(No Model.)

3 Sheets—Sheet 1.

J. V. DAVIS.

ROTARY ENGINE.

No. 516,431. Patented Mar. 13, 1894.

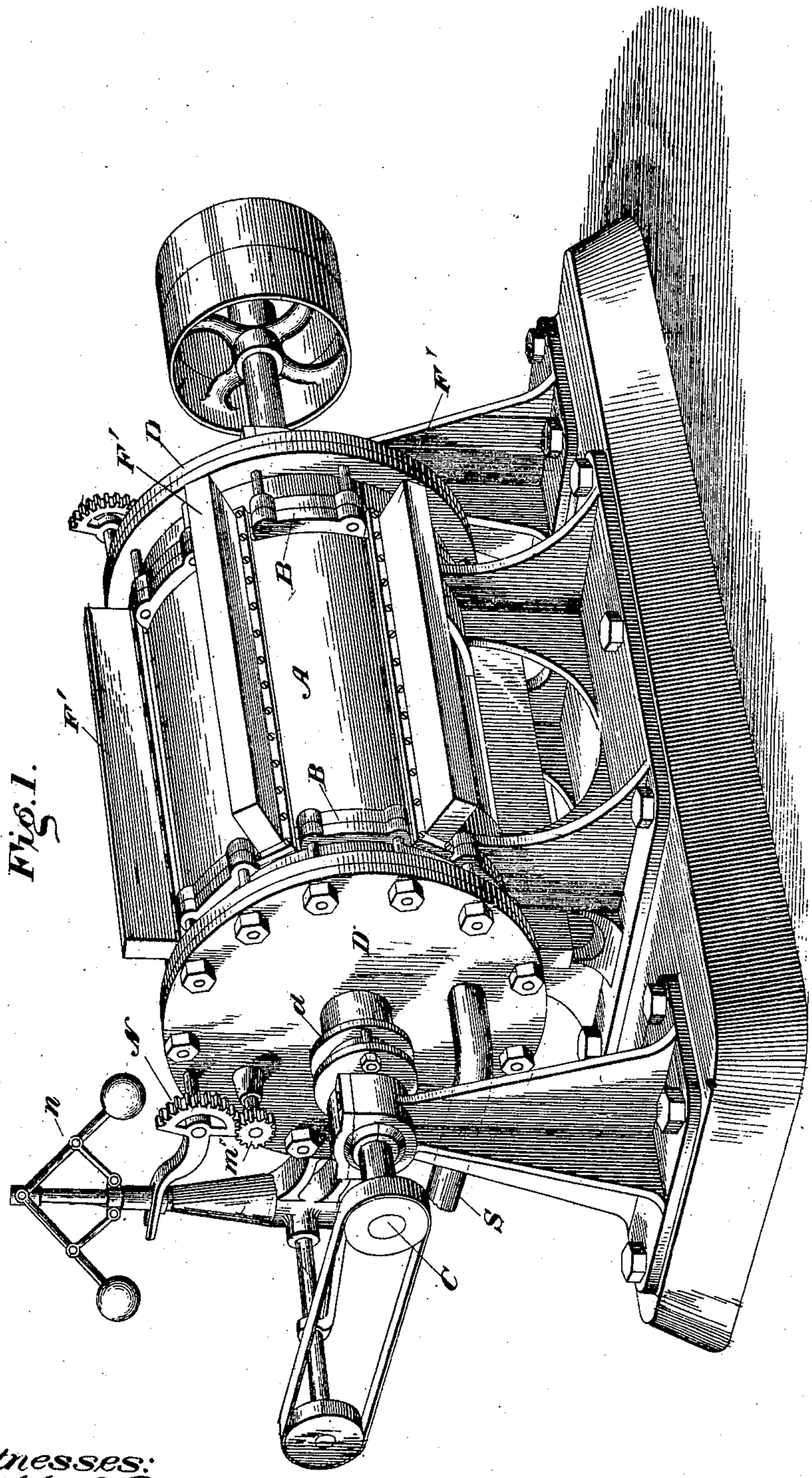

Fig. 1.

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THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

(No Model.)

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Fig. 3.

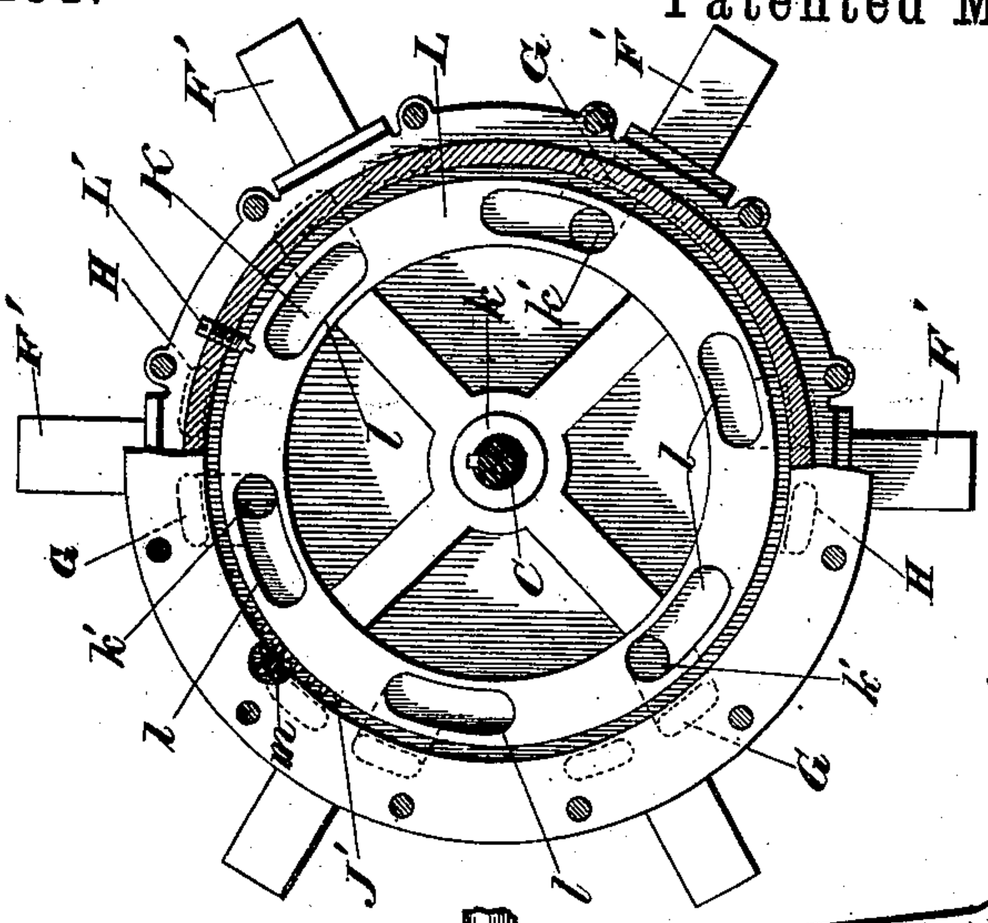


Fig. 2.

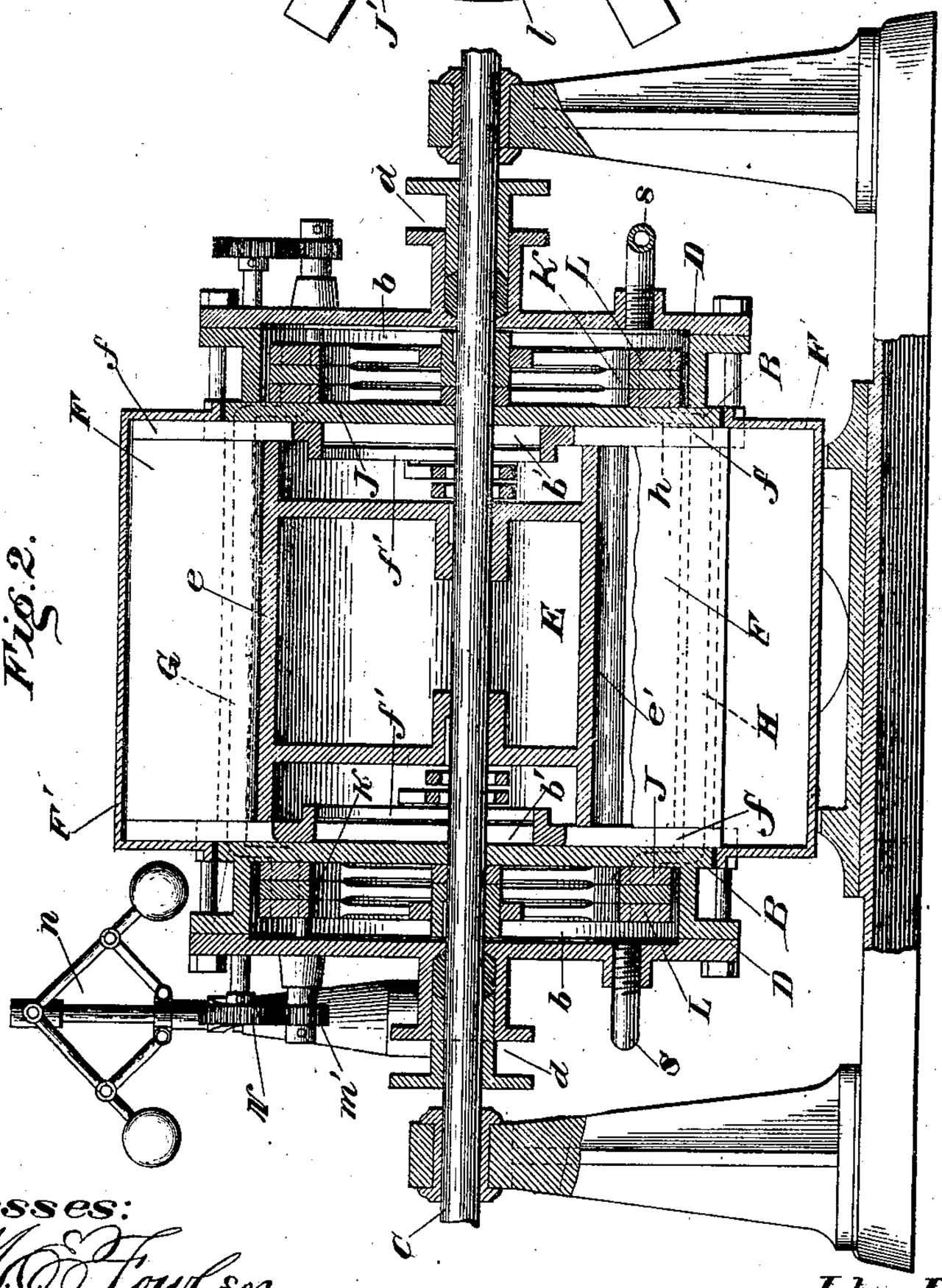
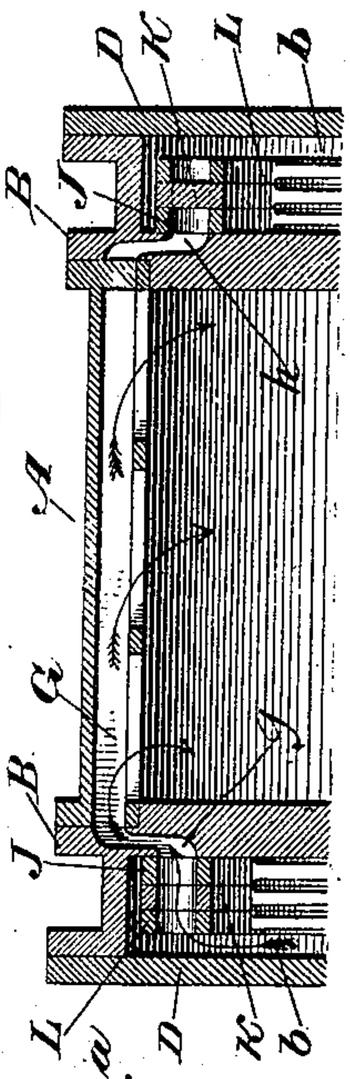


Fig. 2a.



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(No Model.)

3 Sheets—Sheet 3.

J. V. DAVIS.

ROTARY ENGINE.

No. 516,431. Patented Mar. 13, 1894.

Fig. 6.

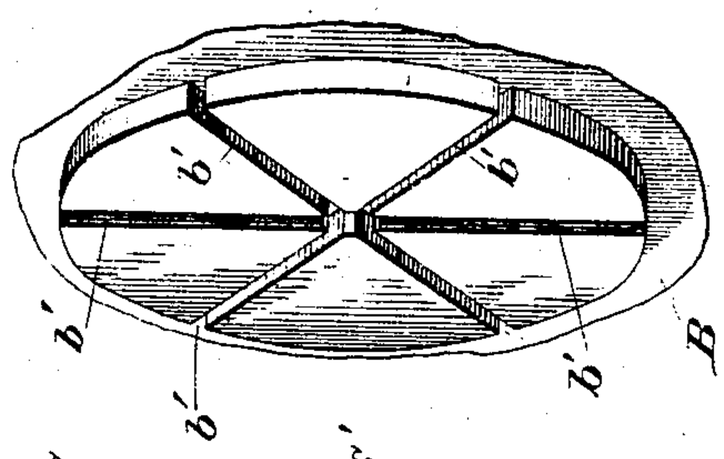


Fig. 8.

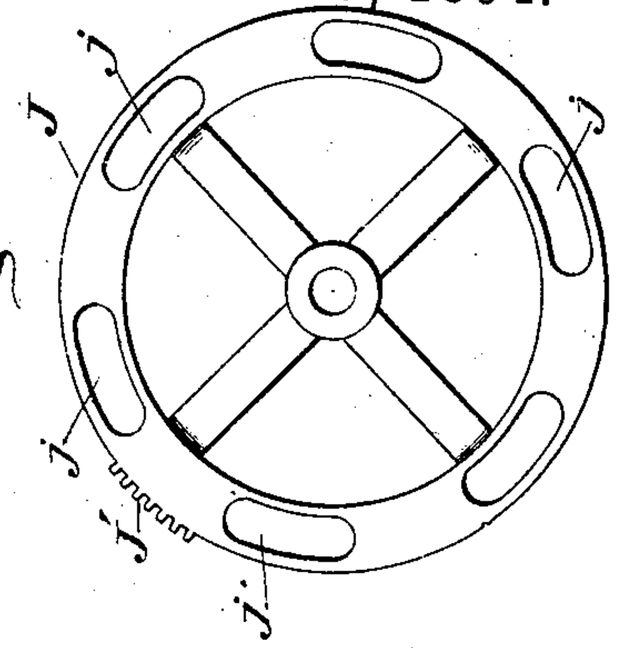


Fig. 7.

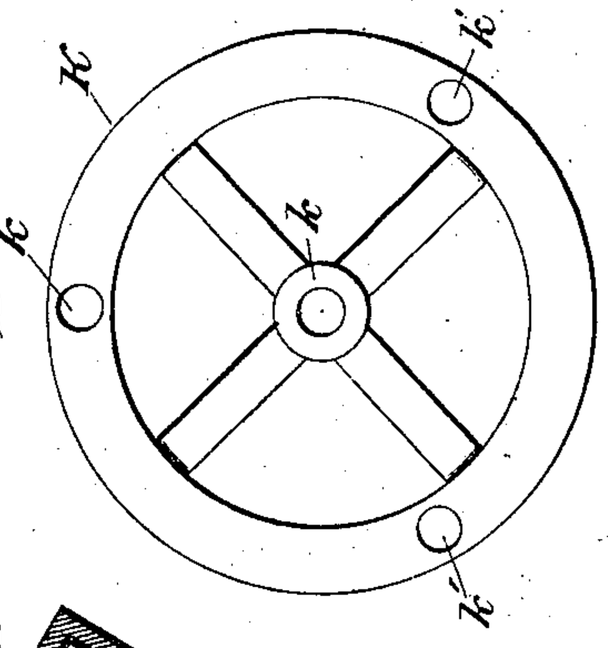


Fig. 5.

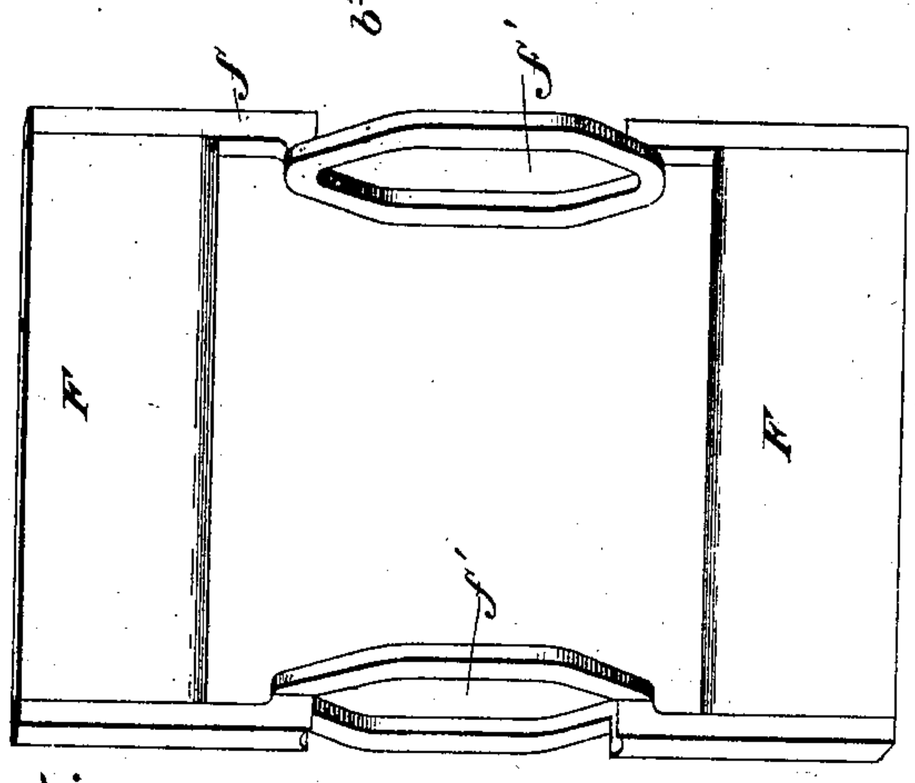
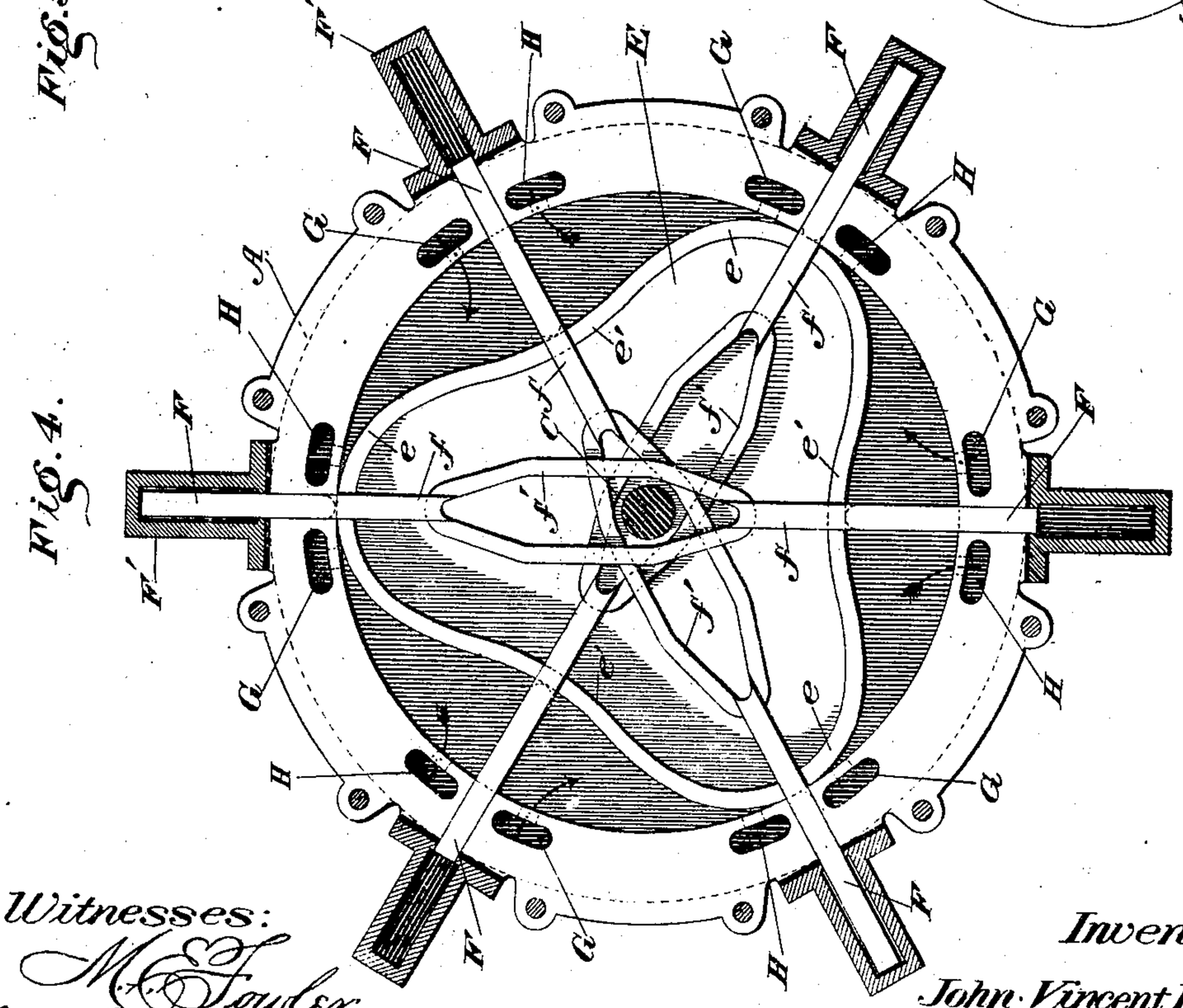


Fig. 4.



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UNITED STATES PATENT OFFICE.

JOHN VINCENT DAVIS, OF NEW YORK, N. Y., ASSIGNOR TO THE CHALLENGE HIGH SPEED ENGINE COMPANY, OF LEXINGTON, KENTUCKY.

ROTARY ENGINE.

SPECIFICATION forming part of Letters Patent No. 516,431, dated March 13, 1894.

Application filed June 13, 1893. Serial No. 477,417. (No model.)

To all whom it may concern:

Be it known that I, JOHN VINCENT DAVIS, of New York, in the county of New York and State of New York, have invented certain new and useful Improvements in Rotary Engines, Concentric Pistons; and I do hereby declare that the following is a full, clear, and exact description thereof, reference being had to the accompanying drawings, and to the letters of reference marked thereon, which form part of this specification.

This invention is an improvement in rotary engines of the concentric piston type, and its object is to produce an automatic cut-off, direct acting, rotary engine, in which the pressure of live steam on the operative parts will be perfectly balanced, and lateral thrust on the main shaft be obviated, by making the steam balance the piston on the shaft at the same time that it acts to rotate the piston and shaft.

Another object is to prevent a substantially uniform amount of abutment surface for the steam to act against in driving the piston; and another object is to provide novel valve mechanism for directly controlling the admission and emission of steam from the piston chamber or cylinder.

My improved engine has an undulating surfaced piston formed with an unequal number of longitudinal alternating lobes or projections and intermediate depressions. The piston is so formed that its diameters are equal, taken through its axis from any point, the depressions gradually merging into the lobes or projections and vice versa. It also has an equal number of abutment valves, exactly twice as many as there are lobes on the piston, or one for each lobe and each depression on the piston, and these abutment valves are arranged at equal distance apart radially of and exterior to the piston. The diametrically opposite abutment valves are connected together at their ends, and owing to the shape of the piston, one of the valves in a pair will be opposite a depression in the piston, when the other is opposite a lobe, and vice versa at all times. The inner edges of the abutment valves fit neatly against the piston, and as the diametrically opposite valves are connected they are both kept in proper contact with the surface of the piston, as the latter acts as a cam, and when one valve is forced outward by a lobe of the piston moving therepast, the opposite valve is drawn inward in to the depression in the valve diametrically opposite such lobe. The piston is thus made to actuate the abutment valves without the employment of springs, steam pressure, cams, or other auxiliary means, and each abutment valve actuates the diametrically opposite abutment valve and is in turn shifted thereby. The piston is axially centered in a cylinder whose interior diameter is such that its outermost portions of the lobes fit closely against the inner wall of the cylinder, so that a series of longitudinal chambers are formed in the cylinder between the lobes of the piston. These chambers are again longitudinally divided by alternate abutment valves. These abutment valves are non-rotatable and play through longitudinal slots in the cylinder, being housed in, so that steam cannot escape from the cylinder through the slots, and suitable packings may be employed at the joints of the housings and cylinder and on the sides and inner edges of the abutment valves to prevent leakage of steam. It will be understood however that the steam chambers above mentioned are not constant in position because the piston rotates and the abutment valves in succession divide the chambers.

In operating the engine, steam is admitted between every alternate pair of abutment valves, and simultaneously exhausted between every other alternate pair of abutment valves, the steam inlet and exhaust ports being at opposite ends of the engine. In other words steam is admitted at one side of each abutment valve occupying a depression of the piston, and simultaneously exhausted at the opposite sides of such valves, consequently the steam expanding between the cylinder, abutment valves, and lobes of the piston will cause the piston to rotate sufficiently to move the lobes past the abutment valves which were on top thereof when the engine started, and then the steam is admitted be-

tween such valves and the lobes, and as soon as the pressure of steam between and against any two adjoining abutment valves is equalized, the inlet valve is closed and the outlet port opened, thus in an engine having a three lobed piston, and six abutment valves, I first admit steam at three or more equidistant points simultaneously, and exhaust steam at three or more intermediate equi-distant points, and then exhaust steam at the first three points, and admit it at the latter three points during each complete revolution of the piston, and so on during the operation of the engine. The piston in such engine thus has three impulses given it for each revolution. The steam being admitted at three or more equidistant points, it will be obvious that the radial pressure of the steam in the chambers upon the shaft or axis of the piston is mutually counteracted, and consequently lateral thrust of the shaft or piston is prevented, and there is no wear on the journals produced by such radial pressure. This radial pressure is one of the great defects in ordinary rotary engines wherein the steam is alternately admitted at opposite sides of the piston, as the radial pressure of steam on one side of the piston not being counteracted by an equal pressure on other sides, or equi-distant points, has to be borne by the piston journals, or main shaft, and thus excessive wear is engendered, and the piston soon begins to "wabble," and the engine always jars and trembles in action. This is especially true of rotary engines employing eccentric arranged pistons. In my engine these defects are obviated and the piston is actually counterbalanced and floated by the working steam pressure in the cylinder. It will be understood that when steam is working against one valve, it is exhausting in front of the connected diametrically opposite valve. As the piston turns however, this connected valve is moved inward at the same speed and to the same extent that the first valve is moved outward, and as soon as the lobe has moved past the inlet port beside the second valve, steam is admitted thereagainst; thus the amount of abutment valve surface against which the live steam is working is substantially maintained at all times, as the amount of abutment surface presented by one of each pair of diametrically opposite valves is increased in the exact ratio that the amount of abutment surface presented by the other of such valves is diminished, and vice versa. In my engine I employ a novel valve mechanism composed of three disks; the outer and inner disks have a series of equi-distant slots corresponding in number to the abutment valves of the engine, and the slots of the inner disk communicate with ports leading through the cylinder walls beside the respective abutment valves. The intermediate disk has half as many equi-distant perforations in it as the other disks have slots and it is fixed on the main engine shaft and rotates with the piston, while the outer and inner disks are fixed, or non-rotatable. These disks are inclosed in a steam chest on the end of the cylinder in such manner that no steam can enter the cylinder ports except through the openings in the disks. The slots in the outer and inner disks coincide and when the openings in the intermediate disks coincide with the slots in the other disks steam can enter the cylinder. As there are only half as many perforations in the intermediate disk as there are slots in the other disks it will be obvious that steam will enter the cylinder only through every other port, at one time, but that all the ports will be opened once during the revolution of the piston. The same valve mechanism can be used for the inlet and exhaust ports, by applying a set of the disks at opposite ends of the engine. In order to regulate the admission of steam to the engine the inner disk may be made slightly rotatable so that it can be partially turned so as to vary the register of its slots with those of the outer disk, and consequently the length of time when the perforations of the inner disk coincide with the slots in the inner and outer disks. A governor can be used to control the position of the inner disk, and thus the supply of steam be automatically controlled by the speed of the engine.

The accompanying drawings illustrate a good form of working engine and the valve mechanism, and referring thereto by letters of reference for a more detailed description of my invention, Figure 1 represents a perspective view of the complete engine. Fig. 2 is a longitudinal vertical section through the same; Fig. 2ª a detail longitudinal section showing the valve ports. Fig. 3 is a face view of the valve mechanism partly in section. Fig. 4 is an end view of the cylinder with head removed showing interior parts. Fig. 5 is a perspective view of an abutment valve. Fig. 6 is a detail view of the inner face of one of the valves. Figs. 7 and 8 are detached views of the valve disks.

I have illustrated an engine having a three lobed piston, and consequently six abutment valves.

A designates a cylinder mounted on a suitable base.

B, B, are the cylinder heads rigidly secured to the ends of the cylinder, each having an annular chamber *b* on their exterior faces in which are fitted the valve disks, and a central opening for the passage of the main shaft C. The chambers *b* are closed by removable plates D which are provided with stuffing boxes *d*, in which shaft C is journaled. The piston E is roughly trefoil-shaped, having three lobes *e* and three intermediate depressions *e'*.

F, F, designate the abutment valves, six in number arranged at equi-distant points around the piston, and playing through lon-

gitudinal slots in the cylinder and protected by housings F′ attached to the cylinder as shown. Each pair of diametrically opposite valves are rigidly united by means of bars *f* which are fastened to the ends of the valves and work in radial grooves *b′* in the inner faces of heads B, and are slotted as at *f′* for the passage of shaft C, and to permit the longitudinal movement of the bars. These bars cause the opposite valves to alternately and simultaneously move in and out, as the piston rotates, the surface of the piston acting as a cam to move the valves. At one side of each abutment valve, a longitudinal inlet port G is made in the walls of the cylinder, said port being closed at one end, but communicates at the other end with one of the ports *g* in one head B. At the opposite side of each abutment valve is a similar exit port H, closed at the end adjoining ports *g*, but communicating at the other end with one of the exit ports *h* in the opposite head B. The inlet valve consists of three annular disks J, K, L; disk J is centered on the end of shaft C within chamber *b*, and is provided with six transverse equi-distant slots *j*, adapted to register with ports *g*. This disk does not turn with the shaft C. The disk K is similar in size to disk J, but has a hub *k* by which it is splined on shaft C as shown. It also has but three openings *k′* much smaller than the slots *l*. Disk L is similar to disk J, having six slots *l*, and is mounted on the hub of disk K but is kept from rotating by a set screw L′ tapped through the wall of the chamber as shown. Only disk K rotates, and it revolves with the piston; consequently as it rotates, its openings *k* register with three alternate slots *j*, and *l*, alternately. When the openings in disks J, K, L, register, steam is admitted into the cylinder and the engine is operated, as above described.

The exhaust valve mechanism is constructed like the inlet valve, but the intermediate disk K thereof is fixed on shaft C so that its openings stand intermediate the openings in the disk K of the inlet valve mechanism, consequently steam will be exhausted from one side of the abutment valves simultaneously with its admission at the other side thereof, or in other words, steam will be admitted between alternate pairs of abutment valves, and simultaneously exhausted between the intermediate alternate pairs of abutment valves, as indicated by the arrows in Fig. 4.

It will be clear from the foregoing description that the simple rotation of one valve disk controls the admission of steam into the cylinder at six equi-distant points, during one rotation of the piston, and that steam is admitted at but three equi-distant points at one time. The piston therefore is continually balanced, and lateral thrust of the main shaft is prevented. Steam is admitted to and exhausted from the opposite chambers *b*, *b*, by pipes S, *s*.

In order to automatically regulate the admission of steam into the engine, the disk of the inlet valve mechanism is made partly rotatable, and is provided with a segmental rack J′ at a convenient point of its periphery. This rack is meshed by a small pinion *m* on the inner end of a stub shaft M journaled in the head and plate as indicated in the drawings, and a small pinion *m′* is fixed on the outer end of said shaft, and is meshed by a segmental rack N pivoted on a suitable support and connected in any suitable manner with a governor *n* which is driven from the main shaft.

The construction of the governor and of connections between it and shaft M and main shaft, whereby it is caused to rock shaft M is not of the essence of the invention, and may be of any suitable construction. As shown, the governor tends to rock shaft M when the speed reaches the maximum point, and by so doing it causes the slight rotation of disk J, and consequently alters the position of its slots with relation to those in disk L, and consequently the length of time when the perforation in disk *k* will register simultaneously with slots in disks L and J is shortened, and the supply of steam to the engine diminished. Thus in a simple and effective manner I provide an automatic cut-off for the engine and am enabled to perfectly control it. By using similar valve mechanism for the inlet and outlet ports I can reverse the engine by admitting steam at the exhaust side and exhausting it from the inlet side. The disks J, K, L, are really wheel-shaped, having the slots and perforations in their rims, and as steam can pass freely between the spokes thereof there is very little frictional contact surface between the disks. The piston may have a greater but unequal number of lobes, and must be of equal diameter in any cross section through its axis. The engine must have an equal number of abutment valves in order that the diametrically opposite valves may be connected and operated as above described.

When it is not desired to make the engine reversible, the outlet valve mechanism may be modified, by making disk J fast to the head, or by omitting said disk and dressing the bottom of chamber *b* and the ends of the cylinder ports so that the latter correspond to the slots in disk J, and disk K works against the head in the bottom of chamber *b*. This would be equivalent to making disk J integral with the head. I would therefore consider such changes as equivalents for my valve mechanism and as embraced in my claims, excepting where the cut-off feature of the valve mechanism is included.

Having described my invention, what I claim as new, and desire to secure by Letters Patent thereon, is—

1. A rotary steam engine having a concentric piston of equal diameter throughout formed with an odd number of longitudinal

lobes, in combination with a series of equi-distant abutment valves arranged in diametrically opposite pairs, one pair for each lobe of the piston, the opposite valves in each pair being rigidly united so as to move synchronously, and operated only by their direct contact with the piston and connection to each other, substantially as described.

2. In a rotary engine the combination of the cylinder, a piston having an odd number of longitudinal lobes, and similar number of intermediate depressions, and a series of abutment valves, one for each lobe and depression of the piston, with means for admitting steam at one side of three or more alternate valves at a time, until all the valves have been in active work once during each revolution of the piston, substantially as described.

3. The combination of the cylinder and piston therein, and abutment valves; with the inlet ports beside each valve, and valve mechanism substantially as described for admitting steam successively into alternate ports, and to three or more such ports at a time, substantially as described.

4. In a rotary engine the combination of the cylinder, a piston having an odd number of longitudinal lobes, and similar number of intermediate depressions, and a series of abutment valves, one for each lobe and depression of the piston, with means for admitting steam at one side of three or more alternate valves at a time, until all the valves have been in active work once during each revolution of the piston, and means for simultaneously exhausting steam at one side of such valves simultaneously with the admission of steam against the other side, substantially as described.

5. A rotary steam engine having a concentric piston of equal diameter throughout formed with an odd number of longitudinal lobes, in combination with a series of equi-distant abutment valves arranged in diametrically opposite pairs, one pair for each lobe of the piston, the opposite valves in each pair being rigidly united so as to move synchronously, and operated only by their direct contact with the piston and connection to each other, and mechanism for admitting steam against one valve of each pair, and exhausting it in front of the opposite valve, substantially as and for the purpose specified.

6. The combination of the cylinder, the series of radial abutment valves, the outlet and inlet ports at each side of each abutment valve, and the piston having an odd number of lobes and depressions the sum of which equals the number of abutment valves, and valve mechanism whereby steam is admitted successively into alternate inlet ports; and to three or more such ports at a time substantially as described.

7. The combination of the piston having an odd number of lobes but of equal diameter in cross section throughout; with the cylinder, the cylinder heads, the abutment valves arranged in diametrically opposite pairs, one pair for each lobe on the cylinder, and the valves in each pair being connected together so as to move synchronously; with inlet and exhaust ports on opposite sides of each abutment valve, and mechanism substantially as described for simultaneously admitting steam at one side of one valve in each pair, and then admitting it at one side of the opposite valve in each pair, and simultaneously exhausting steam at the opposite sides of such valves, substantially as and for the purpose specified.

8. The herein described valve mechanism for rotary engines consisting of three disks, the outer and inner disks having corresponding slots, and the intermediate disk a perforation adapted to intermittently register with those of the outer and inner disks, the outer and inner disks being non-rotatable, while the intermediate disk rotates, substantially as described.

9. The combination of an engine cylinder having an even number of inlet ports, with a rotating disk having half as many openings adapted to simultaneously register with alternate ports, substantially as and for the purpose described.

10. The combination in the rotary engine of the cylinder having an even number of equi-distant ports, and a piston therein; with a rotating disk adapted to revolve synchronously with the piston provided with equi-distant openings adapted to simultaneously register with three or more alternate cylinder ports, and to register with all the cylinder ports once during each revolution thereof substantially as described.

11. The combination of the cylinder, its equi-distant inlet ports, the rotating piston, the disk mounted on the piston shaft having equi-distant openings adapted to register with three or more alternate cylinder ports simultaneously, and diametrically opposite abutment valves intermediate the cylinder ports, the opposite valves being connected substantially as described.

12. The combination of the cylinder, its inlet ports and the piston and main shaft; with the valve mechanism consisting of three disks, the inner and outermost disks being stationary having corresponding slots equal in number to the ports of the cylinder, and the slots of the inner disk communicating with said ports, and an intermediate rotating disk having openings adapted to register with alternate openings in the other disks, and mechanism whereby the inner disk may be slightly rotated so as to vary the length of register between the openings in the intermediate disk and the slots in the outer and inner disks, substantially as described.

13. The herein described engine consisting of the cylinder, the piston having an odd number of lobes, the diametrically opposite

but connected abutment valves, one pair for each lobe of the cylinder, the inlet and outlet ports on opposite sides of each abutment valve, and the chambered cylinder heads, with the valve mechanisms in the chambers of said heads, constructed and operated substantially as herein shown and described.

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

JOHN VINCENT DAVIS.

Witnesses:

AUGUSTA TILESTON,

C. W. MERRIAM.