(No Model.) 2 Sheets—Sheet 1.

D. D. HARDY.

STEAM ENGINE.

No. 313,728. Patented Mar. 10, 1885.

Fig. 1.

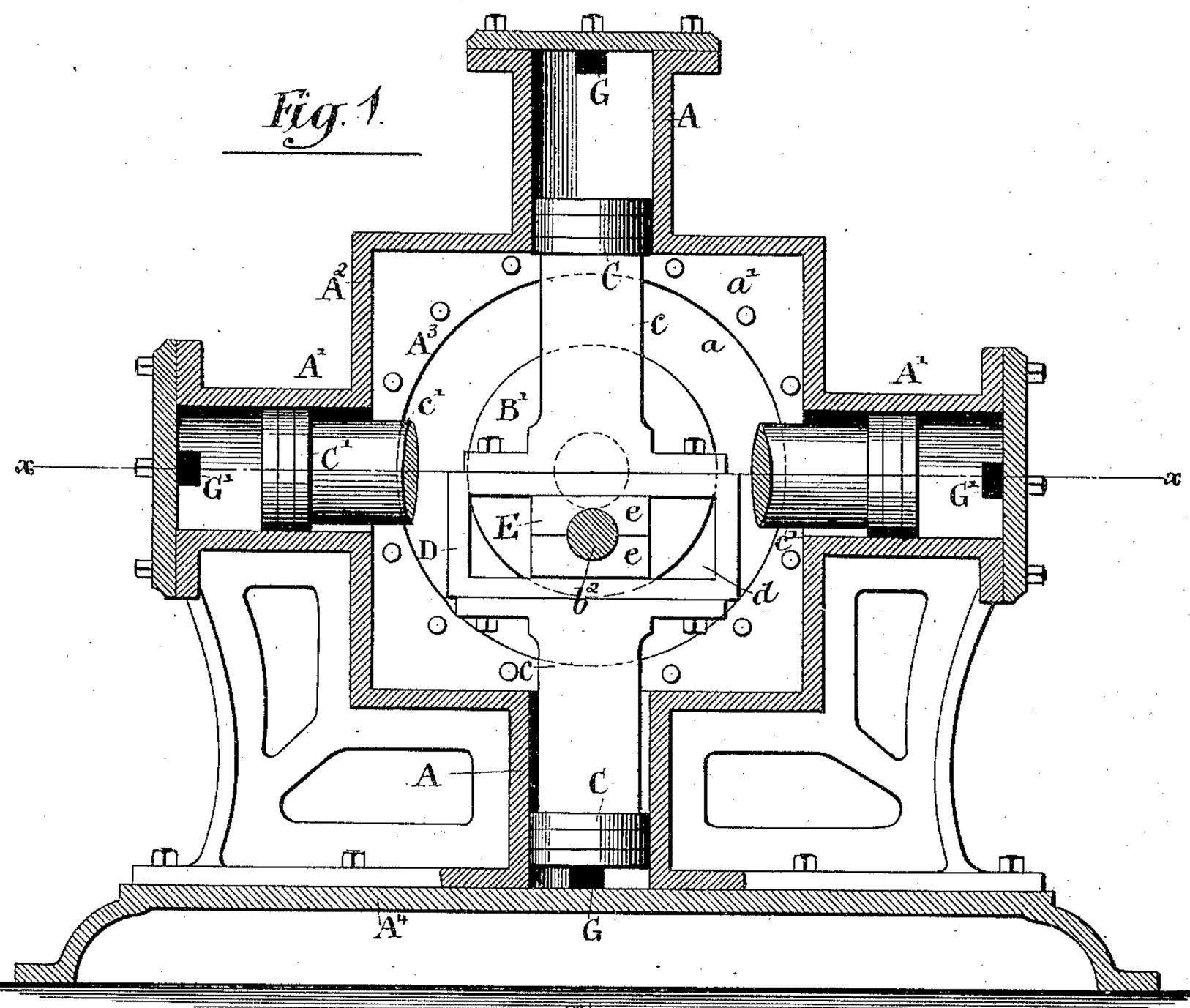
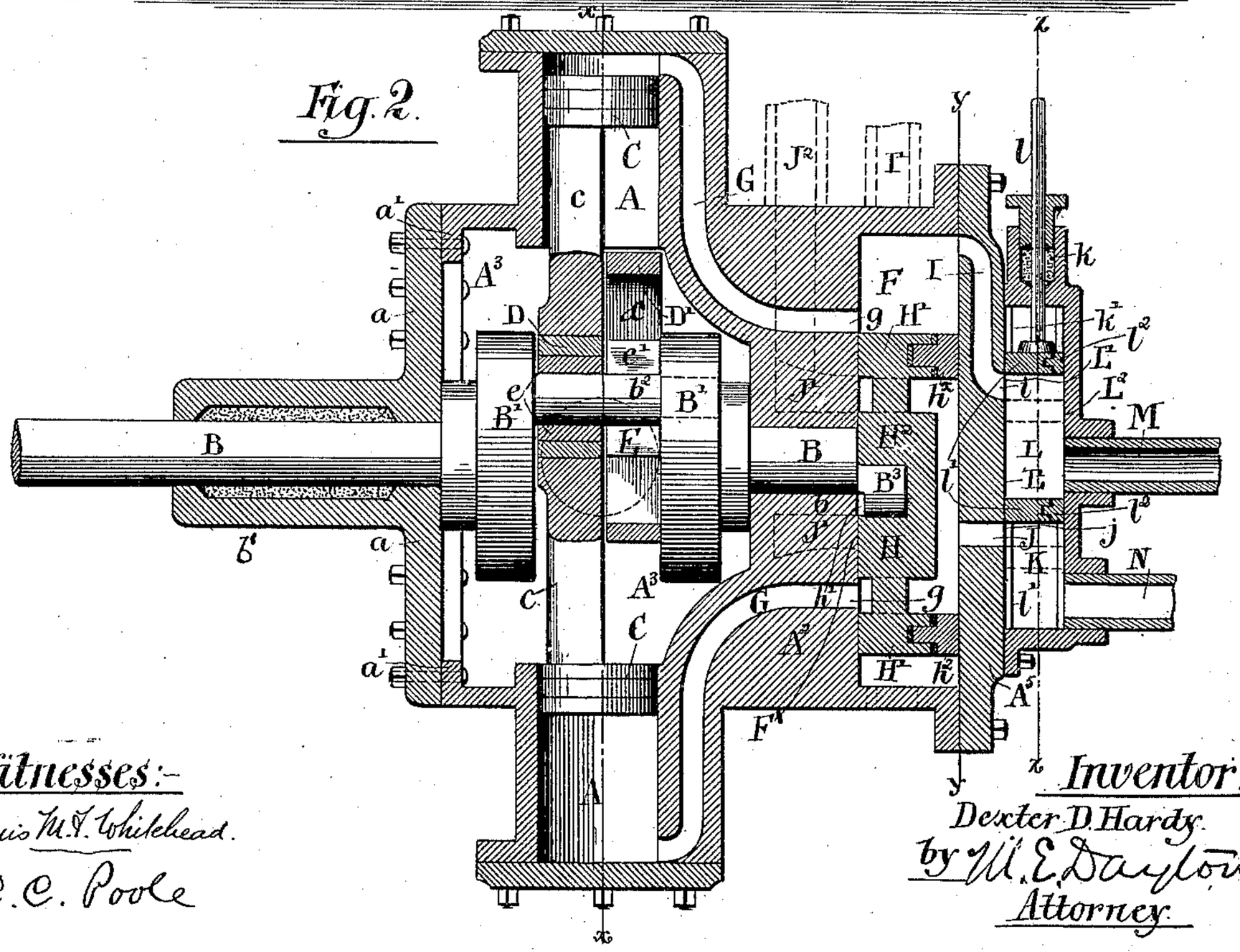


Fig. 2.



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(No Model.) 2 Sheets—Sheet 2.

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Fig. 3.

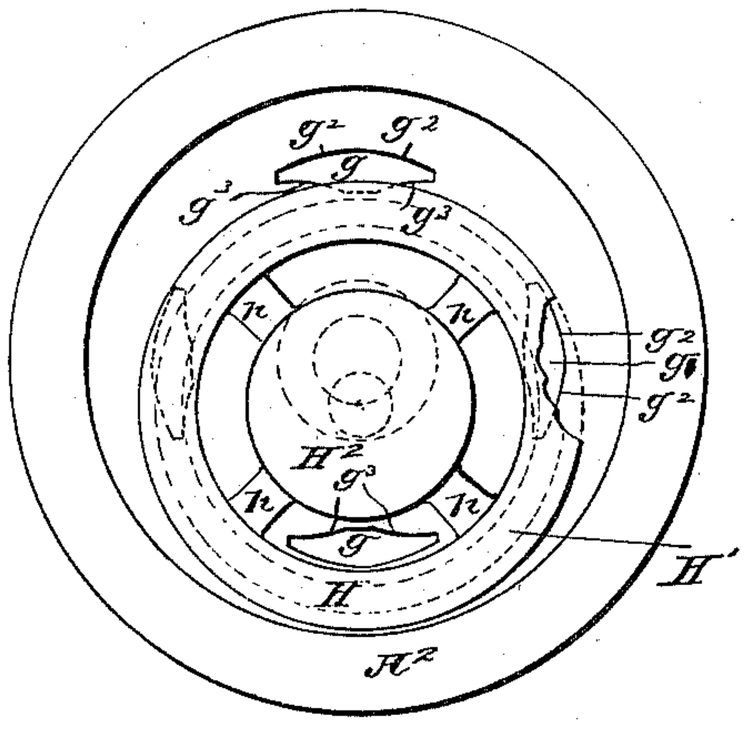
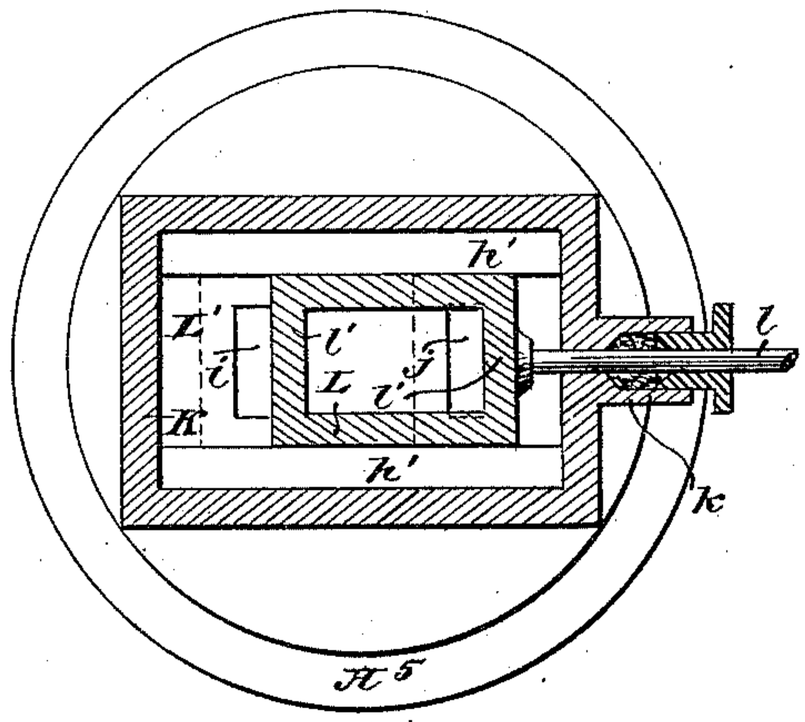


Fig. 4.



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UNITED STATES PATENT OFFICE.

DEXTER D. HARDY, OF CHICAGO, ILLINOIS, ASSIGNOR TO ROBERT H. COWDREY, OF SAME PLACE.

STEAM-ENGINE.

SPECIFICATION forming part of Letters Patent No. 313,728, dated March 10, 1885.

Application filed May 1, 1884. (No model.)

To all whom it may concern:

Be it known that I, DEXTER D. HARDY, of Chicago, in the county of Cook and State of Illinois, have invented certain new and useful Improvements in Steam-Engines; and I do hereby declare that the following is a full, clear, and exact description thereof, reference being had to the accompanying drawings, and to the letters of reference marked thereon, which form a part of this specification.

This invention relates to an improved construction in steam-engines, and has reference more especially to improvements in the valves for such engines; and the invention consists in the matters hereinafter described and pointed out in the claims.

The engine herein illustrated as embodying one form of my invention is provided with four cylinders arranged at equal distances apart around the center of a crank-shaft having a single crank, the pistons in the opposite cylinders being rigidly connected with yokes having transverse slots with which the crank-pin is engaged. The cylinders are preferably open at their ends adjacent to the crank-shaft, and steam is admitted at the outer ends of the cylinders only, the steam-pressure being arranged to operate in alternation upon the opposite rigidly-connected pistons. The valve for controlling the admission of steam to the several cylinders, as herein shown, embodies improved features of construction that will hereinafter be described.

In the accompanying drawings, Figure 1 is a central vertical section of a steam-engine embodying one form of my invention, taken upon line *x x* of Fig. 2. Fig. 2 is a vertical section of the same, taken upon line *x x* of Fig. 1. Fig. 3 is a section taken upon line *y y* of Fig. 2, showing the valve controlling the admission of steam to the several cylinders and its seat. Fig. 4 is a section taken upon line *z z* of Fig. 2, illustrating devices for reversing the engine.

As shown in Figs. 1 and 2, A A′ are two pairs of opposite cylinders arranged at equal distances apart about a single driving-shaft, B, said cylinders being located radially with reference to the axis of said shaft. In the form of engine herein shown the cylinders A and A′ are cast integral with the walls A^2 of a central box or chamber, A^3, within which a crank, B′, upon the shaft B is located, and the several cylinders and the chamber are supported upon a base, A^4, which also forms the end of the lower cylinder, A. The shaft B, as herein shown, is supported in bearings *b b′* in the casting A^2, one end of the shaft being arranged to pass outwardly through the bearing *b′*, which is provided with a suitable packing to prevent the escape of steam.

The cylinders A and A′ are provided with pistons C and C′, respectively, the said pistons being rigidly attached to short piston-rods *c c′*, which are rigidly secured at their inner ends to yokes D and D′, having transverse slots or apertures *d d′*, which are engaged by the crank-pin b^2, secured in crank-disks B′ upon the crank-shaft. The crank-pin is preferably fitted in bearing-blocks E and E′, constructed to slide in the slots *d d′* in the yokes D and D′, each of said blocks, as herein shown, consisting of two parts, *e e* and *e′ e′*, which are held in contact with the pin by being held within the slot of the yoke. The blocks E E′ may, however, be made in one piece and slipped on the end of the crank-pin, or said blocks may be made in two pieces and bolted or otherwise fastened together so as to form a single block.

The inner ends of the cylinders A and A′, as shown in Figs. 1, 2, and 3 and preferably constructed, are in open communication with the chamber A^3 in which the crank B′ is located, and the several pistons are actuated by the admission of steam to the several cylinders successively in such manner that each pair operates alternately upon the crank-pin in a direction at right angles to each other. The opposite pistons C and C′ in the construction described being rigidly connected by means of the piston-rods *c c′* and the yokes D and D′, each opposite pair of pistons will operate, as far as the action of the steam is concerned, as one piston—that is to say, the opposite pairs of pistons will be moved in one direction by the pressure of steam in the outer end of one cylinder, and in the other direction by the pressure in the outer end of the opposite cylinder.

By arranging the cylinders and pistons in the manner above described, the important advantage is gained that stuffing-boxes for the piston-rods are entirely dispensed with, the only packing connected with the cylinders being that upon the pistons. In the construction described there will obviously be no steam-pressure in the chamber A^3, and the packing shown in the bearing *b'*, through which the shaft passes to the outside of the chamber, is not essential, but is merely used to prevent the escape around the shaft-bearing of steam that may accidentally enter the said chamber.

As an improved construction in steam-valves for engines adapted for use with one or more steam-cylinders, and when said cylinders are or are not arranged as herein shown, a valve is herein illustrated, which is constructed as follows:

In the casting A^2, at a point adjacent to the bearing *b*, at the inner end of the shaft B, is located a valve-chamber, F, which is preferably circular in form and concentric with said shaft, and is provided with opposite parallel plane sides forming valve-seats F' and F^2, which are arranged in planes at right angles to the axis of the shaft, the valve-seat F' being located at the side of the chamber adjacent to the cylinders. Suitable steam-passages, G and G', are formed at the sides of the cylinders A and A', and in the casting A^2, said passages terminating at their inner ends in ports *g* and *g'*, formed in the valve-seat F' at equal distances from the axis of the shaft B, as clearly shown in Fig. 3. Within the chamber F and operating in contact with the opposite valve-seats, F' and F^2, is placed a valve, H, Figs. 2 and 3, said valve consisting of an outer annular portion or open ring, H', fitted closely at its edges to the valve-seats F' and F^2, and joined by means of arms *h* to a central part or hub, H^2, which is provided with a central cylindrical aperture, *h'*, which is placed over a correspondingly-shaped pin, B^3, attached eccentrically to the end of the shaft B, which extends through the bearing *b* into the said chamber F. By this construction it is obvious that when said shaft B is rotated the valve H will have a continuous revolving or gyratory motion about the axis of the shaft, so as to bring the parts *g* and *g'* alternately into communication with the steam-inlet and exhaust-passages of the chamber F, as hereinafter more particularly described.

Steam is admitted to the chamber F exterior to the ring H' by an inlet-passage, I, and is permitted to escape from the chamber by means of a passage, J, entering the central part of the chamber within the said ring, the passages I and J, as shown, being formed in a plate or head, A^5, forming the bearing-surface or valve-seat F^2 opposite the valve-seat F'. The passages I and J, as herein shown, terminate in ports *i* and *j*, formed in a valve-chamber, K, which is provided with a slide valve, L, that operates to bring either of said ports into communication with the inlet or exhaust passage, as desired, in order to enable the direction of the motion of the engine to be readily reversed, as hereinafter more particularly set forth. The said passages I and J may, however, be connected with suitable pipes, so that they will themselves form the inlet and exhaust passages to the valve-chamber F; or the inlet and exhaust passages may be otherwise connected with the said valve-chamber, as, for instance, is illustrated in dotted lines in Fig. 2, in which an annular passage (indicated at J') is formed in the casting A^2, upon the side of the chamber adjacent to the cylinders, said annular passage being connected with a pipe (indicated at J^2) which may serve either as a steam supply or exhaust pipe, and in which a separate passage, I', operating in connection with the passage indicated at J' either as an inlet or exhaust, is also indicated in dotted lines as entering the side wall of the chamber F. When the steam inlet and exhaust passages communicate directly with the chamber F, as last described and indicated in dotted lines in Fig. 2, means for reversing the engine may be entirely dispensed with, or said passages may communicate with a four-way cock arranged to bring either of them into communication with the steam-supply pipe, as desired.

The ring H', before mentioned as forming part of the valve H, is made of the same width or thickness in both of its opposite bearing-faces, so that it will have the same area of contact with both valve-seats, F and F', and is preferably provided with a separate packing-ring, h^2, constructed to form a steam-tight joint between the valve and the sides of the chamber. Said packing-ring may be of any well-known or preferred construction—as, for instance, metal or other springs may be applied to hold the said packing-ring and the ring H in contact with the opposite valve-seats, or a steam-packing may be formed by the entrance of steam between the packing-ring and the adjacent part of the valve in a well-known manner.

An important advantage of the construction by which the valve is constructed with an annular portion, H', constructed to operate in contact with the opposite parallel valve-seats F' and F^2 of the chamber F is, that the surfaces of the said annular port which are in contact with the opposite valve-seats being the same, the steam-pressure has no tendency to press the valve against either seat, and a perfectly-balanced valve is thereby obtained.

The part H' of the valve H is made of such diameter, and the ports *g g'* are so located with reference thereto that when the pin B^3 is at one limit of its throw with reference to the two opposite ports, as *g*, one of said ports will be outside of the ring and in communication with the steam-space of the chamber exterior thereto, and the opposite port will be within the ring and in communication with the space formed by the annular passage between said ring and the hub H^2, this position

of the parts being clearly illustrated in Figs. 2 and 3. The motion of the gyratory valve H obviously has no effect upon the inlet and outlet passages I and J, one of said passages being constantly in communication with the space within said annular valve, and the other of said passages with the space of the valve-chamber exterior thereto.

In the operation of the valve described in connection with the form of engine herein illustrated, the gyratory movement of the valve operates to open and close the several ports communicating with the ends of the cylinders successively, and the ports are so constructed and located that as soon as one piston is given its forward movement and has carried the crank-pin past the dead-center, steam will be admitted behind the piston at right angles thereto, and cause such piston to operate with the piston first mentioned, to carry the crank-pin through the quadrant lying between the axial lines of the two adjacent cylinders. The operation of the said gyratory valve is the same with reference to all four of the ports shown in the drawings, and it is therefore obviously possible to arrange any number of pairs of ports around the axis of rotation of the valve to operate in connection with the said valve, according to the number of cylinders it is desired to group about a single shaft. A single pair of ports will operate equally well in connection with the valve shown, and such valve may therefore be advantageously used in connection with a single steam-cylinder, and in the latter case the valve may be operated by a pin upon the crank-shaft, as herein shown, or by suitable intermediate driving-connections, as preferred.

In case an annular passage or port, J′, is used, as indicated in dotted lines in Fig. 2, such passage will obviously be constantly in communication at some point in its circumference with the space inside of the ring H′ in the same manner as is the passage J shown in full lines in said figure.

The ports *g* and *g′* may be of any shape found desirable to properly admit the steam to the cylinders. As herein shown, however, the outlines of said ports are formed upon curves disposed in a manner calculated to cause said ports to be entirely opened and shut by a relatively slight movement of the valve. For this purpose, the outer margins of the apertures forming the ports are preferably formed of two short arcs, g^2, arranged approximately parallel with the periphery of the ring H′ when the port is covered by the ring, as illustrated in the case of the ports *g′* shown in Fig. 3, and portions of the inner margins of the ports are formed upon lines g^3 approximately concentric with the inner surface of the ring H′ when the ring is in position to cover the ports, as also shown in the case of the ports *g′* shown in Fig. 3.

It is obviously not essential that the gyratory valve above described should be operated directly from the crank-shaft of the engine, and the valve-chamber F may be otherwise located than as herein shown, and the valve operated by any suitable connection with the driving-shaft. By actuating the valve directly from the shaft, however, an exceedingly cheap and simple construction in the engine is obtained, and an accurate operation of the valve with reference to the ports always results without the necessity of adjusting or changing the relative location of the parts for this purpose. The valve described, being hung loosely upon the pivot-pin B^3, is free to rotate upon said pin, and the gyratory movement of the valve will obviously tend to produce a slight movement thereof upon its axis of rotation. By this means the wearing-surfaces in contact are constantly being changed during the operation of the valve, so that the wear will be uniform throughout such surfaces, and a perfect joint thereby constantly maintained between the valve and its seat.

The hub H^2 of the valve H is preferably fitted closely to the valve-seat F′ in its portion around the shaft B, so as to prevent the escape of steam from the chamber F through the bearing of the shaft. The opposite side of the said hub may be extended so as to come in contact with the seat F^2, but a space is desirably left between the hub and the seat, so as to avoid the friction which would be consequent upon the contact of the parts mentioned, and to allow the free movement of steam within the valve.

The means for reversing the engine, consisting of the valve-chamber K and slide-valve L operating in connection with the passages I and J, as hereinbefore mentioned, forms the subject-matter of another application for patent hereafter to be made by me, and is herein claimed only in connection with the gyratory valve described. The contruction of this device and its operation in connection with the said gyratory valve may be briefly described, as follows: The slide-valve L is of rectangular form and provided with four walls fitted at their edges to opposite valve-seats L′ and L^2, formed in the chamber K, spaces being left between the sides of the slide-valve and the side walls of the chamber, as clearly shown in Fig. 4, to permit the passage of steam from one end of the chamber to the other around the valve. The said valve is, as shown, operated by means of a stem, *l*, extending through a suitable stuffing-box, *k*, in the wall of the chamber K, and is held in position by suitable parallel guides, *k′*, at either side of the seats L′ and L^2 of the chamber. The steam-inlet passage M is connected with the central part of the chamber, so as to remain constantly in communication with the interior of the valve L, and the steam-exhaust passage N is connected with said chamber in its portion exterior to the valve. The passages I and J terminate in ports *i* and *j*, formed in the valve-seat L′, and the valve L is constructed with transverse end portions, located at the same dis-

tance apart as the ports *i* and *j*, so that by moving the valve a distance equal to the width of one of the ports plus the thickness of one of the parts L′ said parts will be carried over the ports in a well-known manner. The said valve is preferably provided with a packing, l^2, constructed and operating in the same manner as described in connection with the packing of the annular form of valve herein described.

When the valve is in the position shown in full lines in Figs. 2 and 4, the passage I is in communication with the steam-inlet passage M, and said passage I thus forms the inlet-passage to the valve-chamber of the engine, and the passage J is in connection with the exhaust-pipe N, and thus forms the exhaust-passage. By moving the valve L in the position indicated in dotted lines in Fig. 4, the functions of the passages I and J are reversed, the passage I being brought into communication with the exhaust-pipe N and the passage J with the inlet-passage M.

The advantages of the reversing-valve described, when used in connection with the gyratory valve, are obvious, the important one being the simplicity and cheapness of construction thereby obtained.

It will be observed that the valve L, having equal bearing-faces upon the opposite valve-seats L′ and L^2, is perfectly balanced, and has no tendency to press upon one seat more than upon the other, the valve L operating, as far as this feature of construction is concerned, substantially in the manner before described in connection with the gyratory valve herein shown.

In order to provide means for gaining access to the interior of the chamber A^2 of the engine shown in Figs. 1 and 2, and to enable the shaft B to be removed from the engine when desired, the end wall of said chamber, or a portion thereof adjacent to the bearing *b′* of the shaft B is made removable, such removable part, as herein shown, consisting of a circular plate, *a*, adapted to cover a circular aperture in the side of the chamber A^3, formed by an inwardly-projecting flange, *a′*, to which the said plate *a* is bolted at its margin.

I am aware that a gyratory valve has heretofore been used for controlling the admission of steam to several cylinders grouped around a common shaft, which extends through the valve-chamber, and by which the said valve is actuated, and I do not therefore claim, broadly, such a construction; but my invention, as it relates to the parts above mentioned, is limited to a construction in which the shaft extends through one wall only of the valve-chamber, and is provided with a crank-pin engaged with the valve, as set forth in the second claim hereto appended.

One particular advantage of the construction last mentioned is that the valve may thereby remain accurately in position between the opposite valve-seats, notwithstanding any slight change in the position of the shaft caused by the bearings thereof getting out of line or otherwise, for the reason that the valve is held in position and guided by the valve-seats, the crank-pin usually being made relatively short and slightly rounded, so as to permit the said valve to freely adjust itself in its bearings, and to thereby run between the latter without binding. Additional advantages of this construction are that the resistance due to the frictional contact of the moving parts is much lessened by the use of a crank-pin instead of an eccentric upon the shaft, and that the construction is rendered much more simple than that heretofore used and above referred to by the absence of a steam-packing around the crank-shaft at the outer wall of the valve-chamber.

I claim as my invention—

1. The combination, with the crank-shaft of a steam-engine, and a cylinder provided with a suitable piston and piston-rod, of a valve-chamber, an annular gyratory valve, H, located within said chamber, driving-connections for actuating the valve from the crank-shaft, ports in the said valve-chamber communicating by suitable passages with the said cylinder, and located at equal distances from the center of motion of the valve, an auxiliary valve-chamber, K, a centrally-open slide-valve within said chamber K, ports *i* and *j*, in said chamber K, communicating by suitable passages with said valve-chamber F, in its portion inside of and exterior to the said annular valve, and suitable steam inlet and exhaust passages communicating with the said chamber K, substantially as and for the purpose set forth.

2. The combination, with a steam-engine crank-shaft, of two or more radially-arranged steam-cylinders provided with suitable pistons and piston-rods having operative connection with the crank-pin of the shaft, a valve-chamber provided with opposite parallel valve-seats arranged parallel with the axes of the cylinders, steam-ports *g* and *g′* in said chamber, located at equal distances from the axis of the crank-shaft and communicating with the said cylinders, steam inlet and exhaust passages communicating with the said valve-chamber, and an annular gyratory valve, H, constructed to operate in connection with the said ports, the said crank-shaft being arranged to extend through one wall of the valve-chamber only, and having upon its end a crank-pin, B^3, engaged with and constructed to actuate the said valve, substantially as and for the purpose set forth.

3. The combination, with a steam-engine cylinder and crank-shaft, of a valve-chamber, F, having opposite parallel valve-seats, and provided with ports *g*, communicating with the cylinder, a shaft, B, provided with an eccentric or crank pin, B^3, and a valve, H, comprising a central hub, H^2, having an aperture, *h′*, engaged with the pin B^3 and annular portion H′, and arms *h*, connecting said annular

portion with the said hub, substantially as and for the purpose set forth.

4. The combination, with a steam-engine cylinder and a crank-shaft provided with a cylindrical crank-pin, B^3, of a valve-chamber, F, having opposite parallel valve-seats and provided with ports communicating with the cylinder, and an annular gyratory valve, H, constructed to work in contact with the opposite valve-seats, and provided with an aperture, h', fitted to the crank-pin, whereby the valve may freely rotate on said pin, substantially as and for the purpose set forth.

5. The combination, with the steam-cylinder and crank-shaft of a steam-engine, of a valve-chamber, F, having opposite parallel valve-seats, and provided with ports communicating with the cylinder, an annular gyratory valve, H, constructed to work in contact with the opposite valve-seats and provided with a suitable packing, and driving-connections between the crank-shaft and the said valve constructed to actuate the latter, substantially as and for the purpose set forth.

In testimony that I claim the foregoing as my invention, I affix my signature in presence of two witnesses.

DEXTER D. HARDY.

Witnesses:
M. E. DAYTON,
JESSE COX, Jr.