(No Model.) 3 Sheets—Sheet 1.

A. BOYD.

ROTARY ENGINE.

No. 498,618. Patented May 30, 1893.

Fig. 1.

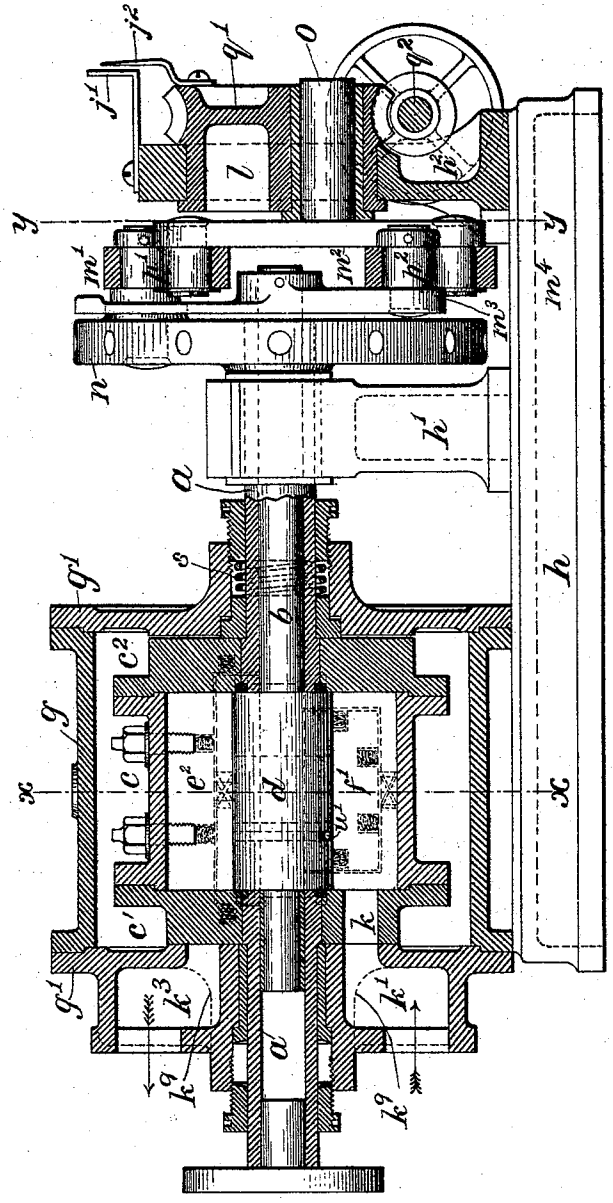
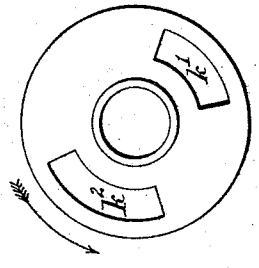


Fig. 4.



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(No Model.) 3 Sheets—Sheet 2.

A. BOYD.

ROTARY ENGINE.

No. 498,618. Patented May 30, 1893.

Fig. 2.

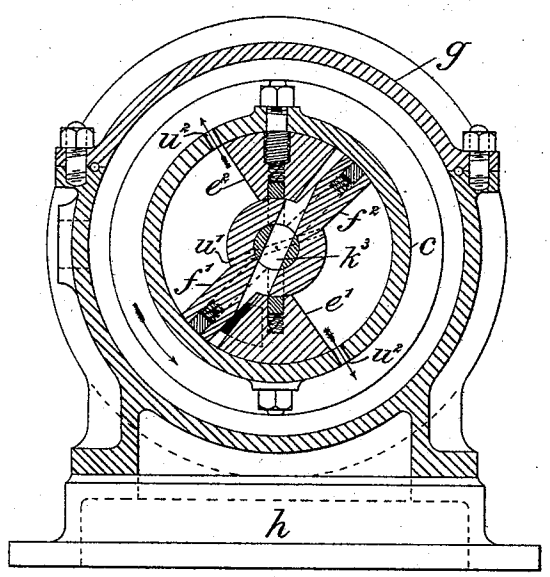
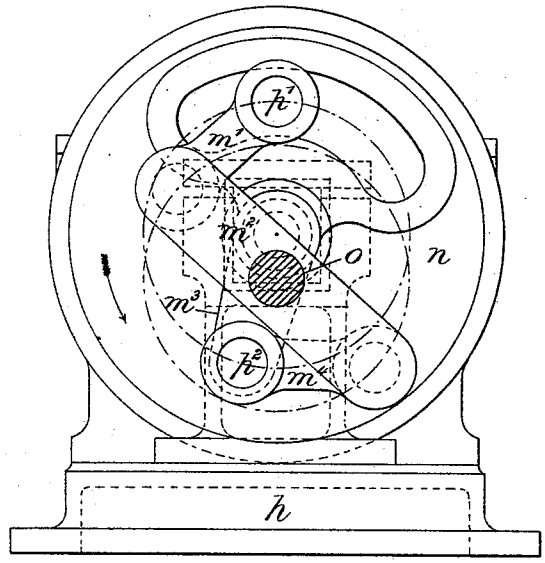


Fig. 3.



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(No Model.) 3 Sheets—Sheet 3.

A. BOYD.

ROTARY ENGINE.

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Fig. 6.

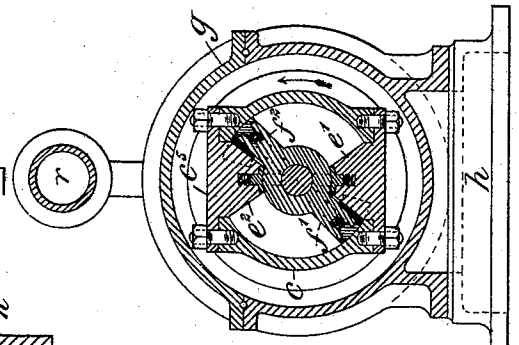


Fig. 7.

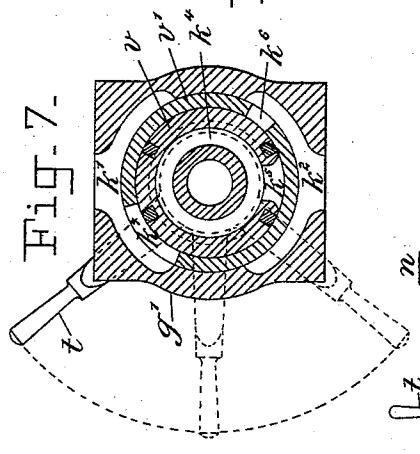
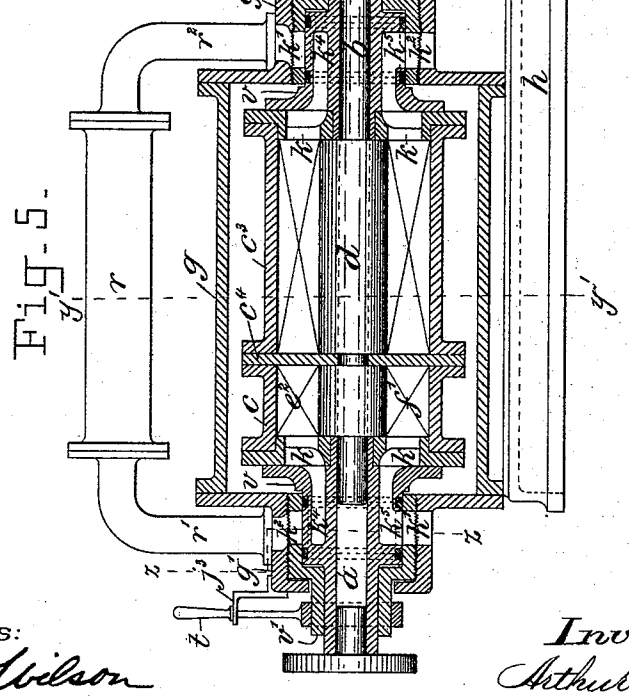


Fig. 5.



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UNITED STATES PATENT OFFICE.

ARTHUR BOYD, OF MIDDLESBROUGH, ENGLAND.

ROTARY ENGINE.

SPECIFICATION forming part of Letters Patent No. 498,618, dated May 30, 1893.

Application filed November 7, 1892. Serial No. 451,278. (No model.) Patented in England February 13, 1892, No. 2,820.

To all whom it may concern:

Be it known that I, ARTHUR BOYD, a subject of the Queen of Great Britain, residing at Middlesbrough, in the county of York, England, have invented certain new and useful Improvements in Rotary Engines, (for which I have applied for Letters Patent in Great Britain, No. 2,820, bearing date February 13, 1892;) and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

My invention relates to motive power engines of the rotary type and is principally applicable to such engines when actuated by steam.

The object of my invention is to construct a high speed rotary engine capable of working smoothly on the single-acting principle, having constant surface contact between the driving cylinder and resistance pistons and in which the defect of line contact is overcome and running pistons over ports is obviated, as well as the disadvantage of having delicately adjusted working parts inaccessible whether the engine is in motion or at rest.

A further object of my invention is to so combine and arrange the moving parts and provide for the admission, distribution and exhaust of the steam or other actuating medium that the moving parts are balanced under the varying pressures whereby the packing is not subject to undue wear, and the energy of the actuating medium is so disposed that the engine is free from shocks and variations of speed when running, the heavy parts having a uniform angular velocity.

Further advantages derived from the improvements constituting my invention are that the engine can be constructed to work as a simple or compound engine, is reversible and can be readily turned off the dead center when required to start the engine without moving the main shaft and its load.

In the accompanying drawings I illustrate my invention as applied to both a simple and a compound single-acting engine, and show separately some of the parts all designed for working in the horizontal position from which it will be readily understood how the engine can be modified in design to work in the vertical or inclined position if so required.

In the drawings in which corresponding parts are designated by corresponding marks of reference—Figure 1 is a central longitudinal vertical section of a single acting simple engine constructed in accordance with my invention. Figs. 2 and 3 are vertical transverse sections on lines x x, and y y, respectively thereof. Fig. 4 is a detail view, showing the inlet and exhaust ports k', and k^2. Fig. 5 is a central longitudinal vertical section of a compound engine constructed in accordance with this invention. Fig. 6 is vertical transverse section taken on lines y' y' of Fig. 5, showing a modified form of construction of the cylinder. Fig. 7 is a transverse vertical section on line z z of Fig. 5.

I will first proceed to describe my invention as applied to a single-acting simple engine.

a is the main shaft, the rotary motion of which is the power of the engine to be utilized. In this case the main shaft a is made hollow for the reception of the shaft b which is employed in connection with certain moving parts of the engine in the manner hereinafter described and which for distinction I will term the resistance shaft. These two shafts are fitted or coupled together to revolve in line with relatively different rotary motions. The cylinder c and its covers c' c^2 are secured axially to and rotate with the main or driving shaft a, their combined weight serving as a flywheel to the engine. The resistance shaft b rotating within the main shaft a is furnished within the cylinder with a drum or barrel d. The annular space thus formed is occupied by radial longitudinal walls or partitions e' e^2 projecting as fixtures from the cylinder to work against the drum and which are the working pistons of the engine, between which are other intermediate wings or partitions f' f^2, which are the corresponding resistance pistons for the same direction of rotation, and which extend radially as fixtures from the drum to work against the cylinder and cylinder covers; all the partitions or wings being fitted and packed so as to be steam tight without excessive friction.

w' is a port through the drum to equalize

any pressure which may be set up against the pistons, u^2 being relief ports to reduce such pressure to a minimum.

A convenient form of mounting the cylinder c, and the main shaft a with their accessory moving parts is shown in the drawings, and consists of a cylindrical casing g with end covers g' g', erected on a bedplate h and forming a chamber in which the cylinder c revolves.

k is the port in the cylinder cover which is shown in Fig. 1 exactly opposite to the inlet port k', k^2 being the outlet port. The relative positions and areas of these ports as they appear in the face of the cover g' are shown in Fig. 4.

For structural compactness the casing g is preferably constructed concentrically with the cylinder c and main shaft a, and is furnished with the usual glands, packings, and metal bearings required in high speed steam engines including a gland spring s for holding the cylinder face up to its work, which gland spring is dispensed with when the steam is supplied into the casing through the aperture k^9 in the head thereof, as is shown in dotted lines in Fig. 1, when the steam pressure behind the cylinder cover c^2 serves the same purpose.

h' h^2 are standards erected on the engine bed plate h, of which h' is simply furnished with bearings for the tail end of the main shaft a, while h^2 is specially constructed for the reception of the eccentric l, by which to adjust the relative leverage and movements of the links and levers m', m^2, m^3 and m^4 which are shown in Fig. 3, by which the lead, cut off, exhaust and compression of the steam are regulated and controlled and the engine reversed and for which purpose an index j' and pointer j^2 are useful when provided in the position shown. In practice the parts being constructed and arranged as shown and described, they are intended to operate as follows:—The engine having been adjusted on its axis by turning the wheel n if necessary so that the pistons are in the starting position as shown in Fig. 2, the steam enters the space between the pistons e' f' and through the port k^3 to the corresponding space between the pistons e^2 f^2. It is obvious that the effect of the steam so admitted is to force the pistons e' and e^2 from their companion pistons f' f^2 as far as possible, and that the pressure of steam on both pistons in each case is necessarily equal and the cylinder in pressure balance, but in order to obtain useful work from the steam, the equal pressures on the said pistons do not meet with equal resistance, that is to say that the steam pressure during admission and expansion meets with a lower resistance from the pistons e' e^2, which are the working pistons, than from the pistons f' f^2, which are the resistance pistons. Upon this differential piston resistance depends the efficiency of the engine and the special combination or arrangement of parts by which it is brought into effect constitutes an important part of my invention which I will now proceed to describe, and which is illustrated in section in Fig. 1 with a corresponding transverse view in Fig. 3.

The disk n is keyed to the main shaft a and is made heavy enough and properly balanced to serve as a fly wheel.

m' m^2 m^3 and m^4 constitute a system of links and levers arranged and adjusted to operate in combination with the shafts a and b, so that while the steam imparts a uniform angular velocity to the pistons e' and e^2 and therefore to the cylinder c and main shaft a, the resistance shaft b revolves with a varying velocity corresponding to the variations of space between the pistons f' f^2 and the pistons e' e^2 as steam is admitted, expanded and exhausted within the engine cylinder. The pin p' is secured to the disk wheel n and is therefore directly connected like a crank pin to the main shaft a; the pin p^2 is similarly directly connected through the lever m^3 to the resistance shaft b, the link m' being in constant compression and the link m^4 in constant tension when the engine is going ahead as shown by the arrows in the figures, and when the engine is running in the opposite direction. The controlling shaft o is placed eccentrically to the axis of the main shaft a, round which it can be moved at a constant radius in the stand h^2. The pins p' p^2 are coupled together by the system of links m', m^4, and cross lever m^2, as shown more particularly in Fig. 3. Taking this system of levers and links as shown in Fig. 3 to represent a position of the pistons at which the steam is giving out work, it will be seen that pressure of steam upon the pistons e' e^2 which is transmitted to the pin p' has mechanical advantage over the pressure of steam upon the pistons f' f^2 which is transmitted to pin p^2, and that as the system of links revolves this mechanical advantage reaches the vanishing point, and is then transferred to the pistons f' f^2 for the remainder of the revolution of the main shaft, after which it reverts to the pistons e' e^2 as before for the like part of another revolution, thus passing through two vanishing or neutral points in each revolution, which neutral points are the dead centers of the engine. In that part of a revolution through which the mechanical advantage is with the pin p', that is with the pistons e' e^2, the steam is entering into and expanding within the steam spaces of the cylinder by driving the working pistons e' e^2 in advance of the resistance pistons f' f^2, and in the remaining part of the revolution in which the mechanical advantage is against the pin p', the exhaust steam is being swept out of the cylinder by the pistons f' f^2 advancing or closing up to the pistons e' e^2, that is to say the resistance pistons f' f^2 have a reciprocal motion relatively to the working pistons e' e^2 as they all revolve together, the said pistons

e' e^2 nevertheless having a uniform angular velocity which is accordingly transmitted to the main shaft a.

The eccentric l is journaled in the standard h^2 in line with the shaft a, and has upon the rear of the periphery a worm wheel q', engaging with the worm q^2, by the rotation of which the eccentric cam l' itself will be rotated, the eccentric having eccentrically therein a shaft o upon the end of which is mounted the hereinbefore described link m^2, the said shaft o being carried by the rotation of the eccentric around the axial line of the main shaft a, the said eccentric thus serving as a means for changing the angular position of the controlling shaft o, thereby moving the pin p^2 with its lever m^3 and therefore the pistons f' f^2 without moving the main crank pin p', the engine being in consequence either altered in grade or expansion, or reversed as shown by the pointer. This can be done when the engine is going.

The whole engine is in mechanical balance by means of counter balances for which purpose the lever m^3 has the slotted extension shown in Fig. 3.

Having now described a single-acting simple engine complete in all its parts as constructed according to my invention, I will now proceed to describe Figs. 5 to 7 inclusive which illustrate my invention as applied to a compound engine. In order to compound the engine, I add to the steam cylinder c the part c^3 divided therefrom by the intermediate partition c^4. Taking c as the high and c^3 as the low pressure cylinders respectively, their relative capacities can be obviously adjusted to suit any conditions within practical limits under which the steam is to be expanded, and in Fig. 5 the capacities of these cylinders are shown in the proportion of about three to one. The steam exhausted from the high pressure cylinder c passes through the pipe r' into a receiver r, from which it is delivered through the admission pipe r^2 into the low pressure cylinder c^3. In other respects my invention involves no essential differences in the arrangement of parts or combination of details suitable to either a simple or compound single-acting engine, the relative action of the pistons under steam pressure in combination with a main and resistance shaft being precisely similar in either case. The modifications of the arrangement of parts for admitting and clearing the steam from the cylinder or the precise means for adjusting the piston resistance in the manner as hereinbefore described which are shown in the drawings must be taken as equally applicable to either a single or compound engine, but for convenience of illustration one arrangement of these details is shown in Figs. 1 to 3 as parts of a simple single-acting engine, while other modifications are shown in Figs. 5 to 7 as parts of a compound single-acting engine. I wish it to be understood that I do not restrict myself to the precise details or arrangement of parts as hereinbefore specified and illustrated in either case, as these details admit of various modifications consistent with the main features of my invention both with regard to the arrangement and position of the passages and ports for admitting and exhausting the steam from the cylinder and also in the combination of parts for providing the same piston resistance against the steam as has already been described with reference to the system of links shown more particularly in Fig. 3. Figs. 5 and 7 however illustrate a modified arrangement of the ports for admitting and clearing the steam from the cylinder which is thought to have practical advantages such as small surface friction. In this modification the valve consists of a cylindrical casing v, inclosing an annular space k^4 round the main shaft a, which casing is flanged up to the cylinder cover, the ports k of which lead direct from the annular space k^4 to the cylinder steam space. v' is the valve liner which screws into the casing cover g', and can be screwed round by the lever t to any position whether for adjusting the cut off of the steam, stopping or reversing the engine, the proper positions for which are marked on the index j^3. In order to effect its purpose the valve and its connections are furnished with the following arrangement of ports.

Referring more particularly to Fig. 7, k^5 is the port in the valve v which passes over the ports k^6 and k^7 in the valve liner v' to the inlet and outlet ports k' k^3 in the casing cover g', which take the form shown in Fig. 7 to admit of the valve liner ports k^6 k^7 being set to different positions as required. The above described provision for adjusting the cut off of the steam and for stopping or reversing the engine serves all the purposes of the angular adjustment of the controlling shaft o, except that if the shaft o is fixed in position, the engine cannot be turned off the dead center without moving the main shaft and its load. Therefore all provision for moving the shaft o as described with reference to Fig. 1 is omitted in Fig. 5.

When the engine is going ahead as shown by the arrows in Figs. 2, 3 and 6, the steam acts directly on the working pistons e' e^2, the reaction being sustained by the resistance pistons f' f^2, and the uniform angular velocity of the main shaft a is converted into the variable velocity of the resistance shaft b; but when the engine is reversed, f' f^2 become the working pistons and e' e^2 the resistance pistons and the variable angular velocity of the resistance shaft b is converted into the uniform angular velocity of the main shaft a.

It will be observed in Fig. 5 that a modified arrangement for coupling the pins p' p^2 is shown in which a grooved cross lever m^5 takes the place of the cross lever m^2 in Fig. 3, in which the pins p' p^2 reciprocate as they revolve together.

By constructing the cylinder in the manner shown in Fig. 6, in which c^5 is a detachable

part with the piston e^2, the interior of the cylinder is made easily accessible for inspection and repair.

Having thus fully described my said invention and the manner of performing the same, I wish it to be understood that I am aware that the method or principle of obtaining useful work from steam by the differential resistance of revolving pistons is not new. I therefore make no claim to such method or principle otherwise than as embodied in and carried into practice by my improvements as above specified.

What I claim, and desire to secure by Letters Patent, is—

1. In a rotary steam engine, the combination with two concentric shafts, of a driving cylinder having pistons attached thereto, secured upon one of the said shafts, pistons secured upon the other shaft and contained within the said cylinder, a crank lever connected to one of the said shafts and a fly wheel mounted upon the other shaft, a link eccentrically pivoted in respect to the said shafts, and links connecting its opposite ends with the said fly wheel and lever, substantially as described.

2. In a rotary steam engine, the combination with two concentric shafts, of a driving cylinder having pistons attached thereto secured to one of the said shafts, pistons secured to the other shaft and contained within the said cylinder, a shaft adapted to be rotated around the said shafts and a link pivoted thereon and having its opposite ends connected to the said first-named shafts, substantially as described.

3. In a rotary steam engine, the combination with two concentric shafts, of a driving cylinder having pistons attached thereto secured to one of the said shafts, pistons secured to the other shaft and contained within the said cylinder, a fly wheel secured to one of the said shafts and a lever secured to the other shaft, a shaft adapted to be moved around the said shafts, a link mounted thereon, and links connecting the opposite ends of the said first named link with the said fly wheel and lever, substantially as described.

4. In a rotary steam engine, the combination with two concentric shafts of a driving cylinder having pistons attached thereto secured to one of the said shafts, pistons secured to the other shaft, and contained within the said cylinder, an eccentric journaled in line with the said shafts, and having a shaft eccentrically mounted therein, and a link journaled on the shaft in the eccentric and having its opposite ends connected with the first named shafts, substantially as described.

5. In a rotary steam engine, the combination with two concentric shafts, of a driving cylinder having pistons attached thereto secured to one of the said shafts, pistons secured to the other shaft and contained within the said cylinder, a flywheel mounted on one of the said shafts, and a lever secured to the other shaft, an eccentric journaled in line with the said shafts and having a shaft eccentrically mounted therein, means for rotating the said eccentric, a link journaled on the shaft in the eccentric, and links connecting its ends with the said fly-wheel and lever, substantially as described.

6. In a rotary steam engine, the combination with a main shaft having a cylinder and a flywheel thereon, the cylinder having pistons secured thereto and a steam port therein, of a resistance shaft concentric to the said main shaft and having a lever and pistons thereon, the said pistons being contained within the said cylinder the said resistance shaft having ports passing diametrically through the said shaft within the said cylinder, a cylindrical casing inclosing the said cylinder and having induction and eduction ports therein, and a link eccentrically pivoted in respect to the said shafts and having its ends secured to the said flywheel and lever, substantially as described.

7. In a rotary steam engine, the combination with two concentric shafts, of a driving cylinder having pistons attached thereto secured to one of the said shafts, pistons secured to the other shaft and contained within the said cylinder, an eccentric journaled in line with the said shafts, and having a pinion secured thereto, a worm shaft gearing with the said pinion, a shaft eccentrically mounted on the said eccentric and a link journaled on the shaft on the said eccentric and having its opposite ends connected with the first named shafts, substantially as described.

In testimony whereof I affix my signature in presence of two witnesses.

ARTHUR BOYD.

Witnesses:
GEORGE JAMES CLARKSON,
EDWARD THOMAS ELCOAT.