A. SUNDH.

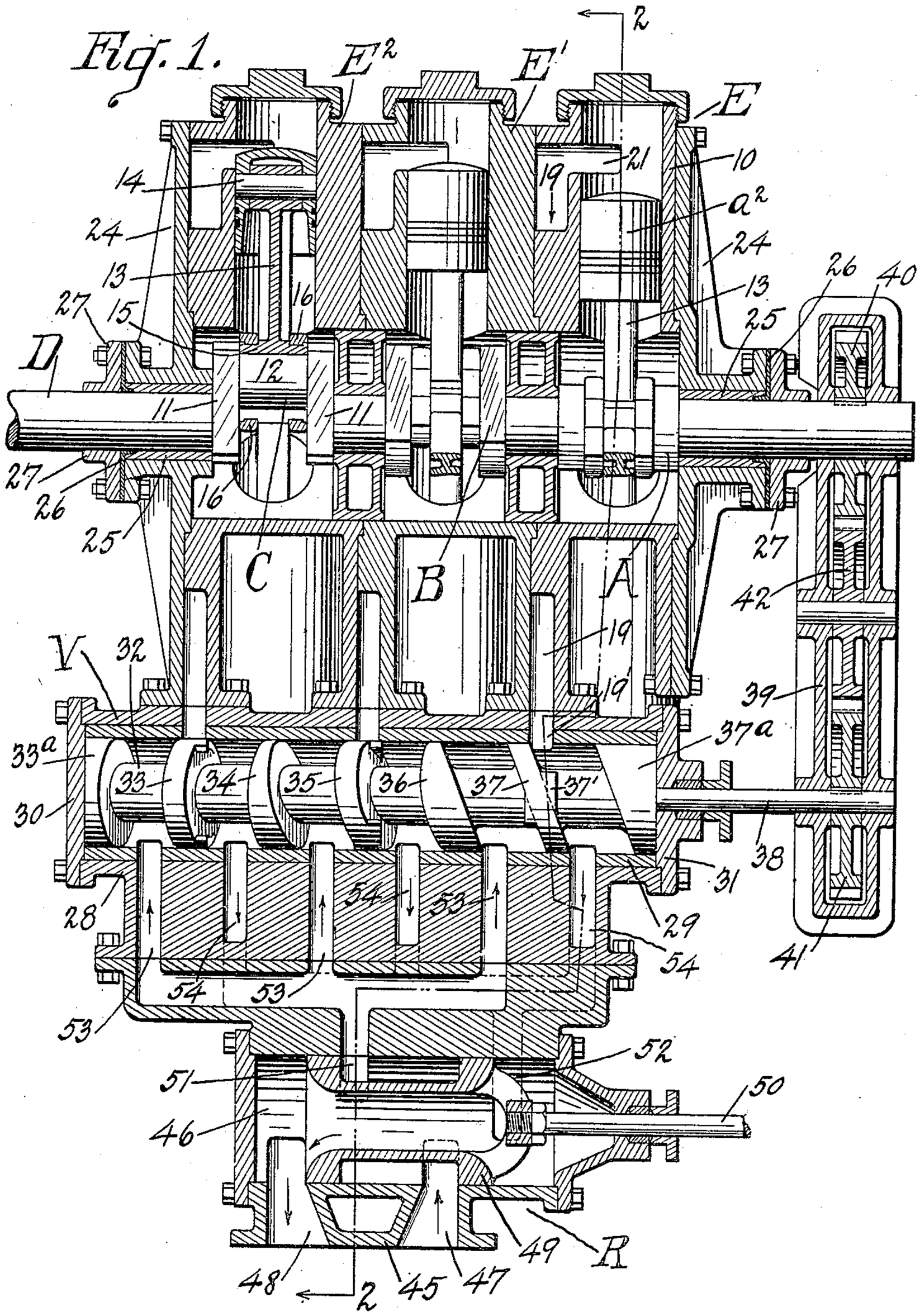
HYDRAULIC ENGINE.

APPLICATION FILED JULY 3, 1909.

980,449. Patented Jan. 3, 1911.

3 SHEETS—SHEET 1.

Fig. 1.



Witnesses:
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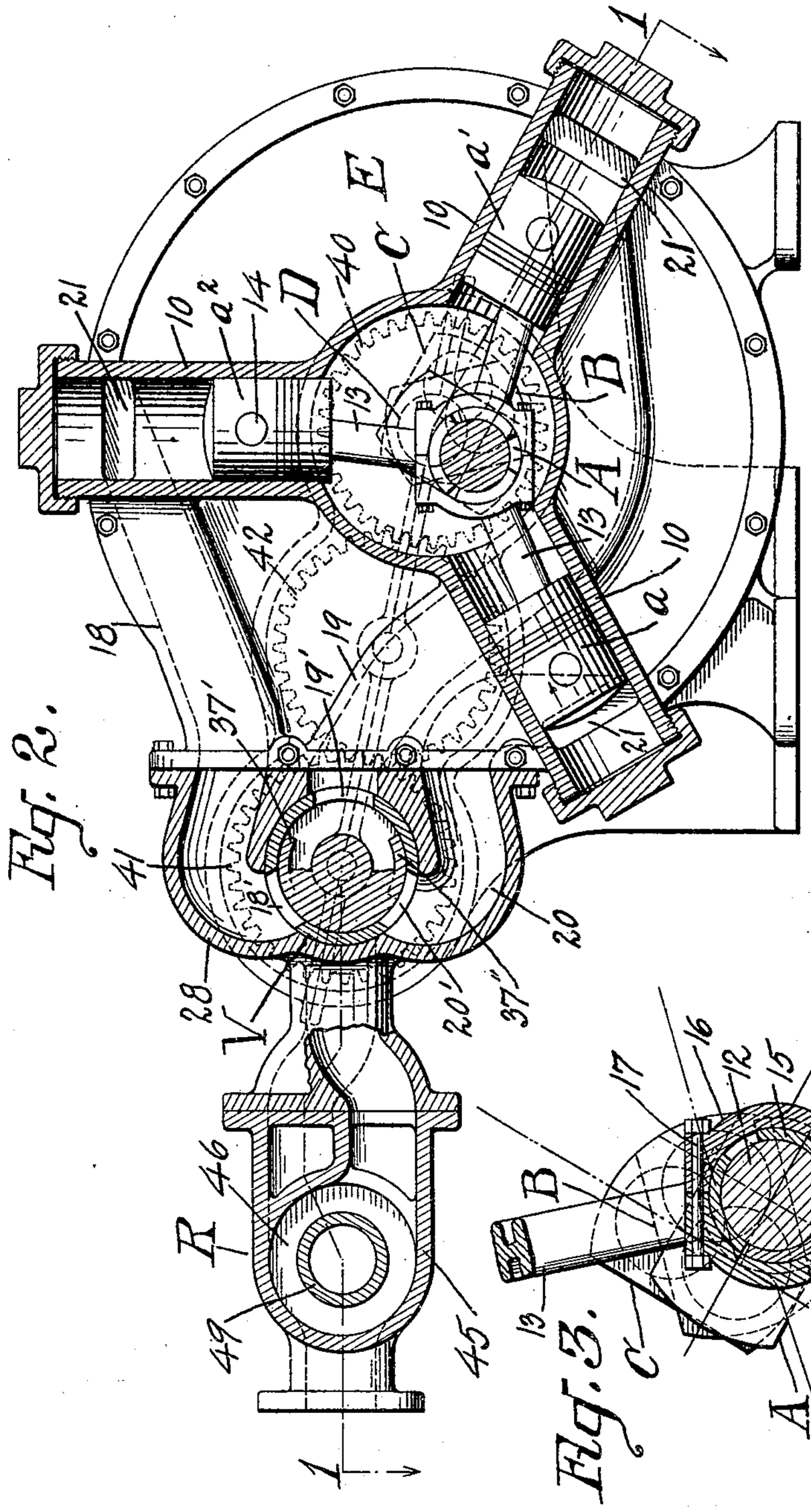

Fig. 2.

Fig. 3.

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Fig. 4.

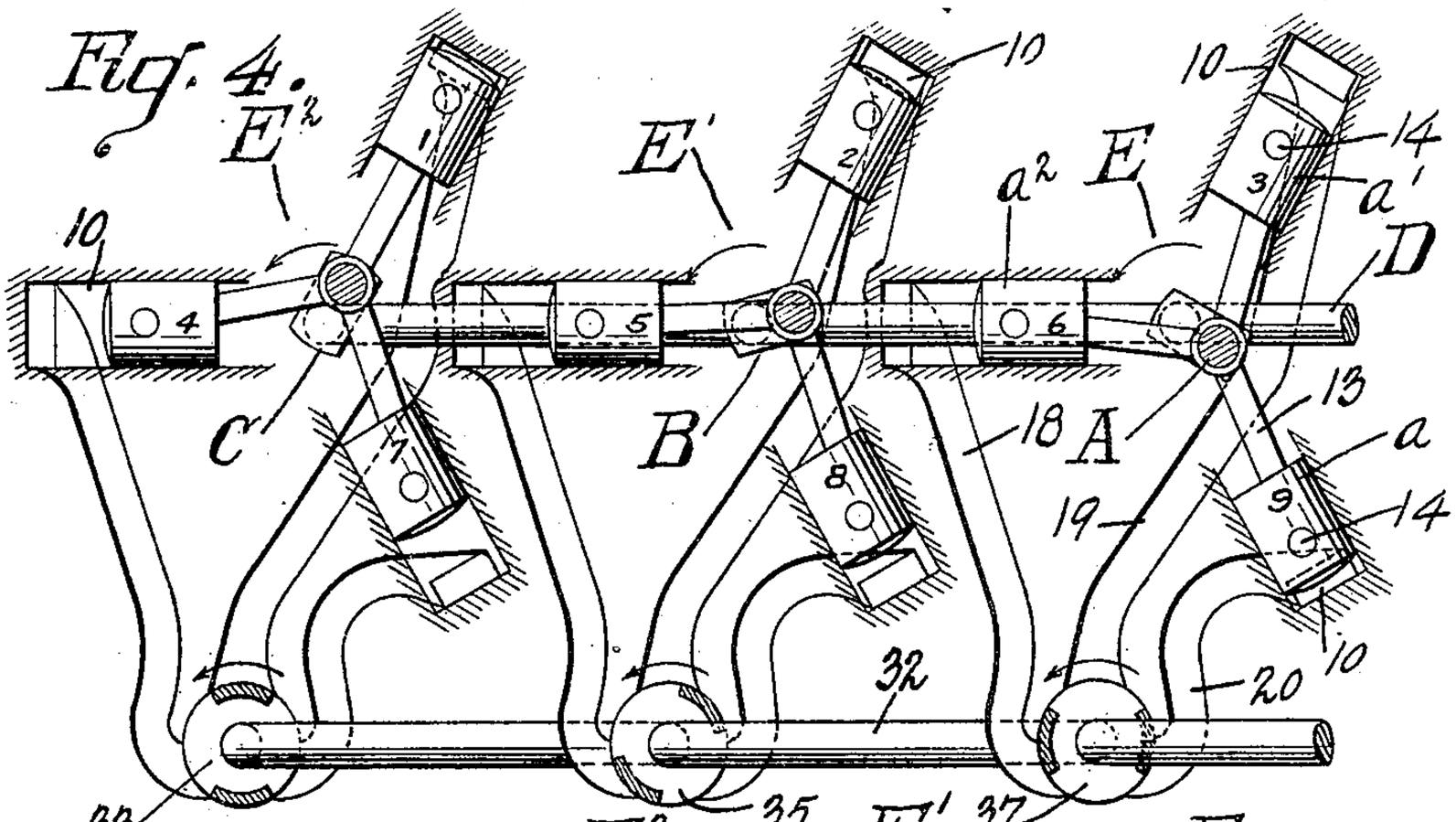
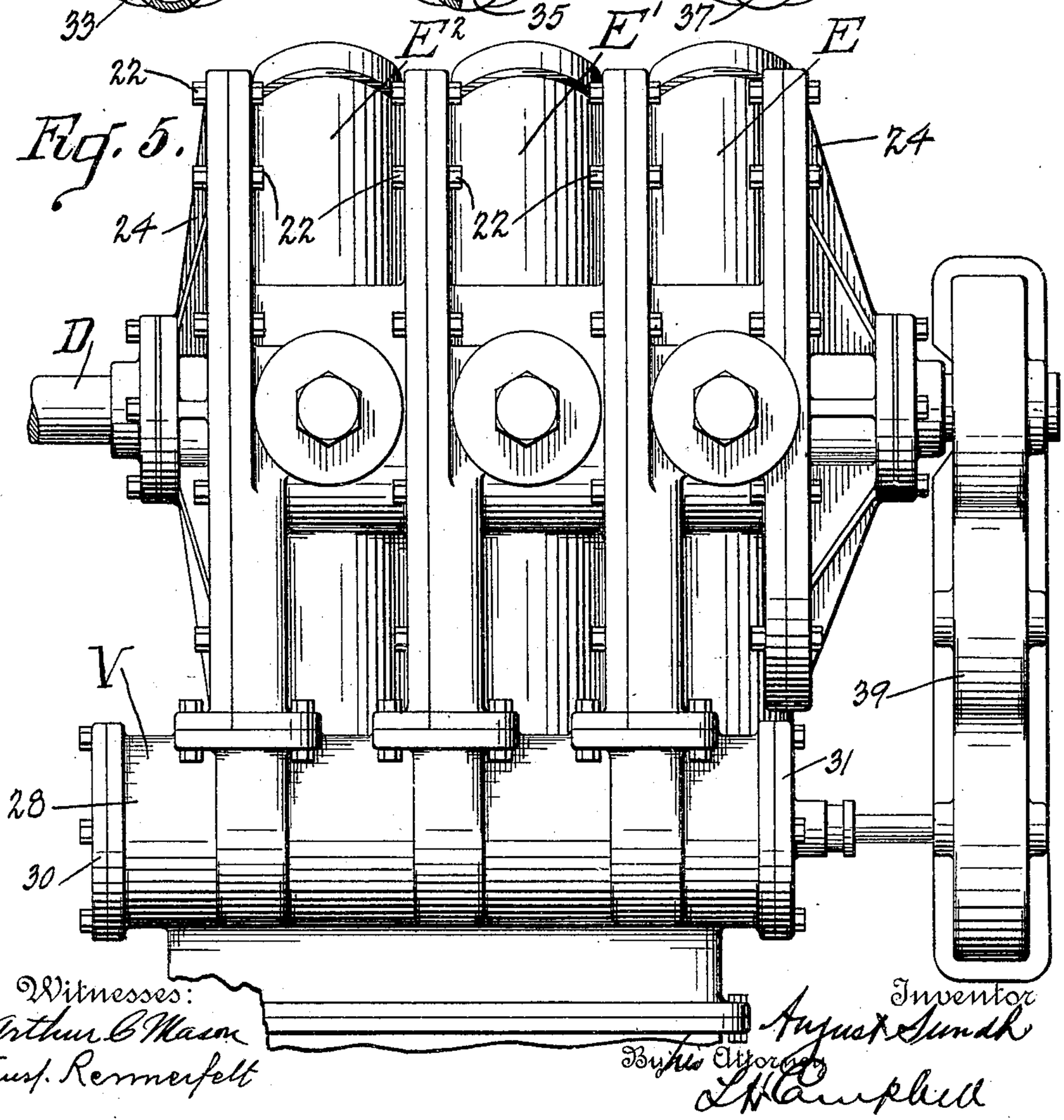


Fig. 5.



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UNITED STATES PATENT OFFICE.

AUGUST SUNDH, OF YONKERS, NEW YORK.

HYDRAULIC ENGINE.

980,449. Specification of Letters Patent. Patented Jan. 3, 1911.

Application filed July 3, 1909. Serial No. 505,818.

To all whom it may concern:

Be it known that I, AUGUST SUNDH, a citizen of the United States, residing at Yonkers, in the county of Westchester and State of New York, have invented a new and useful Improvement in Hydraulic Engines, of which the following is a specification.

My invention relates to a power unit or motor, designed to be operated by a liquid under pressure. The motor is of the type comprising a series of reciprocating pistons operating in cylinders regularly disposed about a driving shaft to which the pistons are operatively connected. In engines or motors of this type in which the power is applied to reciprocating pistons and transmitted to a rotary driving shaft, the power applied to said shaft is necessarily of a fluctuating character.

One of the objects of the present invention is to provide a unit of this type in which the impulses or fluctuations transmitted through the driving shaft cannot be felt even where the engine is run very slowly and under a heavy load, a practically constant power or torque being obtained.

A further object of the invention is to obtain a very compact unit, by means of which great power can be transmitted and only comparatively small space required.

A still further object of the invention is to obtain a simple and compact construction in which the parts, especially those subject to much wear or which may need adjustment, are readily accessible.

In the accompanying drawings which illustrate a construction embodying the present invention, Figure 1 is a sectional plan view of the construction substantially on the line 1—1 of Fig. 2; Fig. 2 is a sectional elevation of the same taken substantially on the line 2—2 of Fig. 1; Fig. 3 is a sectional detail view taken through one of the cranks on the driving shaft, and showing the method of connecting the piston rods to the driving cranks; Fig. 4 is a diagrammatic view showing the relative positions of the pistons and also the controlling valves; Fig. 5 is a plan view of the power unit.

The power unit comprises three engines E, E′ and E², substantially alike in construction, and each preferably comprising a casting formed with three cylinders 10. The cylinders are equally spaced so that the axis of each cylinder is at an angle of 120° with the axes of the other cylinders. The cylinders for the three engines or sections E, E′ and E² preferably extend in the same direction, that is each section comprises a vertical cylinder and two downwardly and outwardly inclined cylinders inclined 60° from the vertical. The ports for each unit are preferably formed in the same casting with the cylinder. The flow of liquid to and from the cylinders is controlled by rotary valve mechanism V, the supply of liquid to the latter being in turn controlled by a reversing valve R, as will be more fully described hereinafter.

A driving shaft D is provided with cranks A, B and C for the engines E, E′ and E², respectively. Each of these cranks comprises crank arms 11 connected by a wrist pin 12. The engine E comprises pistons *a*, *a′* and *a²*, adapted to reciprocate in the cylinders 10. Each of these pistons is connected by a piston rod 13 with the crank A. The outer ends of the piston rods are connected to the pistons by pivot pins 14. The inner end of each piston rod is formed with an arc shaped flange 15 which bears against the wrist pin 12. Divided rings 16 surround the bearing flanges 15 and are secured in position by bolts 17. The bearing flanges 15 are of such length as to permit the oscillating motion of the piston rods 13 which occurs during the reciprocation of the pistons. Passages or ports 18, 19, and 20 extend from ports 21 near the outer ends of the cylinders for the pistons *a*, *a′* and *a²*, respectively, to the casing of the valve V. These passages are preferably in the form of recesses in the casting of the engine E, one wall of each of said passages consisting of the casting for the adjacent engine E′. The three castings for the engines are provided with flanges secured together by bolts 22 (see Fig. 5). End plates 24 are bolted to the engines E and E² and are proveded with bearing sleeves 25 in which the driving shaft D is journaled. Packings 26 are held in place by means of caps 27 bolted to the end plates 24. It should be noted that a very compact arrangement of the engines is provided and economy of space secured.

The valve mechanism V comprises a casing 28 which is preferably in the form of a single casting, and is bolted to the engines. This casing is provided with a cylindrical opening to receive a hollow cylinder 29, which forms the valve chamber. The valve

chamber is provided with end plates 30 and 31. Within the valve chamber is a rotary valve member 32 provided with a series of disks or valve sections 33, 34, 35, 36, and 37, which fit closely within the valve chamber so as to prevent the passage of liquid. The valve member 32 is provided with a valve stem 38 extending through the end plate 31. The lateral faces of the sections 34 and 36 are parallel with the adjacent faces of the valves 33, 35, and 37, so as to maintain a balanced pressure of the liquid on the valve. The valve member 32 is also provided with end sections 33^a and 37^a having lateral faces parallel respectively with the valves 33 and 37 for a similar purpose. The stem 38 and the engine shaft D are journaled in a casing 39 in which are located gear wheels 40 and 41 keyed to the engine shaft and the valve stem respectively, and an intermediate idler gear 42. These gear wheels or at least gear wheels 40 and 41 are the same size, so that the valve member 32 will be rotated at the same angular velocity as the engine shaft D. The passages 18, 19 and 20 extending from the cylinders of the engine E are continued through the casing 28 to ports 18′, 19′ and 20′, respectively, formed in the valve cylinder 29. These ports are all in the same vertical plane and are controlled by the valve 37 which as shown in Fig. 1 extends diagonally across these ports so that as the valve member rotates each port will communicate with the valve chamber alternately on opposite sides of the valve 37. This valve is provided with lugs 37′ and 37″ which insure a quick opening and closing of the ports at the proper moment. The valves 33 and 35 are identical in shape with the valve 37, but are placed in different angular positions. The disks 34 and 36 serve to divide the valve chamber into three sections in which the valves 33, 35 and 37, respectively, are located.

The reversing valve R comprises a casing 45 secured to the casing 28, and formed with a valve chamber 46. A hollow valve member 49 is located within the valve chamber 46 and is adapted to be moved longitudinally by means of valve stem 50. This valve is shown in its left-hand position, in which the pressure port 47 is in communication with the port 51, and the exhaust port 48 is in communication through the valve member 49 with the port 52. The port 51 communicates with three passages 53, which lead to the three sections of the valve chamber 29. The port 52 likewise communicates with three passages 54, also leading respectively to these sections.

Although the sections E, E′ and E^2 are each herein referred to as an engine, and each operates as an engine, it is obvious that as herein combined they form a single unit or engine having a single drive shaft, rotary controlling valve, etc. The parts are so combined and arranged as to transmit a practically constant and uniform driving power through the drive shaft.

With the parts in the position shown on the drawings, the operation of the engine E will be as follows: Liquid under pressure will enter the reversing valve through the port 47 and flow through the valve chamber 46 and passage 53 into the valve chamber 29 at the left hand side of the valve 37. A portion of the liquid will flow through the passage 20 to the cylinder of the piston a which at this time has just commenced its inward stroke. The engine shaft D at this time is rotating in a counterclockwise direction. A portion of the liquid also flows from the valve chamber 29 through the port 18′ and passage 18 to the cylinder of the piston a^2 which is approaching its innermost position. The passage 19 leading from the cylinder of the piston a' is at this time open to the exhaust, the valve 37 being at the left-hand side of the port 19′, as shown in Fig. 1. The liquid from the cylinder for the piston a' is therefore flowing outwardly through the passage 19, valve chamber 29, passage 54, port 52 and through the hollow reversing valve 49 to the exhaust port 48. It will be understood that the valve member is rotating in a counter-clockwise direction in unison with the shaft D. The lug 37′ on the valve 37 as shown in Fig. 2 is nearing a position in which it closes the port 18′, which position is reached as the crank A is brought into alinement with the piston a^2 at which time the latter is at its innermost position. The continued movement of the valve 37 from this position at once opens the port 18′ to the exhaust, thereby permitting the piston a^2 to commence its outward stroke. As the piston a^2 reaches its outermost position, the lug 37″ has been brought into position to again close the port 18′ so that as the piston again commences its inward travel the lug 37″ is moved beyond such closing position and the passage 18 is thereby again brought into communication with the pressure. In a similar manner the valve 37 connects the cylinders for the pistons a and a' alternately with the pressure and exhaust at the proper moment. The individual operation of the engines E′ and E^2 is substantially the same as that of the engine E and need not be described in detail.

The coöperation of the three engines as a unit will be best understood from a consideration of Fig. 4. As diagrammatically shown in this view the crank B is a short distance in advance of the crank A and the crank C in advance of the crank B. The crank B is preferably 40° in advance of the crank A and the crank C 40° in advance of the crank B. The pistons for the three engines are in this figure numbered in the order in which they reach any predeter-

mined position in their cycle of operation. For example the piston of the engine E^2 designated 1 is at the outer limit of its stroke, the crank C being in alinement with said piston. If now the shaft D be rotated in the direction indicated by the arrows through 40° the piston 2 of the engine E′ will reach its outer limit. An additional rotation of the shaft D through 40° will bring the piston 3 of the engine E to its outer limit. An additional rotation through 40°, that is 120° from the initial position shown, brings the piston 4 of the engine E^2 to its outer limit. This would be evident from the fact that the cylinder for the piston 4 is 120° in advance of the cylinder for the piston 1, so that a rotation of the crank C through 120° is required to bring it in alinement with the piston 4. Continued rotation of the shaft D in a similar manner brings the pistons 5, 6, 7, 8 and 9 successively to their outermost positions, each piston being 40° behind the preceding one, as measured by the angular rotation of the shaft D. It will thus be seen that as the shaft D rotates, the nine pistons will be successively brought to their initial positions, that is the commencement of their inward stroke. It will also be apparent that as the innermost position of each position is 180° in advance of its outermost position, said innermost position can never be reached when anyone of the other pistons is at its outer limit. For example with the parts in the position shown in Fig. 4, the piston 6 is approaching its inner limit and is 20° from its inner limit, and will therefore pass the dead center after the piston 1 has started inward and before the piston 2 has completed its outward stroke. The piston 7 is 60° from its inner position and will therefore reach said position after the piston 2 advances 20° on its inward stroke and while the piston 3 is still moving outward and is 20° from its outer position. It will be apparent from a careful consideration of this diagram that as the shaft D rotates, one of the pistons will be brought to the dead center position either at the inner or outer limit of its travel for every 20° through which the shaft rotates, and that therefore no two pistons will be at a dead center position at the same time. It will also be apparent that at any moment at least three of the pistons will be exerting a driving action on the shaft. Owing to the uniform distribution of the pistons a substantially constant driving power is transmitted through the shaft D, the fluctuations or variations in the torque being so slight as to be imperceptible under any conditions found in practice. This feature renders the present invention of a special value, as it practically eliminates the impulses or vibrations which are ordinarily present when motors of the reciprocating piston type are used.

The ports and passages forming communication between the engines E′ and E^2 and valve chamber 29 are similar to those described in connection with the engine E, and are similarly arranged as indicated by Fig. 4. The angular position of the valve members 33 and 35 correspond to the angular positions of the cranks B and C, that is the valve 35 is 40° in advance of the valve 37, and the valve 33 is likewise 40° in advance of the valve 35.

The particular number of pistons employed is of importance, nine being the smallest number that can be used in connection with rotary controlling valves and at the same time secure a smooth operation of the engine. Where the ordinary type of Brotherhood engine is used only three cylinders are employed, and the power transmitted is very irregular. It has been attempted to combine two of these engines, thereby employing six cylinders, but with this arrangement if the cylinders are uniformily distributed each cylinder will reach its dead center position at the same time as the opposite cylinder, so that a uniform application of power to the driving shaft cannot be obtained. If a different number of pistons is employed, as for example, 4, 5, 7 or 8, it is necessary to employ reciprocating valves which are much more complicated and consume much more power in operation than the rotary valve mechanism herein shown. The latter is simple and efficient and consumes but little power.

I wish not to be limited to the particular construction herein shown, as various changes in the details of construction and arrangement of parts might obviously be made without departing from the spirit and scope of the invention.

What I claim is new, and desire to have protected by Letters Patent of the United States is:—

1. In a power unit, the combination of a plurality of sections each comprising radially disposed cylinders and pistons in the cylinders, a drive shaft, a plurality of cranks on said shaft in different axial planes, connections between said cranks and pistons, said parts being arranged to bring each piston to its limits of travel when the other pistons are all in intermediate positions of travel, a rotary valve member controlling the supply of an operating fluid to the cylinders, and operable to connect each cylinder alternately with the supply and exhaust once during each complete rotation of the valve member, and gearing connecting the drive shaft and said valve member for rotation together at the same angular velocity.

2. In a fluid motor, the combination of a plurality of sections each formed with radi-

ally disposed cylinders and ports formed in the faces of said sections and leading from the cylinders, and means for securing said sections together as a unit.

3. In a power unit, the combination with a plurality of sections, each formed with radially disposed cylinders and recesses in the lateral faces of said sections communicating with the cylinders, and means for clamping said sections together to form ports of said recesses.

4. In a power unit, the combination with a plurality of radially disposed cylinders arranged in parallel planes and pistons therein, of a drive shaft, driving connections between said pistons and shaft, and means for supplying fluid pressure to the pistons and thereby rotating the drive shaft, the disposition of said parts being such that all of said pistons are brought in succession to a dead center position during each half revolution of the drive shaft whereby a practically constant turning moment at the drive shaft is obtained.

5. In a power unit, the combination with a drive shaft, of a plurality of radially disposed cylinders, pistons in the cylinders, operating connections between the shaft and pistons, and means for reciprocating the pistons, the number and disposition of parts being such that a plurality of the pistons are at all times being moved inwardly while the drive shaft is rotating and all of the pistons are successively brought to a dead center position during each half revolution of the drive shaft.

6. In a power unit, the combination with a crank shaft and cranks, of piston cylinders radially disposed about the crank shaft, pistons in said cylinders, piston rods connecting the pistons and cranks, the number and arrangement of said parts being such that not more than one piston is at the limit of its stroke at any time during the rotation of the crank shaft.

7. In a power device, the combination with a crank shaft and a plurality of cranks, of a plurality of cylinders disposed about each crank, pistons in said cylinders, and piston rods connecting the pistons and cranks, said parts being arranged to bring each piston to the outer or inner limit of its stroke while the other pistons are in an intermediate position.

8. In a power unit, the combination with a drive shaft, of three cranks connected thereto, three pistons connected to each crank, cylinders for said pistons, and means for reciprocating the pistons and rotating the drive shaft, said pistons being arranged to be brought successively to their limits of travel.

9. In a power unit, the combination of a plurality of sections each comprising a plurality of cylinders, a drive shaft extending through said sections, a crank on said drive shaft for each section, pistons in said cylinders and connected to said cranks, and means for reciprocating the pistons and bringing them successively to dead center positions.

10. The combination with a crank shaft and three cranks arranged at an angle of 40° to each other, cylinders radially disposed about the crank shaft, three of said cylinders being located at each crank, pistons in said cylinders and connected to said cranks, and means for reciprocating the pistons.

11. In a power unit, the combination with a drive shaft, of three sections each comprising three cylinders radially disposed about the drive shaft at angles of 120°, the corresponding cylinders of the three sections extending in the same radial direction, cranks on the drive shaft and located in said sections, the cranks in the outer sections being respectively 40° behind and 40° in advance of the middle crank, pistons in said cylinders, and piston rods connecting the pistons to the cranks.

12. The combination with a drive shaft, of nine cylinders radially disposed about said shaft, pistons in said cylinders, connections between the pistons and drive shaft, valve mechanism controlling the supply of an operating liquid to the cylinders, and driving connections between the drive shaft and valve mechanism for operating the latter to admit liquid to the cylinders successively at intervals of 40° in the rotation of the drive shaft.

13. The combination with a drive shaft, of nine pistons, connections between the drive shaft and pistons, means for applying driving impulses to the pistons, the impulse for each piston being 40° in advance of the following piston as measured by the angular movement of the drive shaft, and each impulse lasting through substantially 180° of rotation of the shaft.

14. In a power unit, the combination with a plurality of sections each comprising a plurality of cylinders, pistons in said cylinders, a driving member connected to said pistons, a valve chamber, a rotary valve member in said chamber and forming therewith a pressure and a discharge compartment for each of said sections, and ports leading from the cylinders to said compartments, said rotary valve member being geared to said driving member and controlling the flow of liquid between said compartments and the cylinders.

15. In a power unit, the combination of a drive shaft, nine cylinders disposed about said shaft, pistons in said cylinders, cranks connected to said shafts in different axial planes, said parts being arranged to bring the pistons successively to their limits of travel while the remaining pistons are in intermediate positions, a valve chamber, ports leading from said valve chamber to

the cylinders, and a rotary valve member controlling the flow of liquid through said ports.

16. The combination with a plurality of cylinders, pistons in said cylinders, a driving member connected to the pistons, a cylindrical valve chamber having pressure compartments and discharge compartments, ports extending from the valve chamber to said cylinders, and a rotary valve member comprising valves each controlling a number of said ports and operable to connect each port alternately to a pressure and a discharge compartment.

17. The combination with a valve chamber comprising a plurality of sections, of valves rotatable continuously in said sections and dividing each section into a pressure compartment and an exhaust compartment, ports communicating with each of said sections, means for rotating said valves into positions to connect each of said ports alternately with a pressure and an exhaust compartment, cylinders communicating with said ports, pistons in said cylinders and a driving member connected to said pistons.

18. The combination with a valve chamber comprising a pressure compartment and an exhaust compartment, of a rotary valve member separating said compartments, said member being inclined to its axis of rotation, a port leading from the valve chamber in positions to be alternately connected with the pressure and exhaust compartments as said valve member rotates, means carried by the valve member for effecting an abrupt opening and closing of said port, a cylinder communicating with said port, a piston in the cylinder, and a device driven by the piston.

19. The combination with a valve chamber, of a valve rotatable therein and dividing the valve chamber into separate compartments, said valve being in the form of a disk inclined to its axis of rotation, ports each extending from the valve chamber in position to be connected alternately with said compartments as the valve rotates, lateral extensions on said valve positioned to effect a quick opening and closing of said ports, and power mechanism operated by fluid transmitted through said ports.

20. The combination with a valve chamber, of a valve member rotatable therein and comprising a disk or disks dividing the valve chamber into separate compartments and valves dividing each of said compartments into pressure and exhaust sections, ports leading from the valve chamber and controlled by said valves, and power transmitting mechanism operated by fluid transmitted through said ports.

21. The combination with a valve chamber, a rotary disk valve in said chamber inclined to its axis of rotation and dividing the valve chamber into pressure and exhaust compartments, a rotary disk on the pressure side of said disk valve and having the face opposite the disk valve parallel with the adjacent valve face, means for rotating said disk valve continuously in one direction, ports controlled by said valve, and power mechanism operated by liquid supplied through said ports.

22. In power mechanism, the combination with a cylindrical valve chamber, of a rotary valve member in said chamber rotatable continuously in one direction and comprising a plurality of inclined disks dividing the valve chamber into separate compartments, the opposing faces of the disks being substantially parallel, ports leading from the valve chamber and controlled by said disks, pistons and piston cylinders communicating with said ports, and a power shaft connected to be driven by said pistons.

23. In power mechanism, the combination with a cylindrical valve chamber, of a rotary valve member dividing said cylinder into a plurality of alined compartments, a reversing valve operable when in one position to connect alternate compartments of said valve chamber with a pressure supply and the remaining compartments with an exhaust port, said reversing valve when in another position reversing said connections, ports leading from said cylindrical valve chamber and controlled by said rotary valve member, cylinders communicating with said last named ports, reciprocating pistons in said cylinders, and a driving member operated by said pistons.

24. In a power unit, the combination with a plurality of pistons and cylinders, of a valve chamber, ports extending from the valve chamber to said cylinders, a plurality of pressure and discharge ports opening into said valve chamber, a balanced rotary valve member in said valve chamber provided with enlarged disk-like portions inclined to the axis of rotation, said disk-like portions being positioned to connect each of the ports leading to the cylinders alternately with the pressure and discharge during each revolution of said valve member, and means for rotating said valve member continuously.

25. In a power unit, the combination with a plurality of sections each formed with piston cylinders and provided in their lateral faces with recesses forming valve ports when the said sections are assembled, a cylindrical valve chamber communicating with said ports, a rotary balanced valve member in said chamber provided with inclined disks forming valves controlling said ports, and means for conveying fluid to and from the valve chamber.

26. The combination with a casting provided with radially disposed cyliners, a drive shaft, pistons in said cylinders and op-

eratively connected to the drive shaft, a valve casing secured to said casting, said casting and valve casing being provided with ports arranged in substantially the same plane perpendicular to the drive shaft, and a rotary valve in said valve casing, said valve being located beyond the cylinders in a direction perpendicular to the drive shaft.

27. In a power unit the combination with a plurality of sections each provided with radially disposed cylinders, pistons in said cylinders, a drive shaft connected with said pistons, a cylindrical valve chamber secured to said sections, said sections and valve chamber being provided with ports communicating with the cylinders and interior of the valve chamber, the ports for each of said sections being disposed in substantially the same plane perpendicular to the drive shaft, a rotary valve within the valve chamber and provided with annular enlargements forming valves controlling the flow of an operating fluid to and from the cylinders.

28. The combination with a valve chamber, of a rotary valve member within said chamber provided with enlarged portions dividing said chamber into a plurality of compartments, a port leading from each of said compartments to a source of fluid pressure supply, an exhaust port leading from each of said compartments, a plurality of piston cylinders, reciprocating pistons therein, a driving shaft connected with said pistons, ports extending from the cylinders to the valve chamber, and valves carried by said valve member and controlling the flow of liquid to and from the piston cylinders.

29. In a power unit, the combination with a plurality of cylinders, of a valve chamber, a rotatable valve in said chamber, ports extending from said cylinders and opening into the valve chamber substantially in a plane perpendicular to the axis of the valve, said valve comprising an annular enlargement or disk inclined to the axis of rotation and positioned to connect each of said ports alternately with the valve chamber on opposite sides of said disk as the disk is rotated.

30. In a power unit, the combination with a plurality of cylinders, of a valve chamber, ports extending from said cylinders to the valve chamber, an inclined disk within the valve chamber forming a valve controlling the flow of an operating fluid to and from the cylinders, pistons within said cylinders, a drive shaft connected to the pistons, gearing between the drive shaft and said valve for causing the rotation of the valve at the same angular velocity as the drive shaft, and pressure and exhaust ports extending from the valve chamber.

In testimony whereof, I have signed my name to this specification in the presence of two subscribing witnesses.

AUGUST SUNDH.

Witnesses:
JAMES G. BETHELL,
JOHN F. RULE.