E. B. TREE.

ROTARY ENGINE.

APPLICATION FILED APR. 8, 1910.

1,104,331.

Patented July 21, 1914.

5 SHEETS—SHEET 1.

Fig. 1.

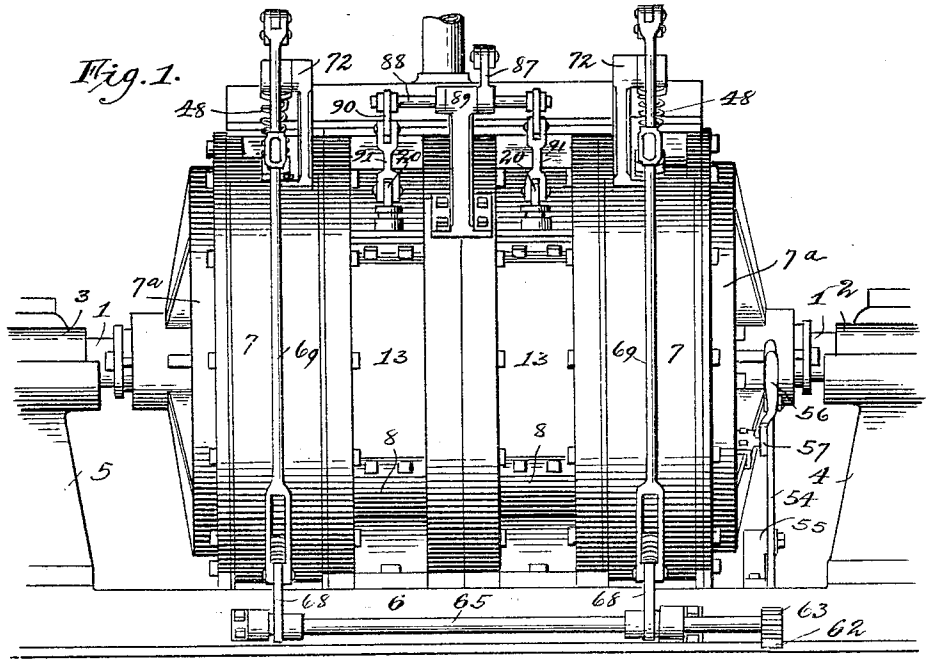
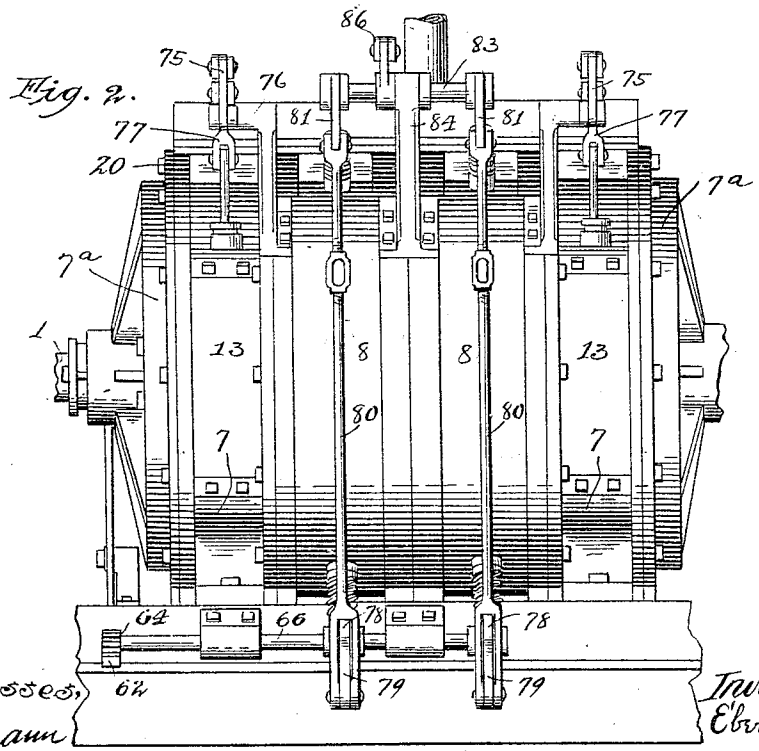


Fig. 2.



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S. N. Pond

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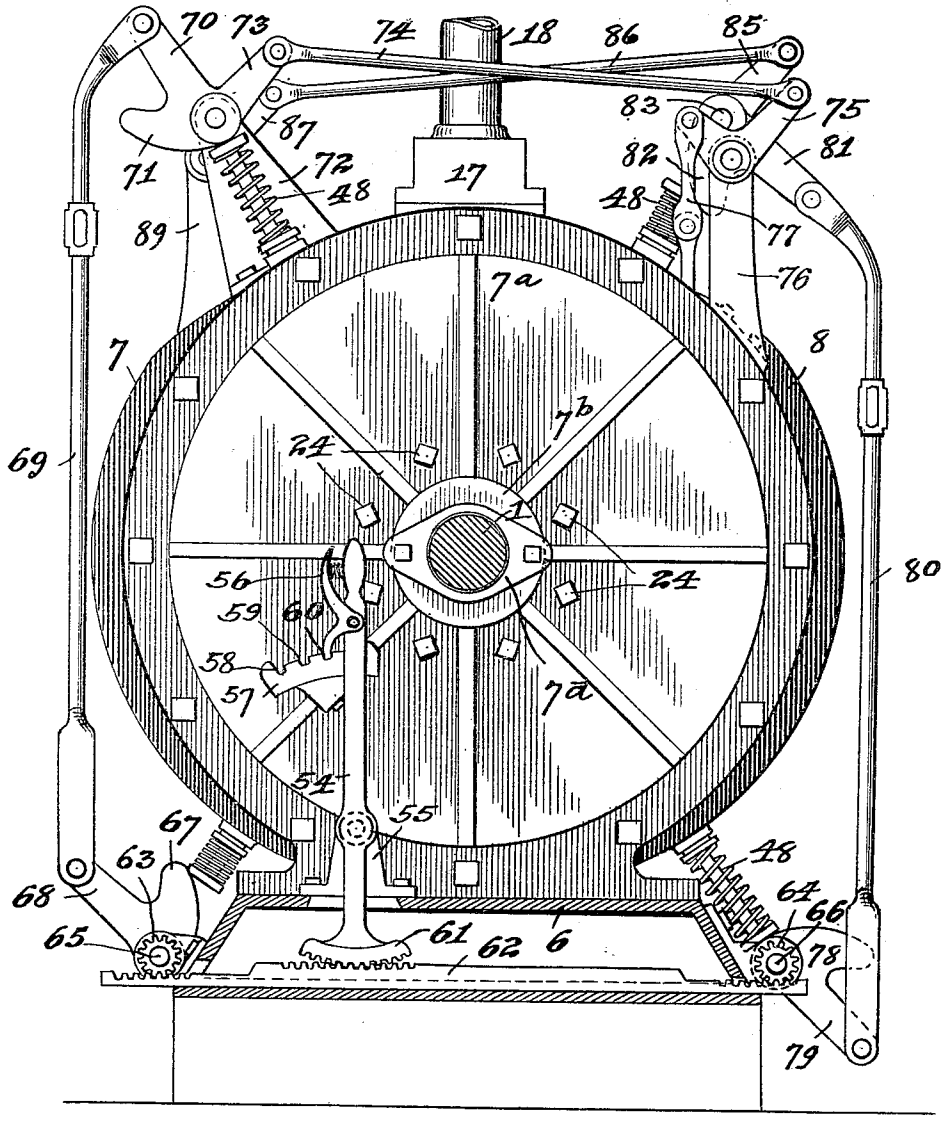
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5 SHEETS—SHEET 2.

Fig. 3.



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5 SHEETS—SHEET 3.

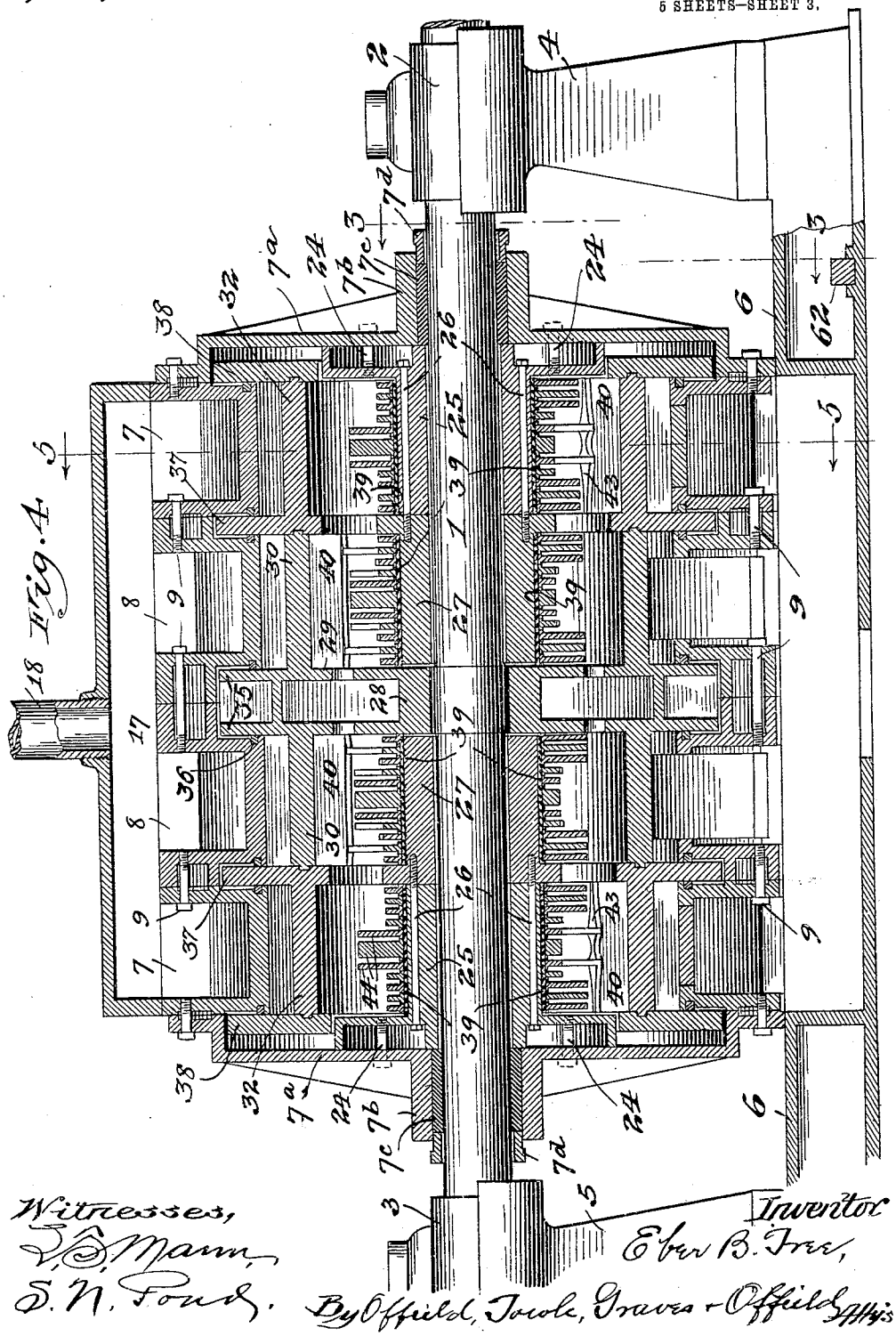


Fig. 4.

Witnesses,
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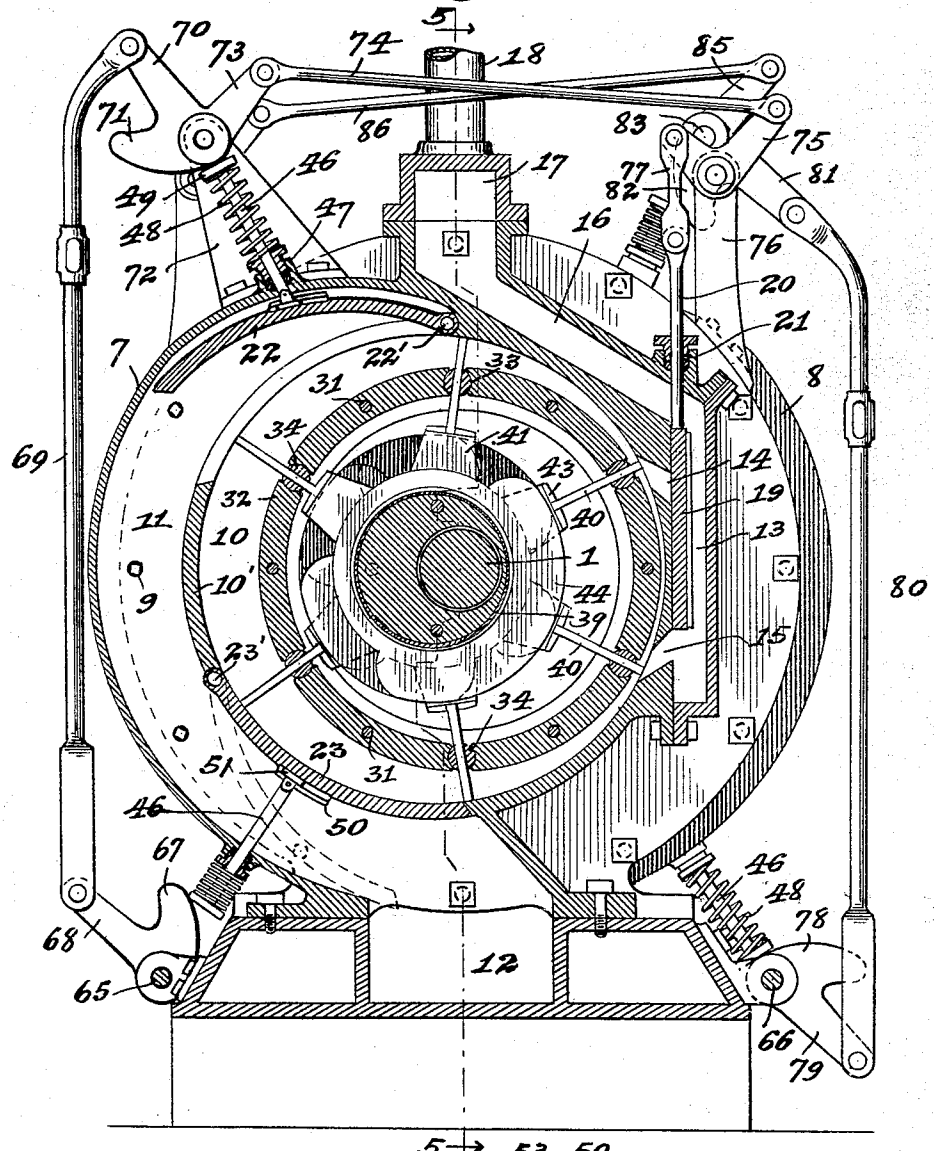
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5 SHEETS—SHEET 4.

Fig. 5.



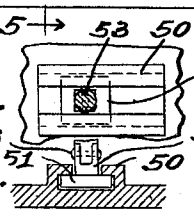


Fig. 12.

Fig. 13.

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5 SHEETS—SHEET 5.

Fig. 6.

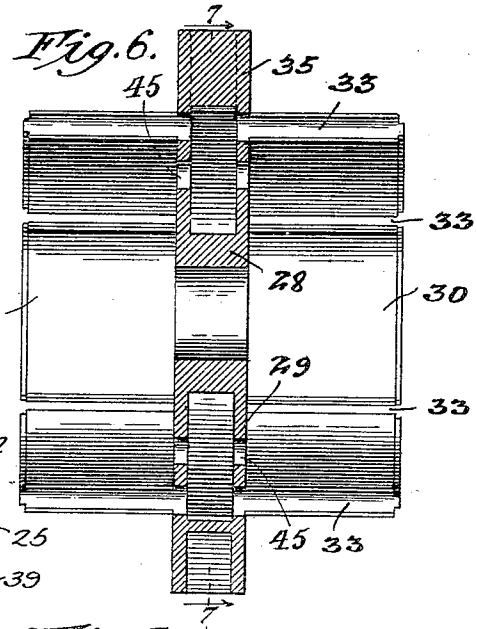


Fig. 8.

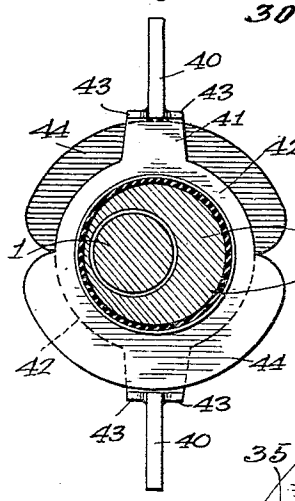


Fig. 9.

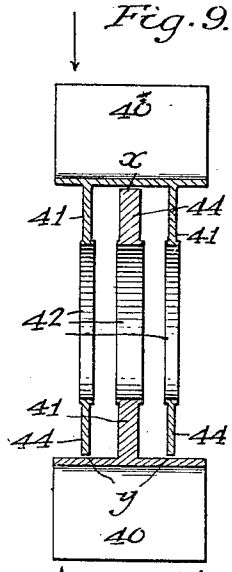


Fig. 7.

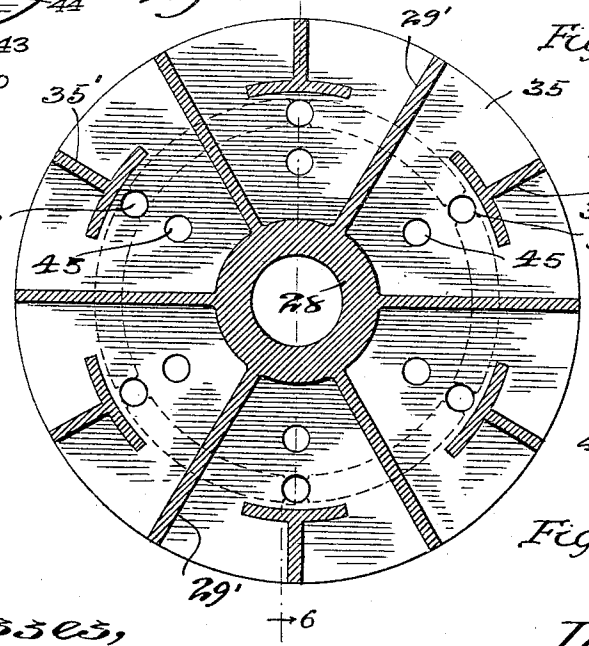


Fig. 10.

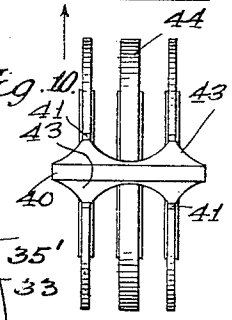
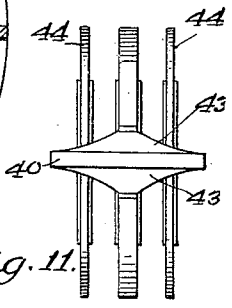


Fig. 11.



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UNITED STATES PATENT OFFICE.

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ROTARY ENGINE.

1,104,331. Specification of Letters Patent. Patented July 21, 1914.

Application filed April 8, 1910. Serial No. 554,122.

To all whom it may concern:

Be it known that I, EBER B. TREE, a subject of the King of Great Britain, at present residing at Chicago, in the county of Cook and State of Illinois, have invented certain new and useful Improvements in Rotary Engines, of which the following is a specification.

My invention relates to rotary engines, and has reference more particularly to that type of engine employing eccentric pistons in the form of radial blades or vanes, cooperating with a piston drum concentric and fast with the driven shaft, through which drum the piston vanes reciprocate radially during their rotation, and have wiping contact at their outer ends with the inner surface of the cylinder, and wherein the rotary piston drum carries radial flanges that overlap and form steam tight joints with the ends of the working chamber of the cylinder, so as to constitute rotating side walls of the latter.

The general and primary object of the invention is to provide an improved engine of this type characterized by increased simplicity of construction, greater durability, and superior efficiency and reliability in operation; among the chief special advantages sought to be attained being a reduction in the wear caused by centrifugal action of the moving parts through a more perfect balancing of said parts; a more perfect neutralizing of the lateral thrusts upon the driven shaft and a consequent reduction in the wear on the shaft bearings which is accomplished mainly through a novel arrangement of multiple-cylinder engine; an improved construction of piston vane, adapted to permit the use of counter-balances in an internested assemblage of the hubs and shanks of such vanes without any sacrifice of strength; an improved construction of exhaust valve; an improved valve-operating mechanism for simultaneously shifting, from the movement of a single lever, all the supply and exhaust valves of a multiple-cylinder rotary engine of that type wherein each cylinder has a pair of exhaust valves that are positively shifted between open and closed positions according to the direction in which the engine is to run.

The above named objects and advantages, with others of lesser importance, are secured through several novel structural features and characteristics, all of which will be readily understood from a consideration of the accompanying drawings wherein I have illustrated my invention as embodied in a multiple-cylinder expansion engine of the eccentric piston type having four cylinders or units, located side by side, and operating on a common driven shaft extending through and journaled outside the series of cylinders, the disposition of the units being such that the lateral thrusts upon the shaft produced by the two outside or end cylinders are balanced and neutralized by the opposing thrusts of the two intermediate cylinders.

Referring to the said drawings, Figure 1 is a side elevation of my improved engine. Fig. 2 is a similar view from the opposite side thereof, omitting the shaft bearings. Fig. 3 is an end view, in cross-section through the drive shaft, as viewed on the line 3—3 of Fig. 4. Fig. 4 is a longitudinal vertical axial section. Fig. 5 is a transverse section on the line 5—5 of Fig. 4. Fig. 6 is a detail in longitudinal section of the integral member forming the intermediate piston drums and their web and hub connection to the shaft, on the line 6—6 of Fig. 7. Fig. 7 is a transverse section of the same on the line 7—7 of Fig. 6. Fig. 8 is a detail side elevation of a pair of oppositely disposed piston vanes, showing also their counter-balancing devices, and the shaft, bearing boss, and wear-sleeve in cross-section. Fig. 9 is a view in section of one interfitting pair of piston vanes, illustrating the manner in which they may be cast. Fig. 10 is a top plan view of the piston vanes shown in Fig. 9. Fig. 11 is a bottom plan view of the same. Fig. 12 is a fragmentary detail of a portion of one of the exhaust valves showing the manner of connecting the valve-operating stem thereto. Fig. 13 is a cross-sectional detail of Fig. 12.

In the accompanying drawings I have illustrated my improvements as embodied in an organization of engine employing four complete cylinders or units disposed side by side on a common driven shaft, since certain features of my improvements are applicable to such a multiple-cylinder organization; but it will be apparent that other features of importance are equally applicable to an engine employing but a single cylinder, and are in no wise dependent upon or peculiar to the multiple-cylinder arrangement.

Referring, then, to the drawings, for a detailed description of the principal coöperating parts, 1 designates the driven shaft journaled in bearings 2 and 3 carried by standards 4 and 5, respectively, rising from the engine base 6. Rigidly mounted on the engine base 6 are a series of 4 cylinders,—a pair of end cylinders 7, and a pair of intermediate cylinders 8. These cylinders are all rigidly united to each other as by screw bolts 9 (Fig. 4) passed through mating flanges on the ends thereof; and secured to the outer sides of the end cylinders 7 are stationary end walls 7^a, formed with central bosses 7^b, through which extends the driven shaft 1. The bosses 7^b contain soft packing 7^c confined by glands 7^d surrounding the shaft with slight clearance.

By reference to Fig. 4 it will be observed that the end cylinders 7 and intermediate cylinders 8 are both disposed eccentric to the driven shaft 1, and that the eccentricity of one pair of said cylinders relatively to the shaft is diametrically opposite that of the other pair. As the several cylinders and their contents are structurally identical, being merely oppositely arranged relatively to the driven shaft, the same characters of reference will for the most part be employed in describing the corresponding parts of the several cylinders.

Referring to Fig. 5, it will be seen that each cylinder is so cored as to present a circular working chamber 10, which is eccentric to the shaft 1, and on one side thereof an exhaust passage 11, which communicates at its lower end with an exhaust conduit 12, that extends beneath and is common to all of the several cylinders. Opposite the exhaust duct 11 there is formed a valve chest 13 communicating with the working chamber 10 by a pair of steam ports 14 and 15, said valve chest being supplied with steam through a suitably cored duct 16 from a main steam supply trunk 17 extending above and common to all four cylinders and itself receiving steam through a supply pipe 18.

Within each valve chest 13 is fitted a slide valve 19 having a stem 20 extending through a stuffing-box 21, and connected to valve actuating mechanism hereinafter described. The valve 19 controls the steam ports 14 and 15 to effect the starting, stopping, and reversing of the engine, as more particularly hereinafter explained. The semi-circular wall 10′ dividing the steam space 10 from the exhaust passage 11 is cut away at two points throughout a considerable extent of said wall, to form elongated exhaust ports which are controlled by hinged valves 22 and 23, respectively, said valves being hinged at one end at 22′ and 23′ in the wall 10′ and curved conformably to the curvature of said wall so that, when closed, they constitute in effect parts of the circular wall of the working chamber. One of said valves is open and the other maintained closed when the engine is running, their condition being reversed when the engine is reversed through a suitable operating mechanism, which will be later described.

Strongly secured to the stationary end walls 7^a, as by screw bolts 24, and extending within and through the outer cylinders 7, are bearing bosses 25, which are eccentrically bored to accommodate the driven shaft 1, it being noted that said shaft passes through said bearing bosses with clearance sufficient to avoid any frictional wear between said parts resulting from any slight bending or other variation of the shaft from true axial alinement with the axis of its bearings; and secured to the inner ends of the stationary bosses 25, as by screw bolts 26, are a similar pair of bearing bosses 27, which extend through the inner cylinders 8 and are similarly bored to accommodate with clearance the driven shaft 1, but which have an opposite eccentricity to that of the hubs 25.

Shrunk upon or otherwise secured to the shaft 1, between the two inner cylinders 8 is the hub 28 of a built-up piston drum that is common to all four cylinders. The hub 28 is, as shown, cast integral with a disk-like web 29 which, as best shown in Figs. 6 and 7 is of hollow skeleton form to best combine strength and lightness; and integral with the web 29 on both sides thereof, and lying within the cylinders 8, are drum cylinders 30 that are co-axial with the shaft 1; and secured to the outer ends of drum sections 30, as by screw bolts 31, are similar drum sections 32. These drum sections 30 and 32 are formed at intervals with longitudinal bearings 33, adapted to receive a corresponding series of slotted cylindrical rockers 34, which form swivel bearings for the piston vanes hereinafter described.

Integral with the web 29 of the drum is a radial extension 35, the opposite sides of which constitute in effect radial flanges of the drum sections 30, such flanges overlapping by suitably packed joints 36, the proximate ends of the working chambers of the cylinders 8; and on the inner ends of the drum sections 32 are formed or secured similar radial flanges 37, which, on their opposite sides, overlap by similar packed joints the proximate ends of the working chambers of the cylinders 7 and 8; and secured to the outer ends of the drum sections 32, preferably by the screw bolts 31, are an outer pair of annular plates or flanges 38, which similarly overlap, by packed joints, the outer ends of the working chambers of the outer cylinders 7. It will thus be seen that the central flange 35 and the annular plates or flanges 37 and 38, on either side thereof, constitute in effect rotating side

walls of the working chambers or steam expansion and exhaust spaces of the several cylinders.

Mounted upon each of the eccentric bosses 25 and 27 is a wear sleeve or bushing 39, upon which latter in turn are mounted the annular hubs of a series of piston vanes, herein shown as 6 in number, disposed 60 degrees apart at their bearing points in the drum. The specific construction of these piston vanes, whereby they are each effectively counterbalanced to reduce and practically eliminate wear resulting from centrifugal action and leverage, and whereby also, an internested arrangement of the several vanes of each piston mechanism without any sacrifice of the requisite strength is obtained, constitutes an important feature of the present invention; and in the detail views, Figs. 8 to 11, inclusive, I have quite fully illustrated the specific construction of these vanes, and a convenient method of manufacturing them. By reference to these views it will be seen that each complete device comprises a piston blade or vane proper 40, one or more stems or shanks 41, and one or more hubs 42. The stems or shanks 41 lie in the same planes as the hubs 42 and at right angles to the plane of the blade 40; and the junction of the inner edge of the blade with the outer edge of the stem or stems 41 is reinforced by laterally extending fillets which preferably, and as shown, extend longitudinally the full width of the blade and transversely the full width of the shank.

The hubs and stems of the several piston vanes are designed to nest within each other and are connectedly coextensive with the length of the eccentric boss on which they are mounted, for which purpose one of said devices has a single central hub and stem, while the other five are provided, respectively, with pairs of hubs and stems spaced at different distance apart so that, when assembled they will interfit in the manner shown in Fig. 4. For convenience in manufacture, diametrically opposite pairs of these devices may be made in a single casting, and subsequently separated or disconnected by simply sawing through the metal at the points indicated at *x* and *y* in Fig. 9. Integral with each hub 42 and diametrically opposite the blade 40 pertaining thereto, is cast a segment 44 that, in dimensions and weight is carefully calculated to afford, under any given speed of rotation, substantially the same centrifugal effect as the blade and shank on the opposite side of the hub, so that the two centrifugal effects oppose and balance or neutralize each other, thus practically eliminating the wearing effect on the wear sleeve 39 that otherwise results from such centrifugal action. By making the stems or shanks 41 of greater width than the thickness of the blades 40 and providing the reinforced fillets 43 at the joint, I obtain fully the required strength without any encroachment upon the space required to accommodate the balancing segments 44.

Other advantages which result from the use of the balancing segments 44 are, a better distribution of the driving impulse of the vanes on the piston drum, and a better distribution of the leverage thrust around the bearing boss. As the piston rotates at a very high speed, the momentum of the balancing segment is considerable, and the driving effect of such momentum is imparted to the drum through the piston vanes while the latter are traveling through the exhaust region of the working chamber. Hence, the rotative impulse is distributed entirely around the drum, instead of being applied wholly on one side of the latter, by reason of the energy stored in the counter-weights during the working travel of the piston vanes. Again, owing to its varying speed of rotation, the leverage thrust of each counterweight on the bearing boss, resulting from its momentum, and exerted while it is traveling from the point of its maximum to the point of its minimum speed, is applied on the side of said bearing boss opposite that on which the leverage thrust of the steam pressure is applied, thus lessening the tendency to lateral displacement of the bearing boss.

From the foregoing it will be apparent that the rotative effect of the piston vanes in all four cylinders is transmitted to the shaft through the single central web 29. This latter is preferably given substantially the skeleton form shown in Figs. 6 and 7, since thereby sufficient strength with a substantial reduction in weight, as compared with a solid web, is gained.

A manufacturing advantage also lies in the fact that the device can be cast without undue "blowing" and without uneven contraction while cooling owing to the substantially uniform thickness of the metal in the walls.

It will be observed that the two sides of the web are connected, midway between the rocker bearings 33, by radial ribs or spokes 29′, which extend from the hub 28 to the periphery of the projection or flange 35; and midway between said spokes the two sides of the flange portion 35 are further connected by T-shaped ribs 35′, located radially in line with the rocker bearings 33 (which extend through the sides of the web) and inner apertures 45 formed through the sides of the web to permit steam pressure, which leaks within the drum, to be equalized on both sides of the web.

Referring to Fig. 5, it will be observed that the exhaust valves 22 and 23 are provided with valve stems 46, which extend through suitable stuffing-boxes 47 in the

outer walls of the exhaust passages 11, and are normally urged to open position by coiled compression springs 48 surrounding the valve stems, and confined each between the gland of the stuffing-box 47 and a head 49 on the valve stem. The inner end of the valve stem 46 is connected to the back of the valve by a pivotal sliding joint, illustrated in detail in Figs. 12 and 13, wherein it will be seen that the back of the valve is formed with a slideway 50, engaged by the head 51 of a pivot lug 52, to which the inner end of the valve stem 46 is connected by a pivot pin 53. When the engine is running one of these valves is, of course, open, and the other closed; and the control of these valves throughout the several cylinders, as likewise the proper actuation of the steam valves 19, is effected through the manipulation of a single lever with suitable connections therefrom to both sets of valves, which will next be described; it being here noted that all of the valves are stationary while the engine is running in one direction, the function of the valves 22 and 23 being solely to control the exhaust ports for reversing, and the valves 19 acting solely to control the supply ports in starting, stopping and reversing.

Referring to Fig. 3, 54 designates the starting, stopping and reversing lever, the same being pivoted to a bracket 55 on the engine base 6, said lever at its upper end being provided with the usual spring actuated dog 56 that coöperates with a segment rack 57, having three notches 58, 59 and 60, the central notch 59 representing the steam cut-off position of the lever, and the end notches 58 and 60 representing the opposite running positions. At its lower end the lever 54 carries a toothed sector 61 that engages a reciprocating toothed rack-bar 62, slidably mounted across the base of the engine bed. The bar 62 at its ends engages pinions 63 and 64 on the ends of shafts 65 and 66, respectively, (see Figs. 1 and 2) that are journaled in suitable bearings on and parallel with the opposite sides of the engine base. Fast on the shaft 65 are a pair of cams 67 adapted to engage the stems of the lower exhaust valves 23 of the two end cylinders 7; said cams 67 are formed with integral arms 68 that are pivotally connected by links 69 with similar arms 70 pertaining to similar cams 71 that are pivoted on brackets 72 secured on the cylinders 7, and engage and control the stems of the upper exhaust valves 22 of the end cylinders 7. The cams 67 and 71 are so positioned (at right angles) that when one is active the other is idle and vice versa. The cams 71 are provided with other arms 73 that are connected by links 74 with bell-crank levers 75 pivoted on brackets 76 above the cylinders 7, the other arms of said bell-crank levers being connected by links 77 with the stems 20 of the steam valves 19.

A similar system of valve actuating mechanism controls the valves of the two intermediate cylinders 8. Fast on the side shaft 66 are a pair of cams 78 that effect the closing and control the opening of the lower exhaust valves 22 of the cylinders 8. These cams have integral arms 79 that are connected by links 80 with the arms 81 pertaining to a pair of cams 82 fast on the ends of a shaft 83 (Fig. 2) that is journaled centrally in a standard 84, mounted on and above the cylinders 8, said shaft 83 having fast thereon an arm 85 that is connected by a cross-link 86 (Fig. 5) with a similar arm 87 fast on a similar shaft 88 (Fig. 1) journaled centrally in a standard 89, mounted on and above the cylinders 8. The shaft 88 has at its ends arms 90 (Fig. 1) that are connected by links 91 to the valve stems 20 of the steam valves 19 of the intermediate cylinders 8. From this it will be seen that the steam and exhaust valves of each cylinder are so interconnected that they are simultaneously operated to effect the starting, stopping or reversing operations, and, further, that the valve actuating devices of the several cylinders are all so interconnected as to operate in properly timed relation to effect similar changes in the condition of all the several cylinders. When the lever is shifted to the intermediate position represented by the notch 59, the several steam valves 19 are shifted to a position to cover both supply ports 14 and 15, and hence cut off the steam supply. In this position of the steam valves the exhaust valves 22 and 23 are both partly open, but this is immaterial as the engine is not running at this time. The shifting of the lever to either extreme represented by the notches 58 and 60, fully closes one of the exhaust valves 22 and 23 of the several cylinders, and simultaneously permits the full opening of the other under the influence of its actuating spring 48.

The described arrangement of the cylinders relatively to the driven shaft secures a perfect balance of the oppositely acting pressures upon said shaft, since the lateral thrust exerted by the two end cylinders is always opposed by the equal thrusts in the opposite direction of the two intermediate cylinders, and hence lateral strain and consequent wear upon the journal bearings of the shaft, resulting from the impulse of the engine, is avoided. The described arrangement also balances the radial pressures on the several drum sections, thus avoiding any tendency to throw the web and hub of the drum and the rotating drum flanges out of true working position normal to the shaft. The chief saving in wear, however, results

from the counter balancing of the piston vanes, which not only greatly reduces the wear on the bushing or sleeve 39, but also reduces the wear upon the packings of the piston blades, which has heretofore proved a vulnerable point in engines of this type, and permits the use of a smaller shaft and bearing-boss than has heretofore been practicable.

Although I have more particularly described my invention as a steam engine, it will be manifest that it is also adapted for use with other similar motive agents, such as compressed air, spirit vapor and the like, and is also readily adaptable for use as a gas-engine.

I claim—

1. In a multiple-cylinder rotary engine of the eccentric-piston type, the combination with a pair of end cylinders of like eccentricity, and a pair of intermediate cylinders of opposite eccentricity to said end cylinders, of a driven shaft extending through and journaled outside of said cylinders, a series of endwise connected piston drums in said cylinders having a single central connection to said shaft, stationary bearing bosses of opposite eccentricity, respectively, in said end and intermediate cylinders, and piston vanes mounted on said bosses, and drivingly engaging said drums, substantially as described.

2. In a multiple-cylinder rotary engine of the eccentric piston type, the combination with a pair of end cylinders of like eccentricity, and a pair of intermediate cylinders of opposite eccentricity to said end cylinders, of stationary end walls secured to the outer sides of said end cylinders, stationary bearing bosses of opposite eccentricity, respectively, in said end and intermediate cylinders and rigidly secured to said end walls, a driven shaft extending through said series of bearing bosses with clearance between itself and the latter and journaled outside of said cylinders, a series of endwise connected piston-drums in said cylinders having a single central connection to said shaft, and piston vanes mounted on said bosses and drivingly engaging said drums, substantially as described.

3. In a rotary engine of eccentric piston type, the combination with a cylinder, a driven shaft extending through the same, a piston drum concentric with and fast on said shaft, and a stationary bearing boss eccentric to and surrounding said shaft within said drum, of a series of piston vanes having stems or shanks provided with hubs rotatably mounted in close lateral juxtaposition on said bearing boss and blades swiveled in and drivingly engaging said drum, and segmental extensions on and wholly in the planes of said hubs, located diametrically opposite the respective blades thereof and constituting counter-weights serving to neutralize the centrifugal force of said blades, substantially as described.

4. As a new article of manufacture, a piston vane for a rotary engine comprising an annular hub portion, a radially extending shank lying in the same plane with said hub portion, a blade extending transversely of said shank, and of a thickness less than the width of the latter, and a reinforcing fillet between the inner edge of said blade and the outer edge of said shank, substantially as described.

5. As a new article of manufacture, a piston vane for a rotary engine, comprising an annular hub portion, a radially extending shank lying in the same plane with said hub portion, a blade extending transversely of said shank, and of a thickness less than the width of the latter, and a reinforcing fillet between the inner edge of said blade and the outer edge of said shank, said fillet extending longitudinally the full width of said blade and transversely the full width of said shank, substantially as described.

6. As a new article of manufacture, a piston vane for a rotary engine, comprising an annular hub portion, a radially extending shank lying in the same plane with said hub portion, a blade extending transversely of said shank, and of a thickness less than the width of the latter, and a reinforcing fillet between the inner edge of said blade and the outer edge of said shank, said fillet extending longitudinally the full width of said blade and transversely the full width of said shank, and a counter-weight in the form of a segmental extension of said hub located on the opposite side of the latter from said shank and blade, substantially as described.

7. In a rotary engine, a working cylinder provided with a valve chest having a pair of steam ports located in one semi-circumference thereof and a pair of exhaust ports located in the opposite semi-circumference thereof, in combination with a single slide valve controlling said steam ports, a pair of exhaust valves formed by hinged sections of the cylinder wall controlling said exhaust ports, a rotary piston in said cylinder, and means for maintaining one of said exhaust valves open and the other closed, according to the direction of rotation of said piston, substantially as described.

8. In a rotary engine, a working cylinder provided with a valve chest having a pair of steam ports located in one semi-circumference thereof, and a pair of exhaust ports located in the opposite semi-circumference thereof, in combination with a single slide valve controlling said steam ports, a pair of exhaust valves controlling said exhaust ports, a rotary piston in said cylinder,

springs normally tending to open said exhaust valves, cam devices for closing said exhaust valves, and connections between said cam devices and said slide valve, whereby all three valves may be simultaneously actuated to reverse the engine, substantially as described.

9. In a multiple-cylinder rotary engine of the eccentric piston type, the combination with a pair of end cylinders of like eccentricity, and a pair of intermediate cylinders of opposite eccentricity to said end cylinders, of a driven shaft extending through and journaled outside of said cylinders, a pair of piston drums in said intermediate cylinders having an integral common connection to said shaft, a pair of piston drums in said end cylinders secured to the outer ends of said intermediate piston drums, flange-like annular projections on the ends of said drums overlapping with packed joints the ends of the working chambers of the cylinders, stationary bearing bosses of opposite eccentricity, respectively, in said end and intermediate cylinders, and piston vanes mounted on said bosses, and drivingly engaging said drums, substantially as described.

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Copies of this patent may be obtained for five cents each, by addressing the "Commissioner of Patents, Washington, D. C."