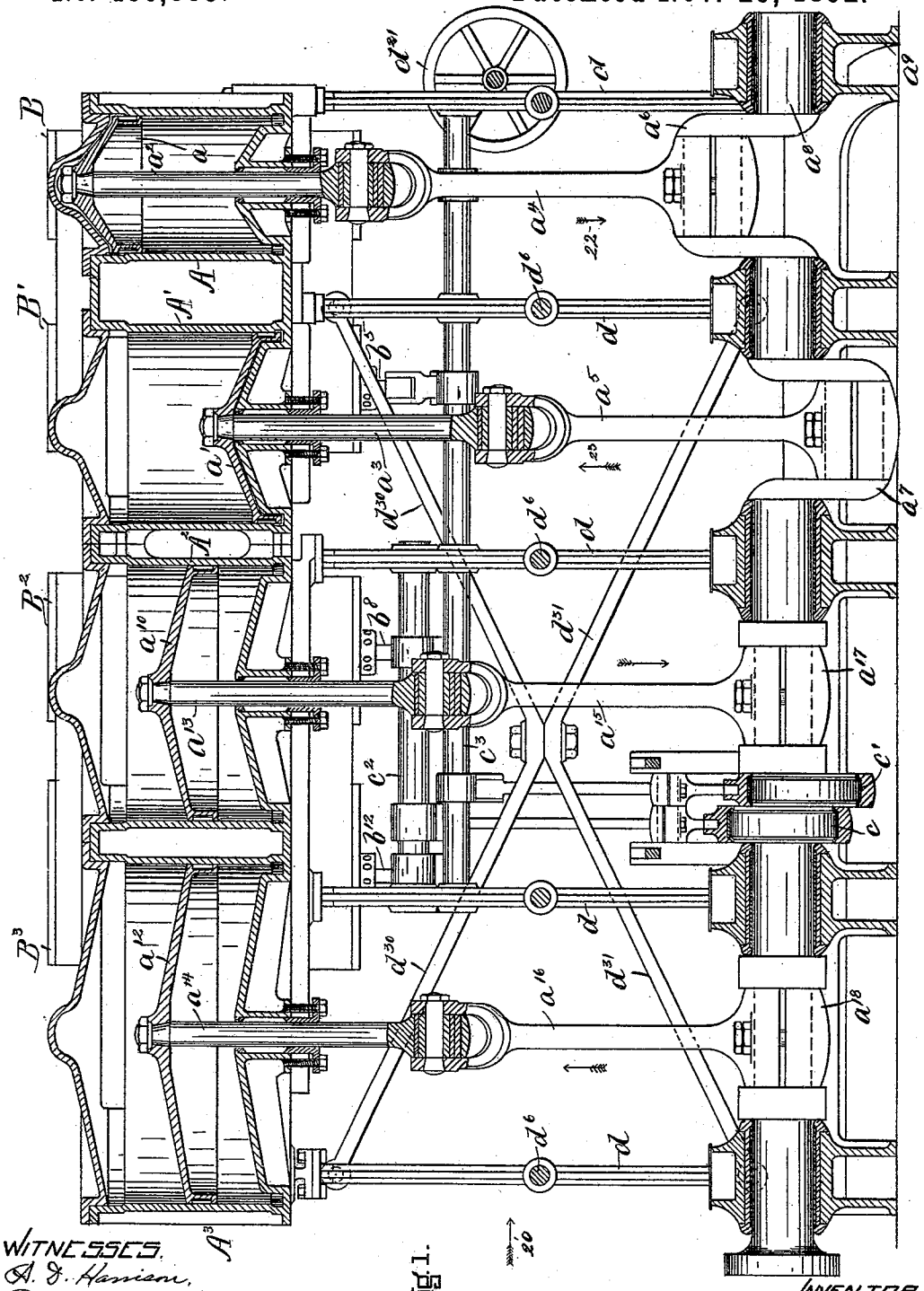
(No Model.) 4 Sheets—Sheet 1.

C. D. MOSHER.

STEAM ENGINE.

No. 486,883. Patented Nov. 29, 1892.



WITNESSES.
A. J. Harrison,
B. A. McShane.

Fig 1.

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(No Model.)

4 Sheets—Sheet 2.

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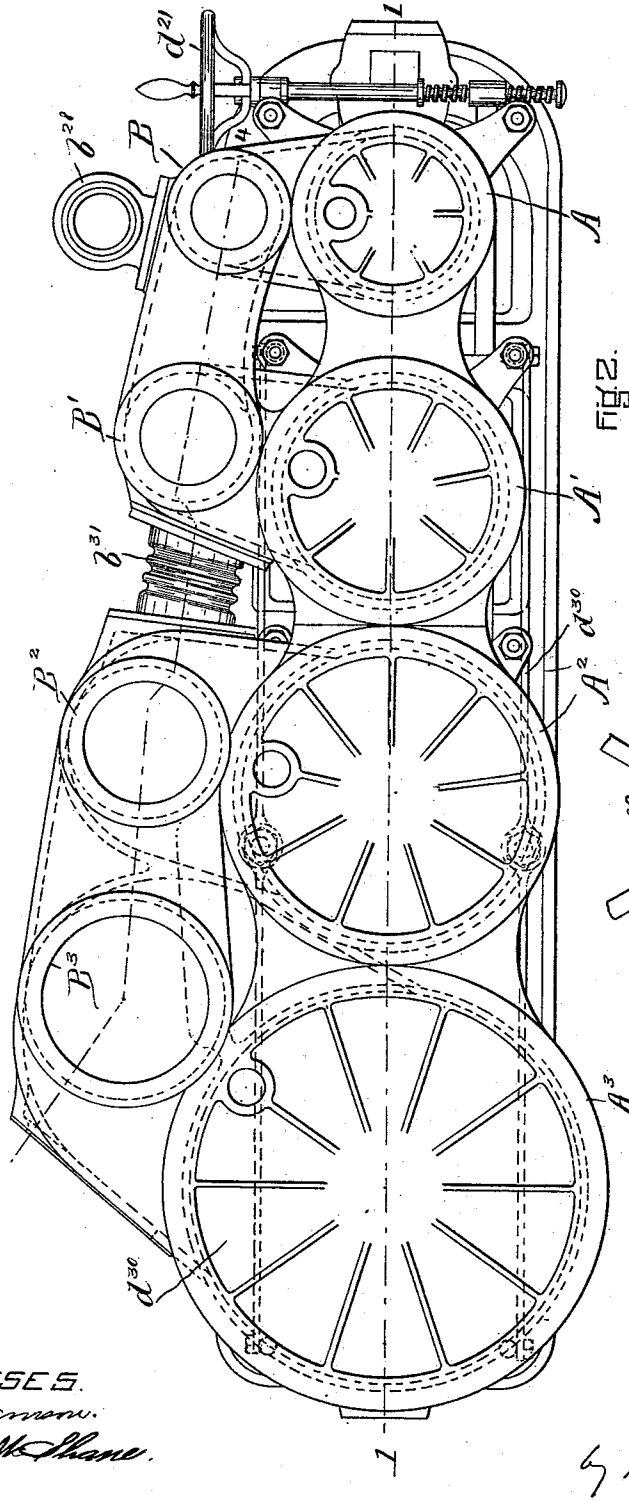

Fig. 2.

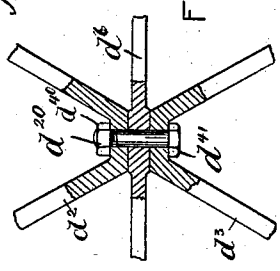

Fig. 5.

WITNESSES.
A. D. Harmon.
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Attys.

(No Model.) 4 Sheets—Sheet 3.

C. D. MOSHER.

STEAM ENGINE.

No. 486,883. Patented Nov. 29, 1892.

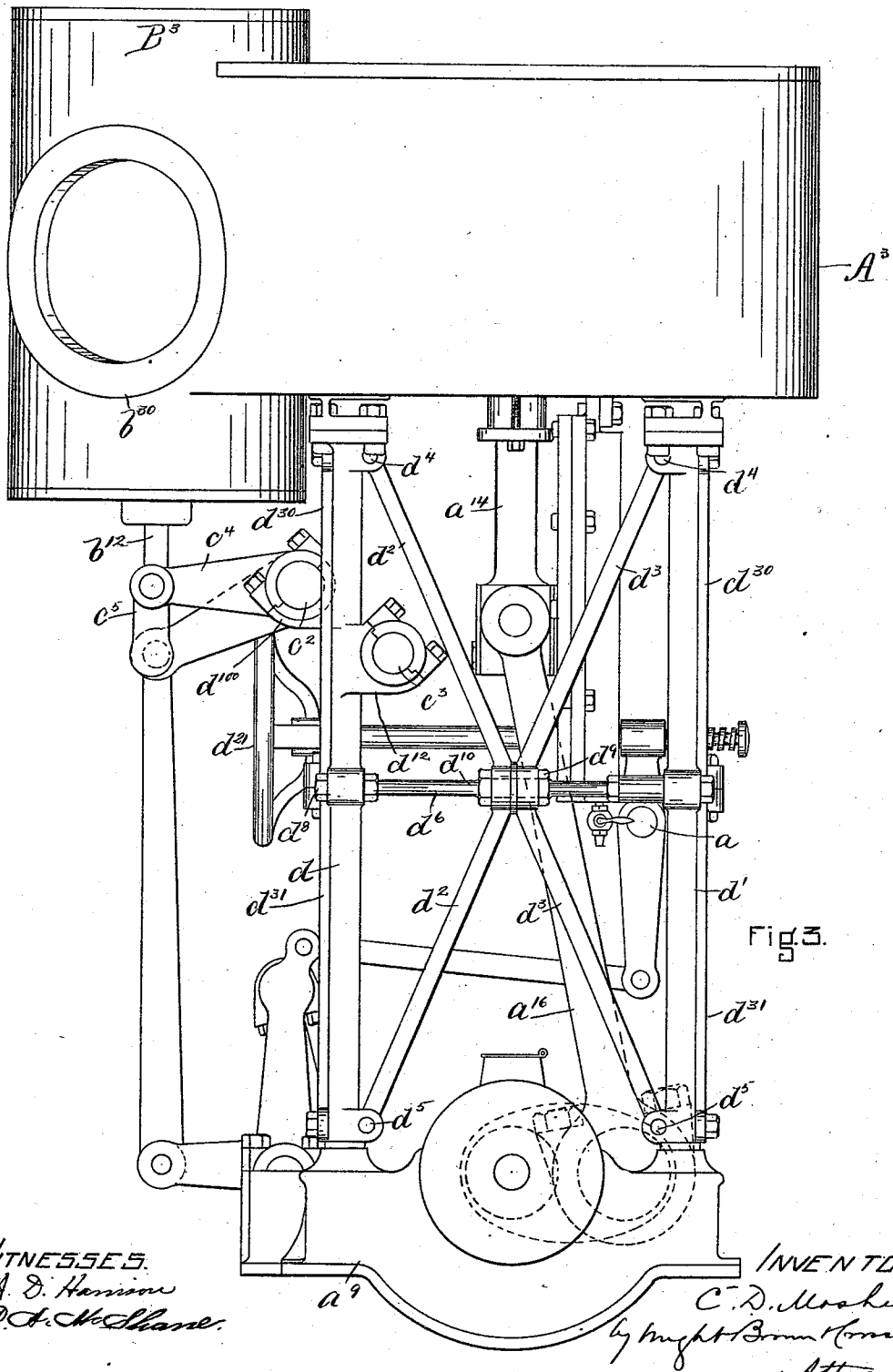

Fig. 3.

WITNESSES.
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(No Model.) 4 Sheets—Sheet 4.

C. D. MOSHER.

STEAM ENGINE.

No. 486,883. Patented Nov. 29, 1892.

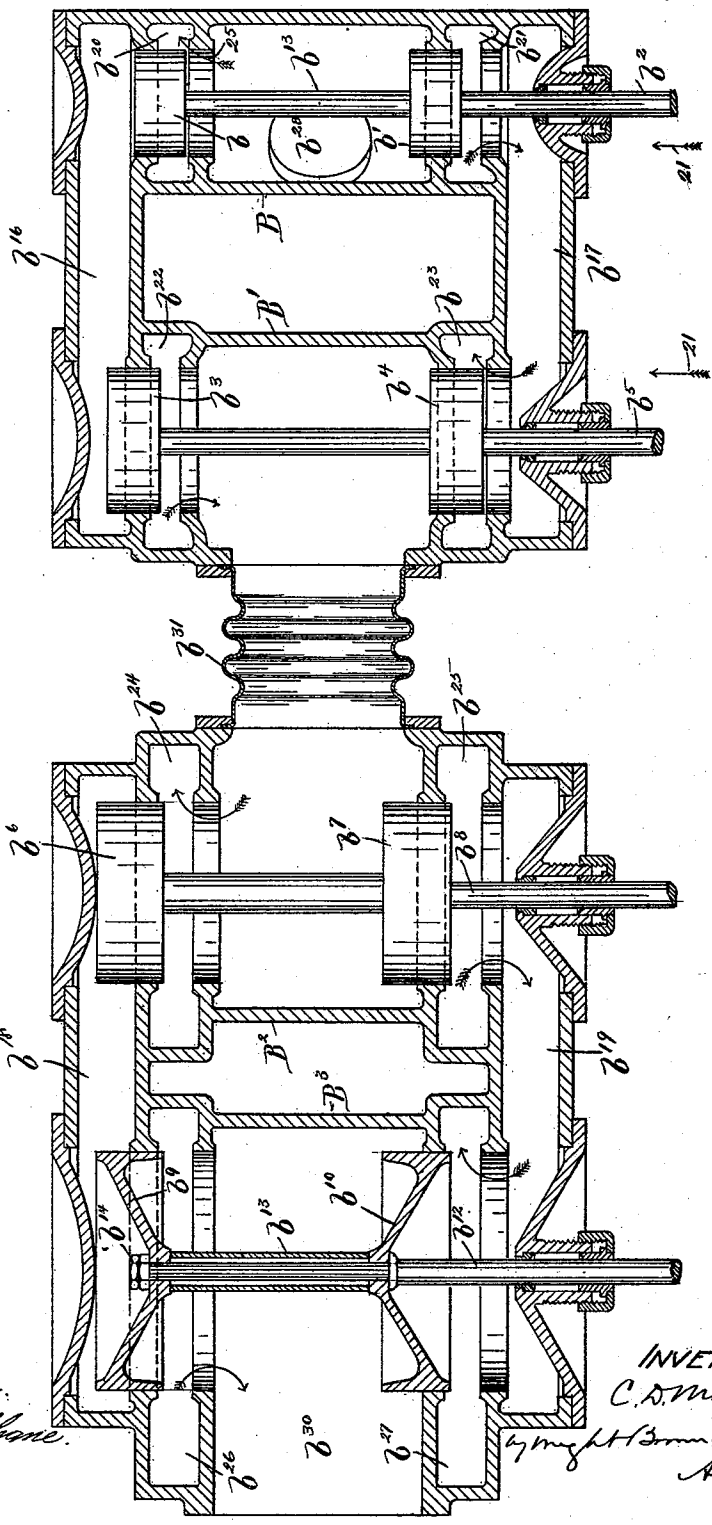

Fig. 4.

WITNESSES.
A. D. Harrison.
B. A. McShane.

INVENTOR.
C. D. Mosher
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UNITED STATES PATENT OFFICE.

CHARLES D. MOSHER, OF AMESBURY, MASSACHUSETTS.

STEAM-ENGINE.

SPECIFICATION forming part of Letters Patent No. 486,883, dated November 29, 1892

Application filed October 19, 1891. Serial No. 409,137. (No model.)

To all whom it may concern:

Be it known that I, CHARLES D. MOSHER, of Amesbury, in the county of Essex and State of Massachusetts, have invented certain new and useful Improvements in Steam-Engines, of which the following is a specification.

This invention in steam-engines has for its object to improve the construction of the same, whereby a strong, durable, and efficient engine is obtained.

My improved engine is of the class known as the "quadruple-expansion" engine; and one of the features of my invention consists in a novel construction and arrangement of the cylinders and their valves, as will be described, whereby a straight unobstructed path is afforded through the various cylinders from the high pressure to the low pressure, and whereby the valves for the said cylinders may be operated from two eccentrics on the main or crank shaft. The cylinders and their valves are supported above a bed-plate by a novel framework consisting of columns and braces, as will be described, constructed and adjusted so that the columns are subjected to a compressive strain at all times and the braces are subjected to a tensile strain, which construction and adjustment makes the frame of the engine rigid and prevents all vibration of the engine due to elasticity of the frame thereof, so that a smoother-running engine is obtained. The valves controlling the admission of steam to their respective cylinders are preferably operated from two rock-shafts connected to the eccentrics on the main or crank shaft.

Other features of my invention will be pointed out in the claims at the end of this specification.

Figure 1 is a partial section and elevation of a quadruplex-expansion engine embodying my invention, the section being taken on the line 1 1, Fig. 2. Fig. 2 is a top or plan view of the engine shown in Fig. 1. Fig. 3 is an end elevation of the engine shown in Fig. 1, looking in the direction of the arrow 20 thereon. Fig. 4 is a vertical section through the valve-cylinders on the line 4 4, Fig. 2; and Fig. 5, a modified form of brace to be referred to.

My improved engine consists, essentially, of four upright cylinders A, A′, A^2, and A^3, the cylinders A and A^3 constituting the high and low pressure cylinders, respectively, and the cylinders A′ and A^2 constituting the intermediate cylinders. The cylinders have cooperating with them valve chests or cylinders B B′ B^2 B^3, and the said steam and valve cylinders are formed in pairs, each pair being formed in one casting. The steam-cylinders A and A′ are provided with pistons a a', having their piston-rods a^2 a^3 joined by connecting-rods a^4 a^5 to cranks a^6 a^7 on the crank-shaft a^8, mounted in suitable bearings on the bed-plate or foundation a^9, and the steam-cylinders A^2 A^3 are provided with like pistons a^{10} a^{12}, having their piston-rods a^{13} a^{14} joined by connecting-rods a^{15} a^{16} to cranks a^{17} a^{18} on the crank-shaft a^8. The cranks a^6 a^7 are set at substantially one hundred and eighty degrees apart, and the cranks a^{17} a^{18} are also set at substantially one hundred and eighty degrees, but are at substantially ninety degrees, or at right angles to the cranks a^6 a^7. The valve-cylinders B B′, cast integral with the first pair of steam-cylinders A A′, are provided with piston-valves, the valve-cylinder B being provided with the piston-valves b b' on the valve-rod b^2, extended through the head of the cylinder B, and the valve-cylinder B′ is provided with two piston-valves b^3 b^4 on the valve-rod b^5. The valve-cylinder B^2 is also provided with two piston-valves b^6 b^7 on the valve-rod b^8, and the valve-cylinder B^3 is provided with two piston-valves b^9 b^{10} on the valve-rod b^{12}. The two piston-valves in each valve-cylinder are preferably connected together by a hollow wrist or tube b^{13}, as best shown in section at left of Fig. 4, and the valve-rod is extended through the hollow wrist b^{13} and through the upper valve of the pair and secured by a nut b^{14}.

The valve chests or cylinders B B′ are provided at their upper and lower ends with connecting ports or passages b^{16} b^{17}, and the valve-cylinders B^2 B^3 are connected by like ports or passages b^{18} b^{19}. These ports or passages are substantially straight and afford an unobstructed passage for the steam. The valve-chest B is connected at its upper end with the upper part of the high-pressure cylinder A by the port b^{20}, and at its lower end the said valve chest or cylinder is connected to the lower part of the high-pressure cylinder by

the port b^{21}. The valve-chest B′ is connected in like manner to the first intermediate cylinder A′ by the ports b^{22} b^{23}, and the valve-cylinder B^2 is also connected to the top and bottom of the second intermediate cylinder A^2 by the ports b^{24} b^{25}, while the valve-cylinder B^3 is connected in like manner to the top and bottom of the low-pressure cylinder A^3 by the ports b^{26} b^{27}. The high-pressure cylinder is connected to the boiler or other source of supply by the steam-inlet pipe b^{28}, Fig. 4, the said pipe communicating with the valve-cylinder B intermediate of the piston-valves b b', and the valve-cylinder B^3 intermediate of its valves is connected to the exhaust-pipe by the port b^{30}. The valve-cylinder B′, co-operating with the first intermediate steam-cylinder, is connected to the valve-cylinder B^2, which co-operates with the second intermediate cylinder by the coupling-pipe b^{31}, preferably made corrugated, as herein shown.

The arrangement of the valves and the ports in the valve-cylinders, as just described, enables the piston-rods of each pair of valve-cylinders to move in the same direction, and consequently the valve-rods of each pair of valves may be driven from a single eccentric, and by means of this construction only two eccentrics c c' are needed to operate the two pairs of valve-rods. The eccentrics c c' are suitably connected, as shown in Figs. 1 and 3, to rock-shafts c^2 c^3, respectively, having bearings in the supporting framework for the cylinders, to be hereinafter specifically described, and the said rock-shafts are connected by suitable arms c^4 and links c^5 to the valve-rods of the piston-valves, the rock-shaft c^3 being connected in this manner to the piston-valve rod b^2 b^5 of the first pair of valves, and the rock-shaft c^2 being connected to the second pair of piston-valve rods b^8 b^{12}. The eccentrics are located between extensions of the axis or center of the cylinder A^2, which is the second intermediate cylinder, and of the cylinder A^3, which is the low-pressure cylinder. These cylinders being of greater diameter than the others, sufficient space is afforded between their centers for the eccentrics without encroachment of the eccentrics on the space required for the shaft-bearings. This arrangement enables me to make the shaft and the total length of the series of cylinders very much shorter without reducing the area of bearing-surface below the proper area or length than by any other possible arrangement. The saving of space thus obtained is very important and desirable in marine engines.

One of the features of this invention consists in providing a supporting-framework for the steam and valve cylinders, whereby the vibration of the engine is prevented. This feature of my invention is accomplished by making the framework of a plurality of columns and connections of braces, said braces being adjusted so that the said columns are at all times under a compressing strain and the braces under a tensile strain, which strain is at all times in excess of the working strains of the engine. The supporting-framework herein shown consists of a plurality of columns d d', arranged in pairs, and adjustable connections between the columns, said connections being adapted to be adjusted so as to subject themselves to a tensile strain and the columns to a compressing strain. I prefer to connect the columns of each pair by braces d^2 d^3, which are preferably diagonal. The braces d^2 d^3 may be formed as shown in Fig. 3, wherein each brace has its opposite ends connected by suitable bolts or pins d^4 d^5 to the upper and lower portions of the same column, and the center portions of the two braces are connected together and to the center of the columns d d' by a rod d^6, secured to the columns d d', as by bolts d^7 d^8 and provided near its center with a threaded portion, which is engaged by nuts d^9 d^{10}, the latter serving to clamp the braces d^2 d^3 firmly together and to put them under the desired tensile strain. The braces are so adjusted that the columns d d' are normally under a compressing strain, which is greater than the strain caused by the working of the engine, the braces being by said adjustment placed under a tensile strain which is also greater than the strain caused by the working of the engine. This tensile strain remains substantially constant during the operation of the engine—that is, on both the up and down strokes of the piston, and by reason of the braces being under a tensile strain greater than the strain caused by the working of the engine the columns are subjected to only a compressing strain, and are not at any time subjected to a tensile strain. It is evident, therefore, that there can be no movement of the frame of the engine until a greater strain is brought on it than that to which the braces are adjusted, so that by suitably adjusting the braces provision is made for resisting any strain that can possibly be exerted under normal working conditions. I am thus enabled to prevent all vibration of the engine, because the braces can be adjusted to prevent the initial or starting movement, without which there can be no vibration. By this construction the danger of fracture due to crystallization of the metal common to supporting-columns subjected to both compressing and elongating or tensile strains is materially lessened. The two strains—viz., the tensile strain on the braces and the compressing strain on the columns, caused by the strain on the braces—should be substantially balanced, each practically equaling the other when the engine is not in motion. Each pair of columns is preferably strengthened by the braces in the manner shown in Fig. 3, and any desired or suitable number of columns may be used, there being five pairs herein represented in Fig. 1. To still further strengthen the supporting framework, I prefer to employ tensile braces d^{30} d^{31}, located outside the columns, and preferably

connected to the outside column of the low-pressure cylinder A^3 and to the inside column supporting the high-pressure cylinder. As shown in Fig. 1, the ends of the brace d^{30} are secured to the upper ends of the second and fifth columns and the brace d^{31} to the lower ends of the same columns, and the said braces are bolted together near their centers. I have herein shown only one set of outside tensile braces for each side of the framework; but I do not desire to limit myself in this respect, as two or more such sets of braces may be used on each side of the engine. The columns d serve to support the rock-shafts c^2 c^3, the rock-shaft c^2, as herein represented, being supported by two columns d and the rock-shaft c^3 by four of the said columns.

The columns d, which support the rock-shafts, are provided with offset portions d^{100} d^{12}, represented in Fig. 3 as on opposite sides of the column, the said offset portions forming the bearings for the rock-shafts.

I do not desire to limit my invention to the particular form of brace shown in Fig. 3, as the columns may be strengthened by other forms of brace—as, for instance, such as shown in Fig. 5, wherein the two braces d^2 d^3 are bent or shaped so as to have their opposite ends connected, respectively, to the tops of the columns d d' and to the lower portions of the said columns, the said braces being separated by the connecting bar or rod d^6, to which they are secured by the vertical bolt d^{20}, provided with nuts d^{40} d^{41}, by which the said braces may be put under an elongating or tensile strain.

My improved engine may be provided with any desired form of valve-reversing mechanism; but I prefer the form known as the "Marshall valve mechanism," it being operated by the wheel d^{21} in the usual manner.

The operation of my improved engine may be readily understood by a comparison of Figs. 4 and 1. As shown in Fig. 4, the valve-rods b^2 b^5 are on their upward stroke, or in the direction indicated by arrows 21, and the pistons a a' of the steam-cylinders A and A′ are about to move in opposite directions, as indicated by arrows 22 and 23 in Fig. 1, the piston a being about to commence on its downstroke and the piston a' about to commence on its upward stroke. With the valves in the position shown in Fig. 4 the live steam enters the steam cylinder or chest B on the inner edge or side of its piston-valves and the said steam passes into the port b^{20}, as indicated by the arrow 25, and from the said port the steam enters the high-pressure cylinder A above the piston a. At the same time the steam-cylinder A is connected by the port b^{21} and passage b^{17} to the port b^{23}, so that when the piston a is on its downstroke the steam in the cylinder A passes through the port b^{21}, passage b^{17}, and port b^{23} into the steam-cylinder A′ below its piston a', and the steam in the cylinder A′ above the piston a' exhausts therefrom through the port b^{22} into the valve-cylinder B′, from which it passes through the pipe b^{31} into the valve-cylinder B^2 to the second intermediate steam-cylinder. It will be noticed that the live steam enters the valve-chest connected to the high-pressure cylinder on the inner side or edge of the valve, while the said steam enters the valve-cylinder B′ of the first intermediate on the outer edge or side of its valve b^4, and as a result both valves move in the same direction and afford a straight path from the valve-cylinder B through the high pressure and first intermediate steam-cylinder to the pipe b^{31}. The steam exhausted from the first intermediate passes into the valve-chest B^2 of the second intermediate on the inner side of the valve, and enters the steam-cylinder A^2 through the port b^{24}, above the piston a^{10}, forcing the latter downward in the direction of arrow in Fig. 1, and the steam in the cylinder A^2 exhausts therefrom through the port b^{25} and passage b^{19}, as indicated by the arrows in Fig. 4, through the port b^{27} into the low-pressure cylinder A^3 below its piston a^{12}, forcing the latter upward, as indicated by the arrow in Fig. 1, and the steam in the low-pressure cylinder A^3 above the piston a^{12} passes from the said cylinder through the port b^{26} of the valve-cylinder B^3 into the exhaust port or passage b^{30}. It will be noticed, also, that the steam is admitted to the second intermediate on the inner side or end of its valve b^6 and to the low-pressure cylinder on the outer end or side of the valve b^{10}. In this manner it will be seen that a substantially straight or unobstructed exhaust-passage is maintained from the high-pressure cylinder through the intermediates and low-pressure cylinders. I prefer to operate the piston-valves by means of two eccentrics, connected to rock-shafts, as herein shown, and located between the third and fourth pairs of columns, as by this construction large-size bearings of substantially-equal proportions may be used with substantially the shortest length of crank-shaft, as clearly shown in Fig. 1. The webs of the cranks on the main shaft are made of different sizes, gradually increasing in width from the crank-webs connected to the high-pressure cylinder, which crank-webs are the narrowest, to the cranks connected to the low-pressure cylinder, which latter cranks are the widest; but I do not desire to limit myself in this respect, as it is evident that any suitable valve motion (of which there are several) may be connected with the rock-shafts; but I prefer the construction shown.

I claim—

1. In a quadruple-expansion engine, the combination of two pairs of steam-cylinders, each pair consisting of two cylinders having valve chests or cylinders, a crank-shaft provided with two sets of cranks, one for each pair of cylinders, the cranks of one pair being set at an angle of substantially one hundred and eighty degrees and the cranks of the second pair being set at an an-

gle of substantially one hundred and eighty degrees to each other, but at an angle of substantially ninety degrees to the first set of cranks, a bed-plate, and a supporting-frame for the cylinders, consisting of a plurality of columns and braces, two eccentrics on the crank-shaft, a rock-shaft supported by the columns and connected to the valve of one pair of cylinders and to one eccentric, and a second rock-shaft supported by the columns and connected to the valves of the other pair of cylinders and to the second eccentric, substantially as described.

2. In a quadruple-expansion engine, the combination of two pairs of steam-cylinders, each comprising two cylinders, the four cylinders being arranged in a line, two pairs of valve chests or cylinders accompanying said steam-cylinders, pistons in the steam-cylinders, a bed-plate, a crank-shaft supported thereby and provided with two sets of cranks relatively arranged, as shown, two sets of piston-valves in the valve chests or cylinders, a rock-shaft to which one set of valves is connected, a second rock-shaft to which the valves of the other set are connected, eccentrics located side by side on the crank-shaft and connected with said rock-shafts, said eccentrics being located between the center of the second intermediate cylinder and the center of the low-pressure cylinder, said location of the eccentrics permitting the employment of the maximum length of bearing-surface and the minimum length of shaft, and of the series of cylinders, as set forth.

3. In a quadruple-expansion engine, the combination of the following instrumentalities, viz: two pairs of steam cylinders, each comprising two cylinders, two pairs of valve chests or cylinders cast integral with said cylinders and connected together, pistons in the steam-cylinders, a bed-plate, a crank-shaft supported thereby and provided with two sets of cranks, each consisting of two cranks set at substantially an angle of one hundred and eighty degrees to one another, the cranks of one set being at substantially an angle of ninety degrees to the cranks of the other set, two sets of piston-valves in the valve chests or cylinders, a rock-shaft to which one set of valves is connected, a second rock-shaft to which the valves of the other set are connected, an eccentric on the crank-shaft connected to one rock-shaft, a second eccentric to which the other rock-shaft is connected, and a supporting-frame for the said cylinders and rock-shafts, consisting of columns $d\ d'$ and braces $d^2\ d^3$, placed under a tensile strain and subjecting said columns to a compressive strain, substantially as described.

In testimony whereof I have signed my name to this specification, in the presence of two subscribing witnesses, this 26th day of September, A. D. 1891.

CHARLES D. MOSHER.

Witnesses:
C. F. BROWN,
A. D. HARRISON.