

No. 715,725.

Patented Dec. 9, 1902.

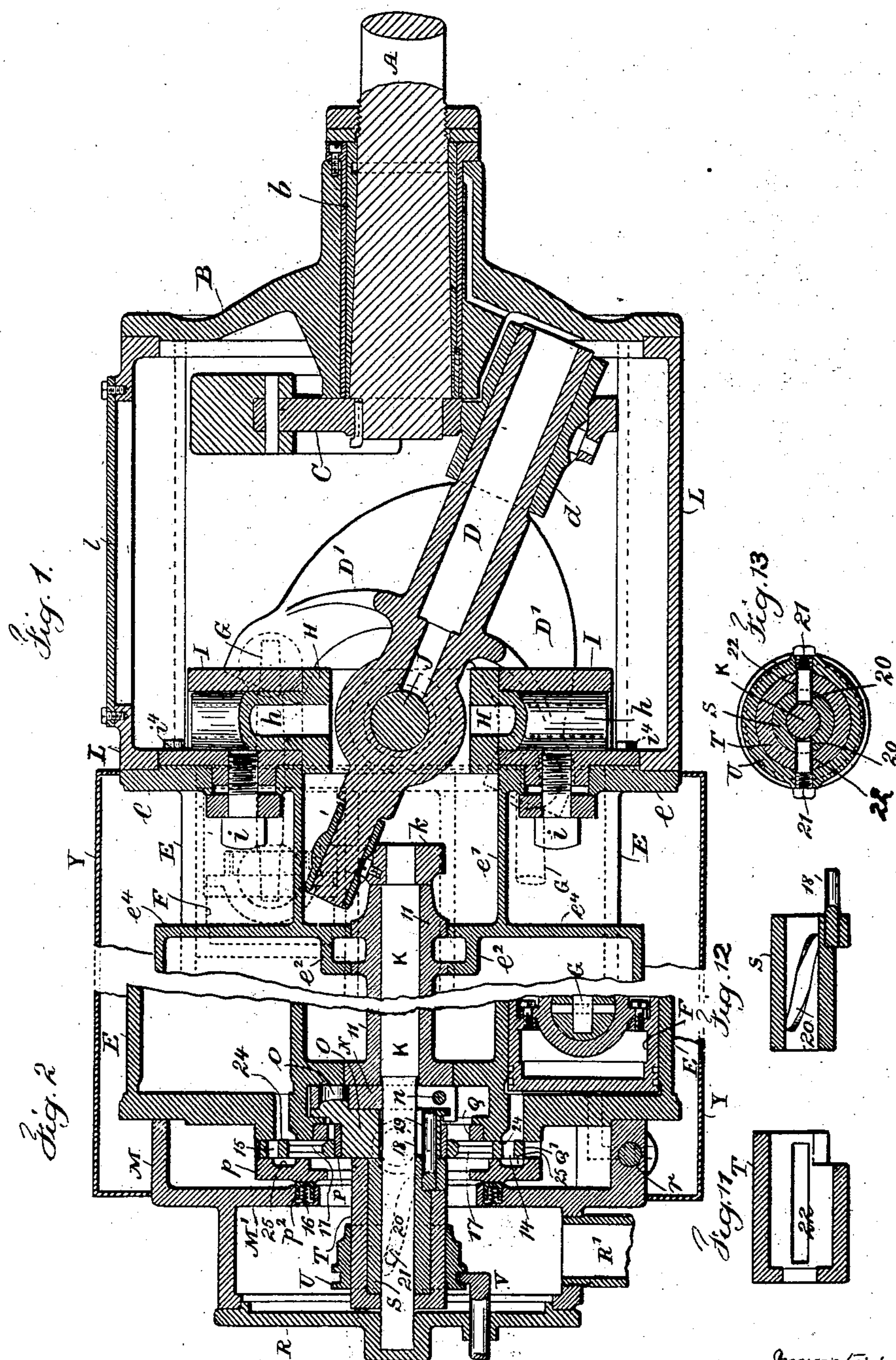
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MULTIPLE CYLINDER ENGINE.

(Application filed Oct. 12, 1898. Renewed July 30, 1902.)

(No Model.)

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UNITED STATES PATENT OFFICE.

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MULTIPLE-CYLINDER ENGINE.

SPECIFICATION forming part of Letters Patent No. 715,725, dated December 9, 1902.

Application filed October 12, 1898. Renewed July 30, 1902. Serial No. 117,693. (No model.)

To all whom it may concern:

Be it known that we, LEWIS C. WORRON and ABRAHAM VANDERBEEK, citizens of the United States, residing at Hartford, in the county of Hartford and State of Connecticut, have invented an Improvement in Multiple-Cylinder Engines, of which the following is a specification.

This engine is to be driven by fluid under pressure—such, for example, as water under pressure or steam or air—and in this engine there are usually four cylinders in a circular range, the pistons in which act outwardly in succession against a crank-pin head to rock the same around a universal center formed by double trunnions at right angles to each other, so that the crank-pin describes a circle and gives rotation to the crank-pin disk and main shaft.

Previous to this invention four cylinders have been made use of and a crank-pin frame or head to give motion to a shaft, the cylinders being in a circular range and the pistons acting outwardly against the crank-pin head, there being intermediate connecting-rods with balls at the ends.

This invention is made with reference to obtaining more reliable bearings for the respective parts and for giving motion to the valves in a peculiar manner, as hereinafter set forth and claimed.

In the drawings, Figure 1 is a partial longitudinal section at 1 1, and Fig. 2 is a similar section at 2 2, Fig. 3, through one of the cylinders and the valves. Fig. 3 is a cross-section of the valve-shaft and an elevation of the valve-seats at the end of the cylinder. Fig. 4 is a face view of the two valves crossing each other, with the eccentric-block and the crank-shaft in section. Fig. 5 is an end view of the cylinders with the connecting-rods and trunnion at one side in section. Fig. 6 is a detached view of the balance-plate. Fig. 7 is a side view, and Fig. 8 an edge view, of the eccentric. Figs. 9 and 10 are similar views of the dog. Fig. 11 shows the second sleeve, Fig. 12 the reversing-sleeve, and Fig. 13 a cross-section of the reversing devices.

The main shaft A is supported in the head B, there being a suitable sleeve or bearing b within the opening in the head B and around

the main shaft A, so that the parts can be set up in case of wear, and upon the end of the shaft A toward the engine is a balanced crank-disk C, one side of this crank-disk being sufficiently heavy to counterpoise the crank-pin and parts that are connected with it.

The crank-pin D receives around it the box d, which is received into an opening in the balanced crank-disk, and this box d goes around with the balanced crank-disk and main shaft and the crank-pin is within the box, and hence there is a turning action of the crank-pin within the box as the box goes around with the disk.

It is to be understood that the crank-pin always occupies an angular position to the main shaft and at the box d the crank-pin describes a circle; but the crank-pin in so doing rocks upon a universal joint, and the crank-pin head D' is formed as a spider or series of arms extending out from the crank-pin and corresponding in number to the number of the cylinders employed in the engine, and we remark that the drawings represent four such cylinders, and there are four arms to the crank-pin head, the cylinders being represented at E as containing the pistons F, between which and the crank-pin head are the connecting-rods G, which are advantageously made with balls at their ends entering similar-shaped boxes or bearings at the ends of the crank-pin head and within the pistons, respectively. Some of these parts have before been made use of; but in the present instance the crank-pin and head are rocked upon double trunnions, so as to move in any direction, there being a trunnion-frame H, having trunnions h, projecting at opposite sides into the trunnion-bearings I, that are secured by the bolts i to the end or flanges e between the cylinders E, and this trunnion-frame has through the middle part a mortise for the crank-pin D to pass through, such crank-pin being enlarged at this point to receive through it the pin J, that projects beyond the crank-pin itself, forming trunnions, one at each side of the crank-pin, which trunnions are within holes or openings in the trunnion-frame H and are at right angles to the trunnions h of the frame. Hence the crank-pin will swing in

one direction upon the pin J and the trunnion-frame H will swing in the other direction upon the trunnions *h*. Hence the crank-pin is connected to the cylinder end in a very reliable manner, and the trunnions present extended wearing-surfaces, and there is no risk of the trunnions upon the crank-pin causing any of the parts to bind. Hence the motion of the crank-pin and its frame received from the action of the pistons is smooth and reliable, and the trunnions of the crank-pin and its frame are easily lubricated, and none of the parts are exposed to undue wear or liable to injury.

The cylinders in the circular range are cast integral with the flanges *e* and with the inwardly-projecting cylinder *e'*, Fig. 1—that is, between the cylinders—and within which the end of the crank-pin describes a circle and acts upon the crank *k* of the valve-shaft K, and this valve-shaft K is axially in line with the main shaft A, and for convenience of construction or repair the valve-shaft K is within a removable bushing 11, which is driven into the casting that contains the main cylinders E and the other parts that have been and are hereinafter described.

Between the head B and the flanges of the cylinders E there is a removable case L, which may be in one or two pieces, bolted, respectively, to the flanges of the cylinder and to the head B, and there is in this case L an opening and a removable cover *l*, by which access can be had to the chamber, in which the crank-pin and crank-disk revolve, for repairs and for the insertion into the chamber thus formed and which is tight of lubricating material, such as oil, by which the respective parts are constantly lubricated in consequence of the crank-pin and crank-pin frame dipping into the oil as the parts revolve, and it will be understood that oil can be supplied from time to time, as may be necessary for the perfect lubrication of all the parts at this end of the engine. It sometimes happens that water may pass into this chamber with the oil, or there may be a vapor generated in consequence of the heat of the engine, and it is necessary to allow this vapor to pass off, so as to prevent any accumulation of pressure. With this object in view there is an opening through the flange or head *e'*, that connects the cylinders, communicating with a pipe *e''*, that leads down and around the crank-shaft bushing and opens at the under side of the engine at 10, Fig. 5, where a cock or other device may be provided for allowing the escape of fluid under pressure from the chamber in which the crank-pin revolves.

At the back or valve end of the casting containing the cylinders E there is a plate forming the valve-seats, terminating advantageously with a circular edge, upon which rests the edges of the valve-chest M, and this valve-chest is advantageously circular and bolted onto the casting containing the cylin-

ders, and through this cylinder-head are the ports to the cylinders for the admission of the fluid under pressure and the exhaust of the same, and the cylinder-head forms the valve-seats, and the valves and devices for driving them are constructed as hereinafter described.

The valve-shaft K passes through the valve-chest, and upon it is the dog N, Figs. 9, 10, which dog is split and provided with a screw *n*, whereby it can be clamped upon the valve-shaft in the proper position, and there is an eccentric O, which is around the valve-shaft and is connected to the dog by the pin *o*, and there is in the eccentric an opening for the valve-shaft, which opening is larger than such shaft, so that the eccentric can be swung upon the pin *o*, and thereby brought into the desired position for giving more or less motion to the valves, and where the engine is to run only in one direction the opening in the eccentric need only to be at one side; but where the engine is to run in either one direction or the other the opening in the eccentric must extend across, so that the eccentric can be moved into the desired position, according to the direction of rotation of the main shaft. Around the eccentric is an eccentric-block P, having a circular central opening to fit the eccentric, and a rectangular exterior outline, and there are two valves Q and Q'. Each valve has a central opening corresponding in width to the block P, but the length of the opening crosswise of the valve is greater than such block in order that the block may slide in this opening by the movement of the eccentric, and the valve Q' is at right angles to and resting upon the valve Q, and the valve-seats in the surface of the cylinder-head are adapted to the valves—that is to say, the valve Q slides upon a transverse seat and the valve Q' slides upon the valve Q and also upon the transverse seats, one at each side of the valve Q, which seats are upon the same level as the surface of the valve Q—and in the valves Q and Q' are the ports 12 13 14 15.

In the valve-chest M there is a central opening through which the valve-shaft K and parts connected therewith pass, and a head R covers the end of the chamber, which becomes the exhaust-chamber, to which a pipe R' is connected, and around the opening in the partition M' of the valve-chest is an annular groove receiving a ring *p'*, resting against the plate *p*, with springs 16, that tend to press the surface of the plate against the outer surfaces of the valves Q and Q', and this plate and ring form a separation between the steam-chamber and the exhaust-chamber as well as pressing the valves to their seats, and it also serves to balance the valves so that the steam or air pressure will not force the valves unduly upon their seats, it being understood that the parts that are in contact are ground steam-tight, but move freely one against the other. The surface of the plate *p* which is next to the valve Q' is recessed at

25, and it is also made with a depression in which the valve Q' slides, so that the surfaces of the balance-plate rest upon the valve Q' and also upon the portions of the valve Q that extend beyond the edges of the valve Q' .
 5 The balance-plate covers the valves at one side, and they rest upon the seats at the other side, and the pressure of the steam or air does not tend to produce undue friction or wear,
 10 and the slight pressure on the back of the pressure-plate simply acts to keep the parts together.

The ports in the respective valves are to be made with reference to the proper admission
 15 of the fluid-pressure to the respective cylinders, and each valve has through it the ports 17, which allow the exhaust to pass off.

In starting up an engine difficulty frequently arises from the water of condensation in the
 20 cylinders, and to allow the same to pass out of the steam or valve chest we make use of a tubular plug r , in which there are holes corresponding to holes passing from the valve-chest through the walls thereof to the cylindrical opening containing the tubular plug r ,
 25 and the portion of the casting in which this tubular plug r is received may have a pipe at one end to convey away water, and a handle at the other end upon the tubular plug gives
 30 opportunity to turn such plug into a position for allowing the water of condensation to escape through the same or to close such openings as soon as the parts become sufficiently warm to prevent condensation. Of course
 35 this tubular plug will not be needed where atmospheric air or gas under pressure is made use of.

From the foregoing description it will be apparent that the slide-valves act in succession
 40 with the respective cylinders and the end of the valve that is moved inward allows the fluid under pressure to pass from the valve-chest into the cylinder, and the corresponding port at the other end of the valve, which is moved
 45 outward, (see Fig. 2,) acts as a passage for the fluid from the cylinder through the ports to the exhaust, and in consequence of the lead that is given to the eccentric and block in their action upon the respective valves
 50 the one cylinder is acting by the pressure upon the crank-pin while the opposite cylinder is exhausting, and the eccentric causes the valves to act in succession with the cylinders, so that the pistons are projected and give motion
 55 to the crank-pins successively, the opposite cylinders being open to the exhaust, so that the pistons are returned to the back ends of the cylinders. If the engine is to be rotated in an opposite direction, it is only
 60 necessary to move the eccentric so that the lead thereof in its relation to the crank-pin is in the opposite direction, and hence the rotation will be reversed. In order, therefore, to give motion to the eccentric and reverse
 65 the action of the engine, the devices next described are made use of, and it will be observed that where the eccentric is in an in-

intermediate position it does not give motion to the valves and the engine will stop, and we avail of this condition to move the eccentric so that its center coincides more or less
 70 nearly with the center of the valve-shaft for lessening the amount of motion given to the valves, and consequently the amount of fluid-pressure exerted in the cylinders, thus using
 75 the eccentric and valves for regulating the amount of fluid-pressure admitted to the cylinders, and consequently the amount of power developed in the engine, according to the load that has to be moved.
 80

Around the valve-shaft K is a reversing-sleeve S , having a pin 18, Fig. 12, that passes into a notch 19, Fig. 7, in the eccentric O , and this reversing-sleeve S can be turned
 85 around the valve-shaft, and in so doing the eccentric will be moved either from one position to the other for reversing the direction of motion of the engine, or else the eccentric can be moved to give more or less throw to the valves, and thereby regulate the amount of
 90 fluid-pressure admitted to the cylinders, and in this reversing-sleeve are the inclined slots 20, receiving the pins 21, that pass through the second sleeve T , and there is a yoke-sleeve U around the second sleeve T , and this
 95 second sleeve T is slotted longitudinally at 22, Fig. 11, for the pins 21, that pass through the longitudinal slot 22 and into the inclined slots 20 in the reversing-sleeve, and there may be slide-blocks on these pins to unify the
 100 wear. Hence when the yoke-sleeve U is moved endwise of the valve-shaft, together with the pins 21, the pins and sleeve cannot turn in relation to the valve-shaft, because the pins 21 are in the longitudinal slots 22;
 105 but these pins 21, passing into the inclined slots 20, give a turning motion to the sleeve S , and in so doing swing the eccentric O upon the pin o and cause the eccentric to be reversed in its position to the valve and crank-
 110 pin and head, or else the eccentric is brought more nearly to coincide with the center of the valve-shaft, and thereby lessen the throw of the valve, and this yoke-sleeve U has a groove in it adapted to receive the pins or fork of a
 115 slider V , which can be operated by hand or by a lever in any convenient manner, the slider passing advantageously through the head R of the exhaust-chamber.

By the foregoing devices the engine may be
 120 run with full pressure and power or it may be maintained in motion and exert a less power, the pressure being lessened in consequence of the valves having a smaller movement.
 125

We do not limit the present improvement to any particular character of valve, but we have shown in Figs. 2 and 4 the valves as having bars or cross-pieces 24 between the inlet-port and the exhaust-port, and each
 130 cross-piece 24 is narrower than the port leading into the cylinder. Hence the fluid-pressure will be admitted into the cylinder by the end of the valve clearing the port into the

cylinder, and when the valve is moving in the other direction the cross-piece 24 does not interfere with the exhaust, because the fluid under pressure passes up through either
 5 of the ports through the recess 25 to the exhaust by the port 17 in the valve, the bar at the end of the valve and the bar 24 preventing the steam or fluid pressure passing direct to the exhaust. Each recess 25 in the plate
 10 coincides in position to one of the ports leading into the cylinder.

In Fig. 2 the valve Q' is shown as just commencing to admit steam to the lower cylinder E, and the exhaust to the opposite or upper
 15 cylinder is fully open and so remains during the further movement of the valve in fully opening to admit steam, and in moving in the opposite direction the supply of fluid is cut off before the piston reaches its full outward
 20 movement and the exhaust is opened, as shown at the upper part of valve Q', Fig. 2.

A jacket may be employed around the cylinders, as indicated at Y, to inclose the cylinders and more or less of the valve-chest, so
 25 as to retain heat when the engine is used with steam.

We claim as our invention—

1. A circular group of cylinders and pistons within the same and connecting-rods, in combination with the main shaft and crank connection thereon, a crank-pin and crank-pin-head connection between the crank of the
 30 main shaft and the connecting-rods of the pistons, a trunnion-frame having trunnions at its ends and mortised for the passage of the crank-pin, a pin passing through the crank-pin at right angles to said trunnions and having projecting ends passing into bearings or
 35 bosses on the trunnion-frame, substantially as specified.

2. A circular group of cylinders and pistons within the same and connecting-rods, in combination with the main shaft and crank connection thereon, a crank-pin and crank-pin-head connection between the crank of the
 45 main shaft and the connecting-rods of the pistons, a trunnion-frame having trunnions at its ends and mortised for the passage of the crank-pin, bearings for said trunnions secured to the casting of the group of cylinders, a pin passing through the crank-pin at right
 50 angles to said trunnions and having projecting ends passing into bearings or bosses on the trunnion-frame, substantially as specified.

3. The combination with the circular group of cylinders, their pistons and connecting-rods, the main shaft and its crank, of the crank-pin and crank-pin head, trunnions projecting from said crank-pin, a trunnion-frame mortised for the passage of said crank-pin and having trunnions projecting at right angles to the trunnions of the crank-pin and bearings or bosses upon said trunnion-frame
 60 receiving the trunnions of the crank-pin, substantially as specified.

4. The combination with the head B, casing L and the group of cylinders connected

to said casing, said cylinders being closed at one end and having the flange e and head e^4
 70 at the open end of said cylinders, of a pipe e^2 formed with the head e^4 , one end of said pipe opening into the chamber formed by the casing L, and the other end of said pipe opening into the atmosphere, substantially as
 75 specified.

5. The combination in a multicylinder engine having a circular group of cylinders, their pistons and connecting-rods, a main shaft, crank, a crank-pin having trunnions and
 80 crank-pin-head connection between said crank and connecting-rods, of a universal joint for said crank-pin composed of a trunnion-frame mortised for the passage of the crank-pin, trunnions upon said frame, and bearings upon
 85 said frame at right angles to said trunnions for the trunnions of the crank-pin, substantially as specified.

6. In an engine having a circular group of four cylinders and a head at one end of the
 90 cylinders and ports through the head, the combination therewith of a crank-shaft, an eccentric and two valves crossing each other and having central rectangular openings that are longest crosswise of the valve, and a block
 95 surrounding the eccentric and occupying the openings in the crossing valves so that one eccentric gives motion to both crossing valves for the four cylinders, substantially as set forth.

7. The combination in an engine with the circular group of four cylinders, of a head to the cylinders having two sets of valve-seats, the one set being adapted to receive a valve
 105 for two opposite cylinders and the other set of seats on the level of the top of the valve and a second valve crossing the first valve and acting with the ports of the other two cylinders, an eccentric and valve-shaft for giving motion to the valves, substantially as
 110 set forth.

8. The combination in an engine with the circular group of four cylinders, of a head to the cylinders having two sets of valve-seats, the one set being adapted to receive a valve
 115 for two opposite cylinders and the other set of seats on the level of the top of the valve and a second valve crossing the first valve and acting with the ports of the other two cylinders, an eccentric and valve-shaft for
 120 giving motion to the valve, a valve-chest and balance-plate between the valves and the chest, substantially as set forth.

9. The combination in an engine with the circular group of four cylinders, of a head to
 125 the cylinders having two sets of valve-seats, the one set being adapted to receive a valve for two opposite cylinders and the other set of seats on the level of the top of the valve, and a second valve crossing the first valve
 130 and acting with the ports of the other two cylinders, an eccentric and valve-shaft for giving motion to the valve, a valve-chest and balance-plate between the valves and

the chest, an exhaust-chamber adjacent to the valve-chamber, there being an opening through the balance-plate for the exhaust from the valves and cylinders, substantially as set forth.

10. The combination in an engine with the circular group of four cylinders, of a head to the cylinders having two sets of valve-seats, the one set being adapted to receive a valve for two opposite cylinders and the other set of seats on the level of the top of the valve, and a second valve crossing the first valve and acting with the ports of the other two cylinders, an eccentric and valve-shaft for giving motion to the valve, a valve-chest and balance-plate between the valves and the chest, an exhaust-chamber adjacent to the valve-chamber there being an opening through the balance-plate for the exhaust from the valves and cylinders, a ring and springs in an annular recess in the valve-chest acting against the surface of the balance-plate to make a tight joint between the valve-chamber and the exhaust-chamber, substantially as set forth.

11. The combination in an engine with the circular group of four cylinders, of a head to the cylinders having two sets of valve-seats, the one set being adapted to receive a valve for two opposite cylinders and the other set of seats on the level of the top of the valve, and a second valve crossing the first valve and acting with the ports of the other two cylinders, an eccentric and valve-shaft for giving motion to the valve, and a dog clamped to the valve-shaft and forming a connection between the same and the eccentric, substantially as set forth.

12. The combination in an engine with the circular group of four cylinders, of a head to the cylinders having two sets of valve-seats, the one set being adapted to receive a valve for two opposite cylinders and the other set of seats on the level of the top of the valve, and a second valve crossing the first valve and acting with the ports of the other two cylinders, an eccentric and valve-shaft for giving motion to the valve, and a dog clamped to the valve-shaft and a pin connection between the dog and the eccentric, the eccentric having an opening for the valve-shaft to pass through large enough to allow the eccentric to be adjusted and means for adjusting the position of the eccentric in relation to the valve-shaft, substantially as set forth.

13. The combination in an engine with the circular group of four cylinders, of a head to the cylinders having two sets of valve-seats, the one set being adapted to receive a valve for two opposite cylinders and the other set of seats on the level of the top of the valve, and a second valve crossing the first valve and acting with the ports of the other two cylinders, an eccentric and valve-shaft for giving motion to the valve, and a dog clamped to the valve-shaft, and a pin connection between the dog and the eccentric, there being an opening in the eccentric for the free passage of the

valve-shaft and mechanism upon the valve-shaft for moving and holding the eccentric in the desired position to the valve-shaft for giving to the valves by the said eccentric a greater or less motion, substantially as set forth.

14. The combination in an engine with the circular group of four cylinders, of a head to the cylinders having two sets of valve-seats, the one set being adapted to receive a valve for two opposite cylinders and the other set of seats on the level of the top of the valve, and a second valve crossing the first valve and acting with the ports of the other two cylinders, an eccentric and valve-shaft for giving motion to the valve, and a dog clamped to the valve-shaft, and a pin connection between the dog and the eccentric, there being an opening in the eccentric for the free passage of the valve-shaft and mechanism upon the valve-shaft for reversing the position of the eccentric and thereby reversing the direction of rotation of the engine and for holding the eccentric in the position to which it is moved while rotating with the valve-shaft, substantially as set forth.

15. The combination with the circular group of cylinders open at one end and having a head for closing the other ends of said cylinders, valve-seats and ports in said cylinders, of pistons and connecting-rods, a main shaft and crank, a crank-pin and crank-pin-head connection, a trunnion-frame receiving the crank-pin, a valve-shaft parallel with the axes of the cylinders, a crank on the valve-shaft receiving said crank-pin, an eccentric moved by said shaft, two valves crossing each other and operated by said eccentric and a valve-chest at the end of said group of cylinders, substantially as specified.

16. The combination in a multicylinder-engine with two crossing oppositely-moving valves and their seats, and means for actuating said valves, of a balance-plate grooved across the face to receive the adjacent moving valve, a ring-frame behind the balance-plate, and springs acting upon the ring-frame to press the same and the balance-plate forward and the valves to their seats, substantially as specified.

17. The combination in an engine having a circular group of cylinders, a valve-shaft central between such cylinders, a dog secured to said shaft, an eccentric upon the valve-shaft pivoted to said dog, two valves crossing each other and acted upon by said eccentric, a sleeve surrounding the valve-shaft and having a pin entering a notch in the eccentric and means for actuating said sleeve so as to change the position of the eccentric, substantially as specified.

18. The combination in an engine having a circular group of cylinders, a valve-shaft central between such cylinders, a dog secured to said shaft, an eccentric upon the valve-shaft pivoted to said dog, two valves crossing each other and acted upon by said eccentric, a sleeve S with inclined slots surrounding the

valve-shaft and having a pin entering a notch in the eccentric, a sleeve T surrounding the sleeve S and having horizontal slots, a yoke-sleeve U having pins passing into the slots of the sleeves S and T, and means for actuating the yoke-sleeve, substantially as specified.

19. The combination in an engine with a circular group of four parallel cylinders their pistons and connecting-rods, and a head at one end of and common to all the cylinders and having valve-seats and ports through the seats, of two valves having ports therein, said valves crossing each other and fitted to slide

upon said valve-seats and to progressively admit steam to said cylinders, said valves moving in a plane parallel with the head of said cylinders, and means for actuating said valves, substantially as set forth.

In witness whereof we have hereunto set our signatures this 1st day of October, 1898.

LEWIS C. WORRON.
A. VANDERBEEK.

Witnesses:

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W. W. GRANT.