3 Sheets—Sheet 1.

G. E. TOWER.

Valve-Gear.

No. 213,261. **Patented Mar. 11, 1879.**

Witnesses:
Chas. C. Abbe
F. C. Brecht

Inventor:
Geo. E. Tower

3 Sheets—Sheet 2.

G. E. TOWER.

Valve-Gear.

No. 213,261. Patented Mar. 11, 1879.

Fig 3.

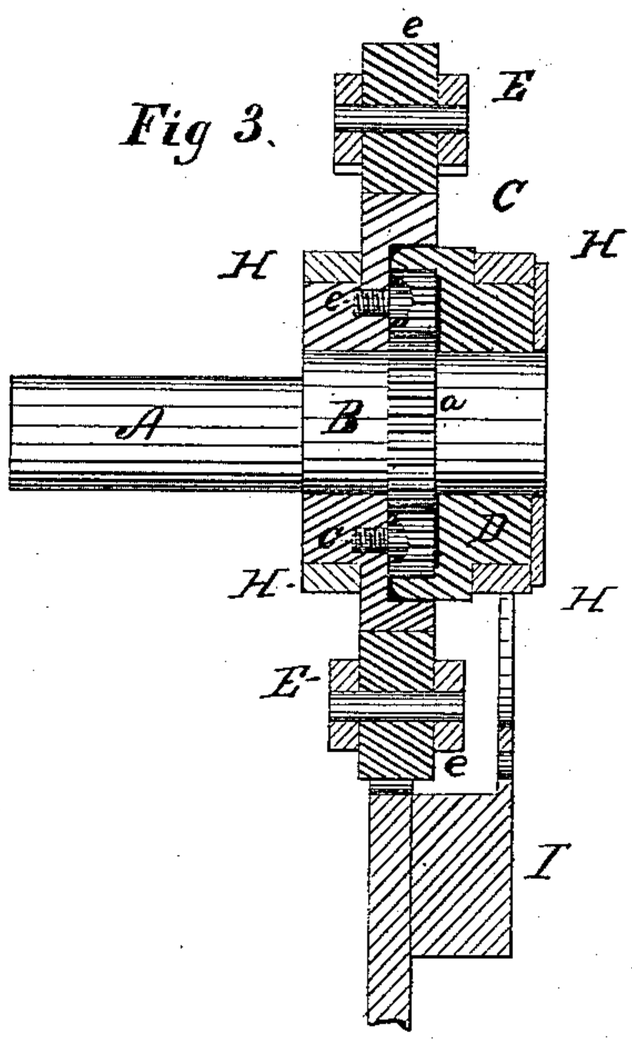


Fig 4.

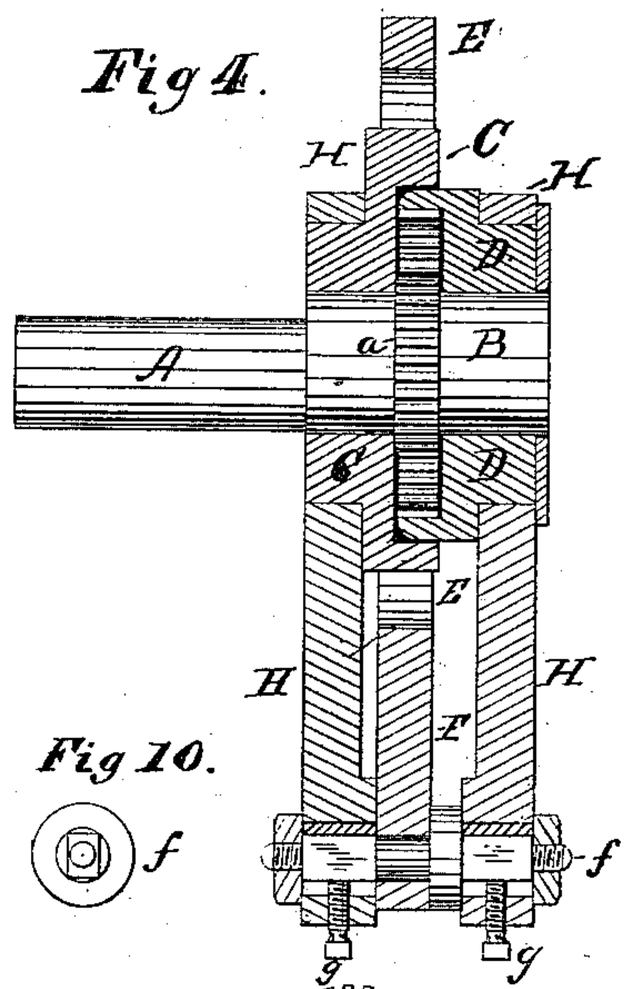


Fig 10.

Fig 8.

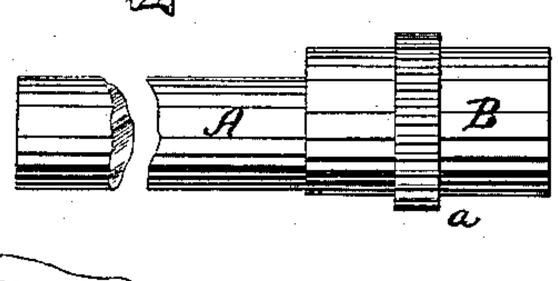


Fig 9

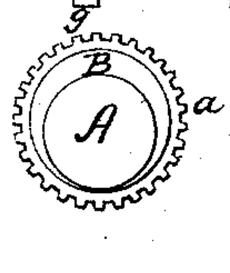


Fig 5.

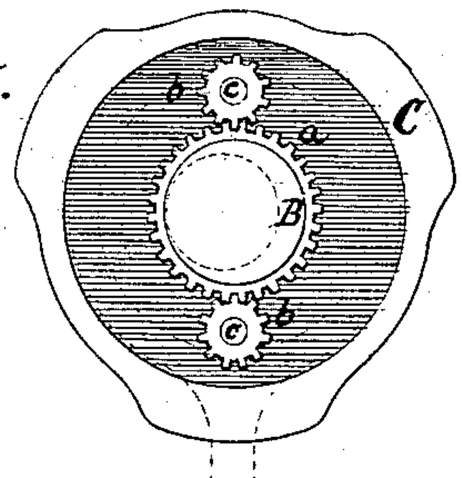


Fig 6.

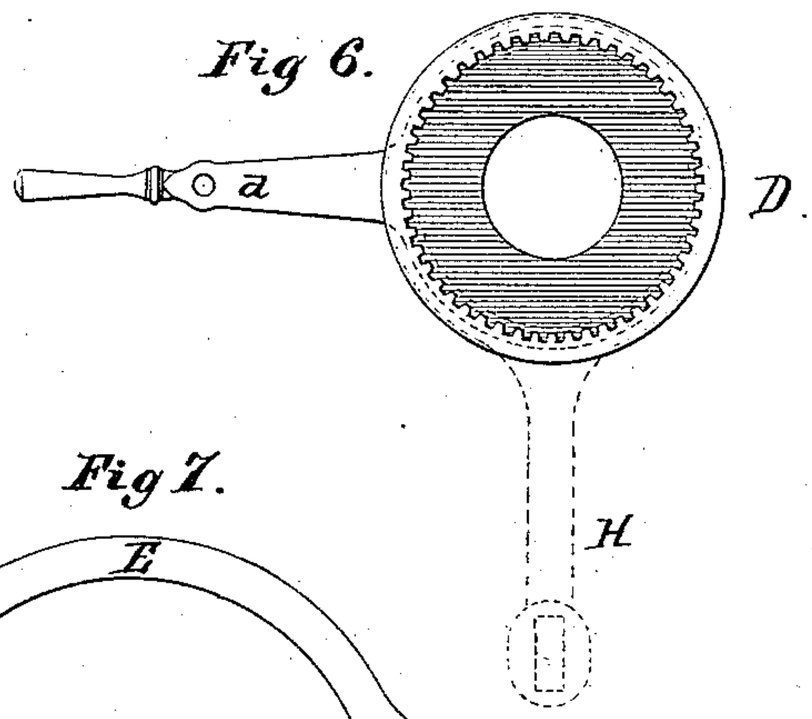
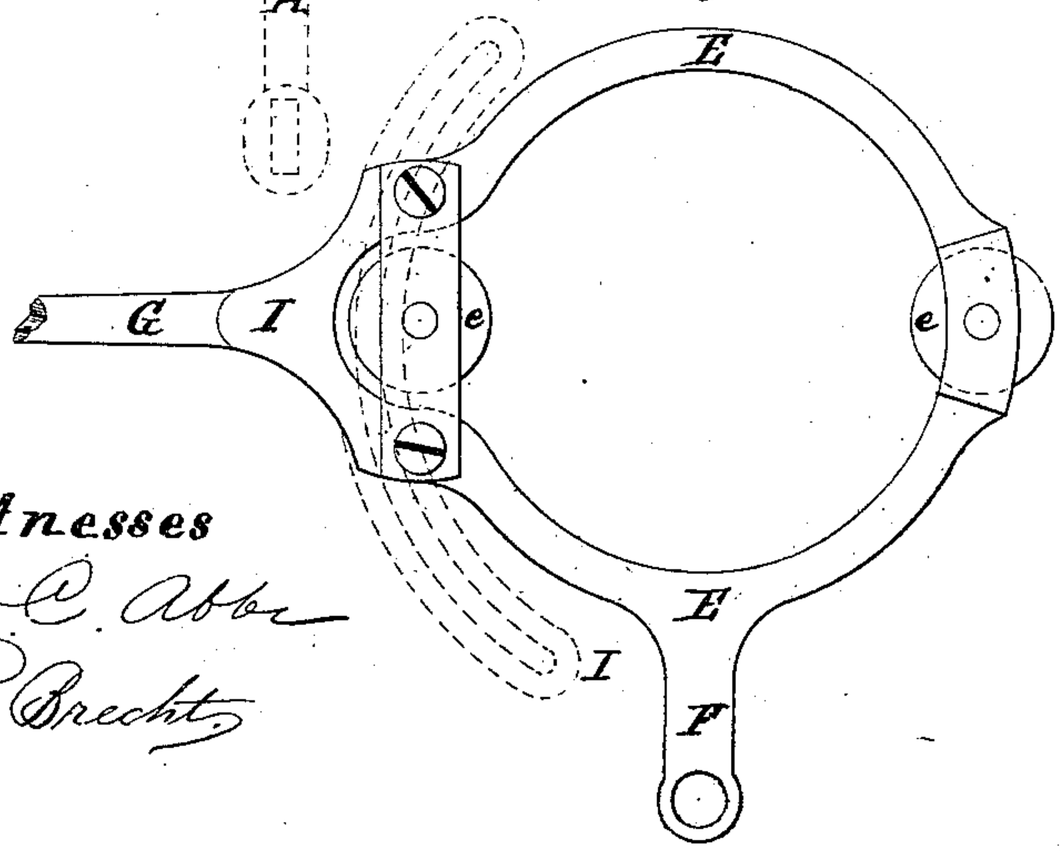


Fig 7.



Witnesses

Chas. C. Abbe

T. C. Brecht

Inventor

Geo. E. Tower

3 Sheets—Sheet 3.

G. E. TOWER.

Valve-Gear.

No. 213,261 **Patented Mar. 11, 1879.**

Fig 11.

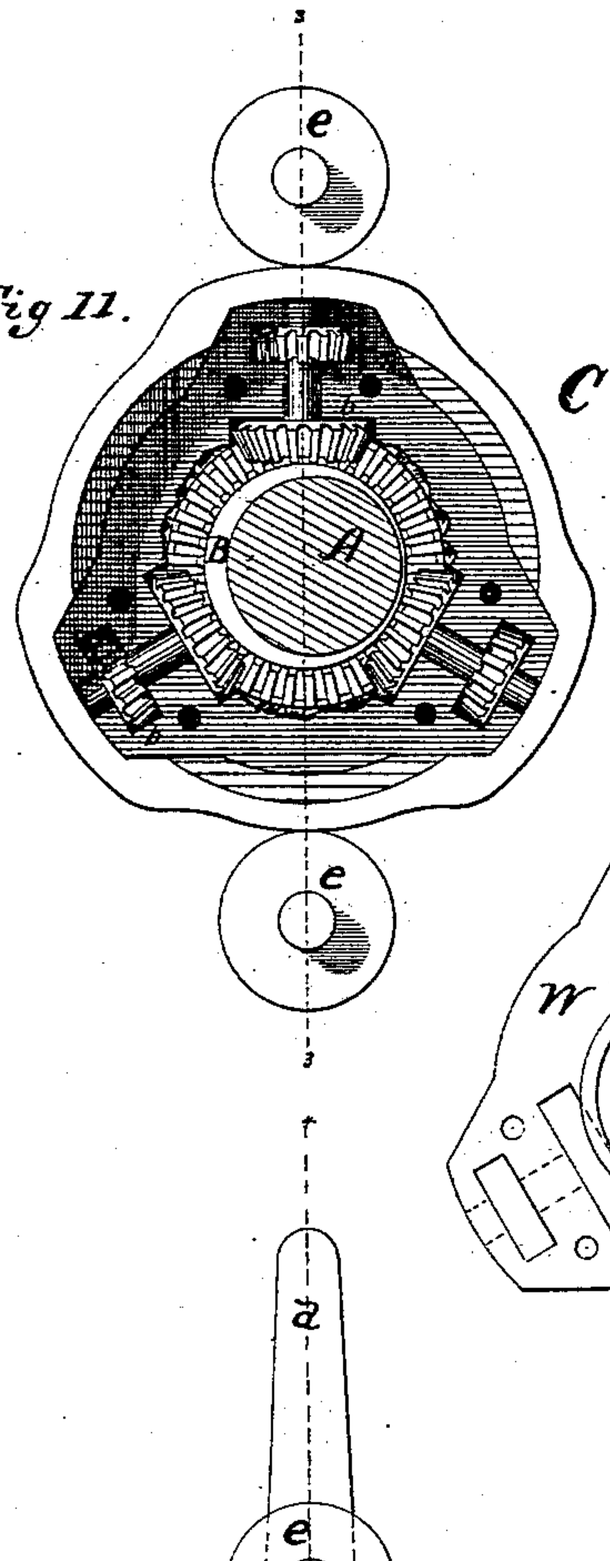
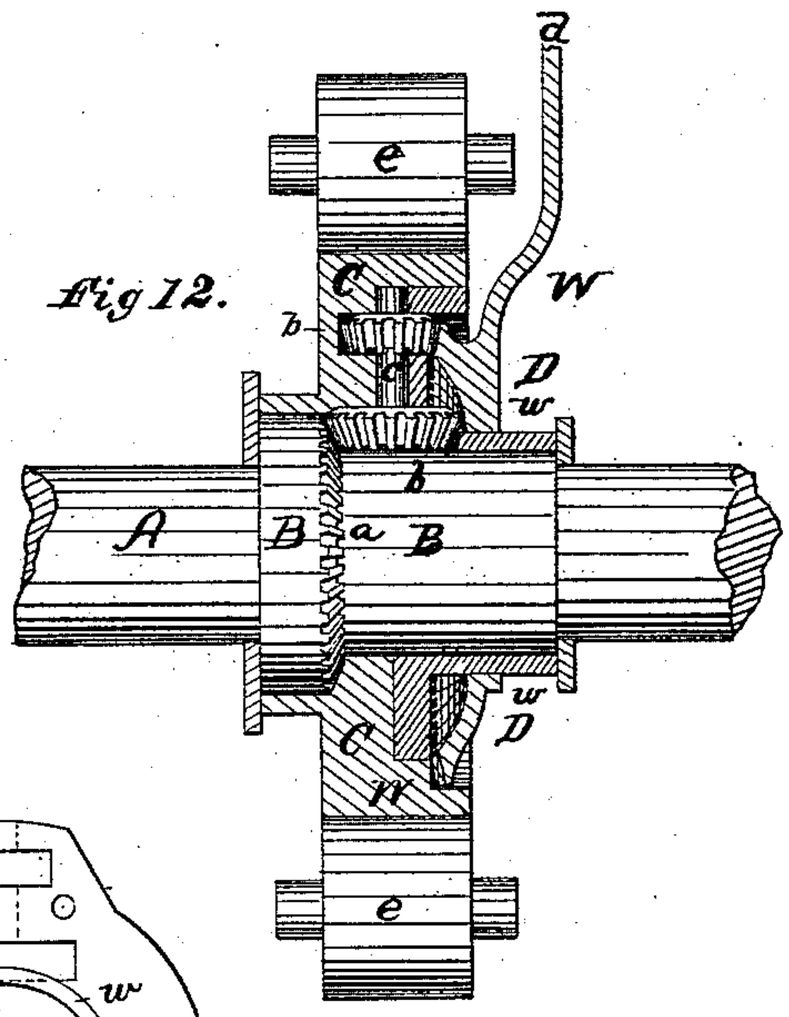


Fig 12.



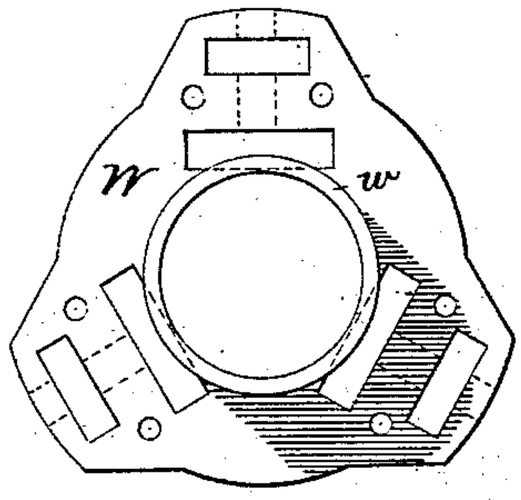


Fig 13.

Fig 14.

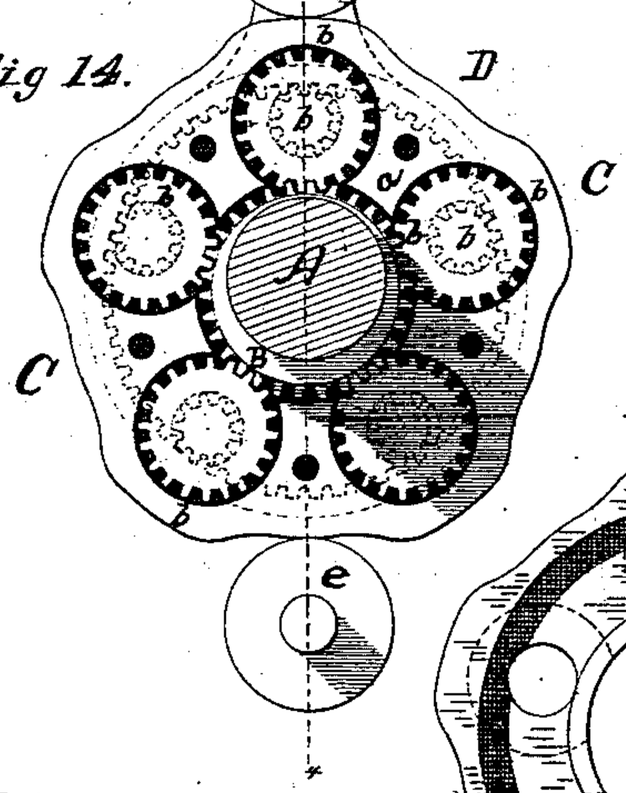


Fig 15.

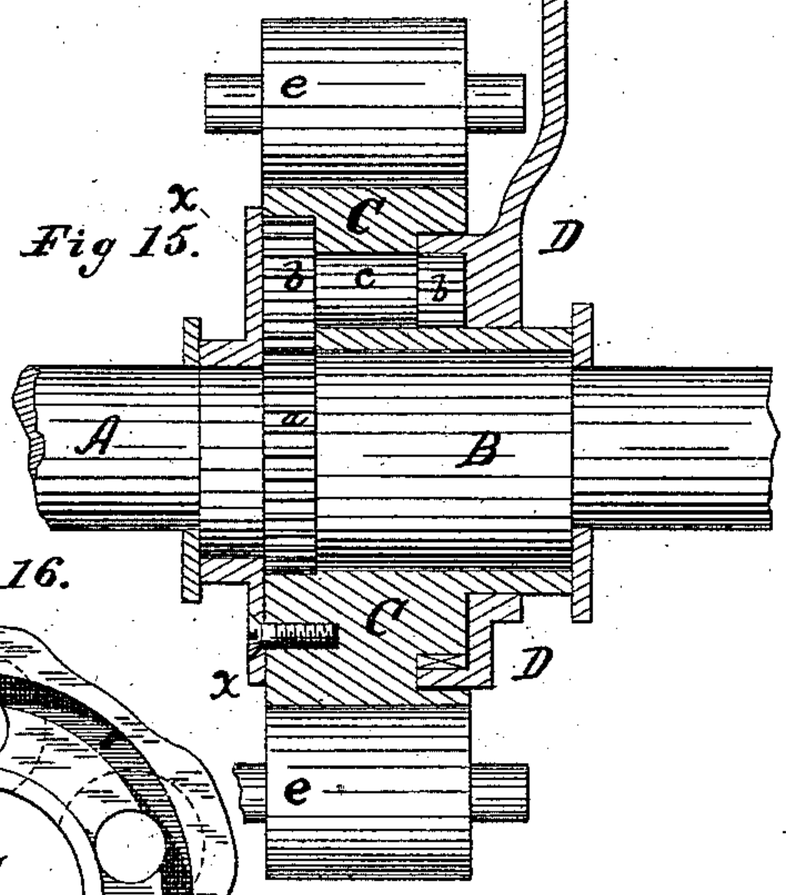
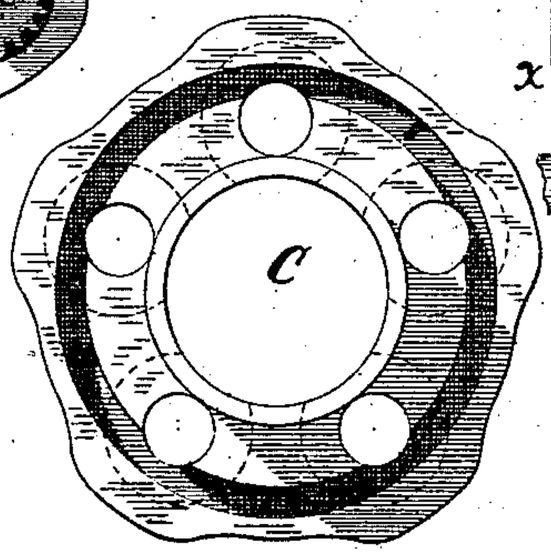


Fig 16.



Witnesses:
Chas. C. Abbe
T. C. Brecht.

Inventor:
Geo. E. Tower

UNITED STATES PATENT OFFICE.

GEORGE E. TOWER, OF WASHINGTON, DISTRICT OF COLUMBIA.

IMPROVEMENT IN VALVE-GEARS.

Specification forming part of Letters Patent No. **213,261**, dated March 11, 1879; application filed February 18, 1879.

To all whom it may concern:

Be it known that I, GEORGE EDWARD TOWER, of the city of Washington, in the District of Columbia, have invented a new and useful Improvement in Valve-Gears for Steam or other Engines, which improvement is fully set forth and illustrated in the following specification and accompanying drawings.

The object of this invention is to operate an engine by a valve-gear which, while causing both the admission and release at the proper time through an actuating-valve of the power which actuates the engine, also cuts off the source of said power from the cylinder at any desired point in the stroke of the piston by means of the same valve, this said result being accomplished without injuriously affecting the release or exhaust of the actuating-power, or in any manner deranging the "lead" or setting of the actuating-valve, although the crank-shaft should revolve in either direction. This gear is applicable to all classes of slide-valves that are moved and operated as one valve, whether the valve be in one piece or in two parts connected by rods, bars, or stems, as is commonly the case, in order that one part may be placed near each end of the cylinder, to economize space in the steam and exhaust ports, or to save "clearance-space." Valves thus constructed in two parts are considered as forming but one valve proper in this specification and its claims.

In pursuance, therefore, of the object above mentioned, the invention consists, in part, of a rotary cam mounted upon an eccentric, and driven thereby in any suitable manner, the said cam thus superadding to the ordinary functions of the main actuating-valve of the engine the additional function of a cut-off. The eccentric is either formed upon or fitted to a rotary driving-shaft, and the said cam so combined with the eccentric that the speed of revolution of the cam may be either equal to or less than that of the eccentric. In the latter case certain toothed gearing is interposed between the eccentric and cam.

The invention also consists of certain operative and adjustable connections between the cam and the actuating-valve of the engine, whereby the functions of admission and release or exhaust of the actuating-power are imparted to said valve by the action of the eccentric, and the function of a variable cut-off of said power is imparted to said valve by the action of the cam at the will of an operator, none of said valve functions impairing the efficiency of the others.

The several figures of the drawings, showing general views and details of the said means by which the results above mentioned are effected, will now be described.

Figures 1 and 2 show, respectively, a side elevation and plan of the valve-gear, valve, and valve-seat, in which views of the invention the cam is designed to revolve at one-third of the speed of the eccentric. Figs. 3 and 4 are sections at the lines 1 1 and 2 2, respectively, of Fig. 1. Fig. 5 shows the interior of the cam, the shaft in dotted lines, and the eccentric and toothed gearing by which the cam is driven. Fig. 6 shows the interior of an internal toothed or annular wheel, by which the cam is adjusted for varying the point of cut-off. Fig. 7 is an elevation of the cam-yoke and rollers. Figs. 8 and 9 are an elevation and end view, respectively, showing the main shaft with the eccentric forged or secured thereon, and driving-teeth cut upon a portion of the eccentric's face or bearing-surface. Fig. 10 is an end view of an adjusting bolt or shaft for maintaining the alignment of the cam-yoke.

The other figures 11, 12, 13, 14, 15, and 16, Sheet 3, exhibit modifications of details, in section and elevation, of the eccentric, cam, and toothed gearing, all of which will be hereinafter particularly and best described by literal reference, the same parts being similarly lettered in all the figures. The figures upon Sheets 1 and 2 will, therefore, first be described, as follows:

To the shaft A is either forged or secured in any suitable manner the eccentric B, and upon said eccentric is mounted the adjustable cam C. Cut upon the eccentric are teeth *a*, which gear with other teeth upon pinions *b*, which pinions rotate upon pins or studs *c*, firmly secured to the cam C. Mounted upon the eccentric B, at one side of the cam C, and concentric with it and the eccentric, is the annular gear-wheel D, provided with teeth which gear with the pinions *b*. Said annular gear-

wheel is provided with an arm or lever and handle, *d*, and serves the purpose of setting or adjusting the cam to any point desired for varying the point of cut-off. For long-stroke engines, however, when it may be desirable not to diminish the speed of revolution of the cam to less than that of the eccentric, the cam may be made adjustable by means of any of the well-known devices used for changing the position of an eccentric, cam, or wheel upon its shaft; but for engines of short stroke, and for economy of space, the gearing illustrated in the drawings is preferred.

Spanning the cam C is a yoke or frame, E, provided with rollers *e e*. Said yoke is provided with an arm or offset, F, and at right angles thereto another arm or cam-rod, G, which transmits the motions both of the eccentric and cam to the main valve of the engine. Suspended from the shaft A, and having bearings respectively upon the cam C and wheel D, are two suspension-rods, H H. These rods are suspended by bearings in their bosses or straps, as seen in the drawings, and are connected at their lower extremities by a small shaft or bolt, *f*. The arm F of the yoke has a bearing on the central portion of this bolt *f*, which bolt is round in cross-section where it passes through the bearing of the arm F; but its ends, which pass through slots in the ends of the suspension-rods H H, are flat or elongated. By this arrangement, as is clearly seen in Fig. 4, the yoke E can oscillate slightly upon this bolt or shaft as it is moved by the cam, and can be so adjusted that the rollers *e* will be held in proper line for the action of the cam thereon, suitable set-screws *g* and nuts, washers, and collars being provided for this purpose, as clearly shown in Fig. 4.

To the cam-yoke E is secured the slotted arc or sector I, within which arc a pin, *i*, and block *u* are caused to traverse, when desired, by means of a link or bar, *k*, which connects said pin to the lever *d* of the adjusting-wheel D. A handled nut clamps the pin *i* to the arc I.

It will be observed that the arc I is secured to the cam-rod G. This is done in order that said arc shall partake of the motion due to that of the eccentric, for if the arc were attached to a fixed support such attachment would cause the lever *d* and adjusting-wheel D to oscillate upon their common point of contact with the arc, and thus, by slightly moving the cam, cause an irregularity in the point of cut-off. It will also be observed that as the yoke must have a movement due to the action of the cam, such movement would therefore be transmitted to the adjusting-wheel D were not the link or bar *k* interposed between the arc I and the cut-off lever *d*; but as the link *k* oscillates on the pin *i*, the cut-off lever *d* and the adjusting-wheel D are unaffected by this movement of the yoke. The cut-off lever *d* can be secured to any part of the valve-gear having the proper movement; or it can be secured to a fixed arc or sector if other and suitable provisions are made for the irregularities in the point of cut-off, or where these irregularities are not considered important.

The arm or cam-rod G is provided with a double hook, *h*, which respectively clasps either of the pins *m* m^2 of the double rocker-arm K, which oscillates upon its central shaft, *o*. The upper end of the rocker-arm K is provided with a lever-handle and a stud or pin, to which latter the rod L, also connected to the valve-stem M, is attached, as is clearly seen in Figs. 1 and 2. The valve V, upon its seat V^2, is connected to its stem M, which is provided with a guide, *p*. To the end of the cam-rod G is secured a link or rod, N, connected to the reversing-lever R, which lever, when turned upon its center *q*, moves the double hook *h* from one pin, *m*, to the other, m^2, and thus reverses the movement of the crank (shown at S) on the shaft A, though the latter need not be the crank-shaft, but any shaft suitable for driving the eccentric.

The lever R is clamped upon the arc *s*, as seen in Fig. 1, or by any other suitable means. This hook-motion is well known, to those skilled in mechanical engineering, as a means of starting, stopping, and reversing engines.

In case a loose eccentric driven by lugs upon the shaft (another well-known means for reversing engines) is desired to be used, neither the rocker-arm nor hooks herein illustrated are required, and the position of the eccentric on the shaft can be changed from its contact with one of said lugs to contact with the other by the mechanism herein described for adjusting the cam, provided the cam is held fast while the eccentric's position is being so changed.

Before describing the complete operation of this valve-gear, the modifications shown on Sheet 3 will now be described, as follows:

Figs. 11 and 12 show a transverse section and a sectional elevation, respectively, of a part of the invention in which bevel-gearing is used. The eccentric is therein seen having two diameters, with the teeth for a bevel-gear wheel cut upon the shoulder forming the difference between said diameters. Fig. 12 is a section at the line 3 3 of Fig. 11.

Fig. 13 shows, in elevation, a plate, W, provided with recesses for the small gear-wheels and semicircular depressions shown in dotted lines, which form caps for the bearings of the shafts of said wheels. The said plate W fits into the recess of the cam C, and is bolted thereto. It is also provided with a long hub or annular journal, (shown at *w*, Fig. 12,) which hub adds to the length of the bearing for the cam upon the eccentric, and also forms a bearing for one of the suspension-rods H, the other one of said rods being borne upon a hub or annular journal on the cam itself, as is also the case in Fig. 4. The hub or annular journal *w* of the plate W also forms a bearing for

the bevel-wheel D, which is substituted for the annular wheel D shown in Fig. 6.

Fig. 14 shows, in side elevation, a cam having five raised surfaces and corresponding depressions, with its interior exposed and exhibiting all the gear-wheels in place, but with the cap *x* (shown in Fig. 15) removed. Fig. 15 shows a transverse section at the line 4 4 of Fig. 14. Fig. 16 is an elevation of the cam as seen from the right side of Fig. 15, with the annular wheel D and pinions *b* removed. The cam in these last three figures being provided with five raised surfaces, the gearing therein shown is such that the speed of revolution of the cam is geared down to one-fifth that of the eccentric—that is, but one revolution of the cam is made to five revolutions of the eccentric, instead of one to three revolutions, respectively, as illustrated in the preceding figures.

The plate *x*, Fig. 15, is secured to the cam C, and holds the geared pinions within the recess of the cam. The said plate has also a hub or annular journal opposite and corresponding to that on the cam C, for supporting one of the suspension-rods H. The said rods are preferably supported as shown on Sheet 3—that is, upon the cam itself and parts secured to it, rather than one of said rods upon the hub of the fixed adjusting-wheel D, as seen on Sheets 1 and 2, because of a greater uniformity in the wear in the eyes or straps of the rods H. If one of said rods be supported upon the cam or upon a part moving with it, and the other rod be supported upon the wheel D, the former rod would sooner be worn loose in the eye or strap, while the latter would be less affected by use. By means also of these modifications shown on Sheet 3 of the drawings a cam of less diameter and of longer bearing upon the eccentric for the same length of cam-face is obtained, and less wear is brought upon the pinions.

The peculiarities and complete operation of this valve-gear will now be described.

In the first place, the cam, its toothed gearing when used, and other connections, being mounted upon the eccentric, all partake of the motion due to that of the eccentric; yet the said parts *inter se*, so far as the eccentric, as such, affects them, are relatively at rest.

Such being the case, the operation of the valve-gear as now described can readily be understood.

If the engine be intended to revolve in both directions, the eccentric need not be set with any angular advance; but if the engine-shaft be intended to revolve in but one direction, the eccentric may be so set as not to arrive quite at mid-throw when the crank is on its center—that is, a little late. By thus setting the eccentric the valve will keep the exhaust-port wider open during a portion of the stroke of the piston.

The duty of the eccentric, as such, is to cause the valve to travel the distance required for a full opening of both the admission and exhaust ports, (or a little farther,) and also to close the latter port after the valve has already been acted upon by the cam for the corresponding stroke of the piston. By causing the outer edge of the valve to travel a little beyond the inner edge of each admission-port, said ports will remain wide open for a longer period when the actuating-power is following full stroke.

The duty of the cam is twofold. Its first office is to place the valve as far from its mid-position as is required for the lap and lead of the valve when the crank is on its center. This office it performs by the contact of either its raised or its depressed surfaces with either one of the rollers in the yoke, depending upon which center the crank is placed.

The second office of the cam is to throw the valve far enough back to fully cover the admission-port, but not to close entirely the exhaust-port, at the proper time for cutting off, although the eccentric may be in position for opening the admission and exhaust ports still farther. The difference in the radii of the contour of the cam is made great enough for the above-mentioned purpose when the valve is at its extreme point of travel. This second office of the cam is, therefore, performed by the transfer of the contact of one of the rollers of the yoke from one of the cam's depressed to one of its raised surfaces, or vice versa, depending upon the position of the crank, as above mentioned.

The position of the cam relatively to either the crank or the eccentric is adjustable by means of the arm or cut-off lever *d* on the adjusting-wheel D, which wheel rotates the cam by gearing with its pinions *b*. In the position of the cut-off lever *d* shown in Fig. 1, the cam is adjusted to cut off at about three-quarters from the commencement of the stroke of the piston.

To cut off at a shorter point in said stroke, the lever *d* is moved to a point nearer the center of the arc I, which brings one of the raised surfaces of the cam nearer to one of the cam-rollers *e;* consequently, the earlier contact of the raised surface with the roller as the cam revolves sooner moves the valve to close the admission-port. The outlines of the cam being circular arcs joined by easy curves, and these arcs being concentric with the eccentric, the rotative movement of the cam given by the lever *d* in order to change the point of cutting off can impart no movement to the rocker-arm K and valve V until the desired point for cut-off is reached. Therefore such movement of the cam cannot change the lead of the valve. Neither will the exhaust-port be either opened or closed sooner, as these functions are performed by the action of the eccentric upon the valve, and not by the action of the cam thereon.

The position of the reversing-lever R shown in Fig. 1 is that for moving the crank in the direction shown by the arrow, the cut-off lever

d being likewise set for the same direction of crank-revolution. To reverse the engine, the cut-off lever *d* is moved to the other end of the arc I, and the hook *h* on the cam-rod G is shifted to the upper pin, m^2, in the rocker-arm K by moving the reversing-lever R. These adjustments place the valve-gear in position for full stroke in the direction opposite to that shown by the arrow, and to cut off shorter the lever *d* is brought nearer to the center of the arc I. The action of the cam is thus seen to be identical in cutting off, in whichever direction the crank may rotate.

The gear-wheels connecting the eccentric and cam (shown in the several figures of the drawings) constitute a train of epicyclic gearing, in which are exhibited several pinions or sets of pinions. While but one pinion or set of pinions is theoretically required, it is evident that the greater the number used the less will be the strain and wear upon the studs or shafts which carry the pinions in driving the cam. The cam being chambered out and all the gearing confined to its interior, much space on the driving-shaft is economized.

It may be well to observe here that care should be taken to accurately proportion the relative throw of cam and eccentric, for if such proportion be an excess in favor of the cam the exhaust-port will be closed too much for advantageous working after the cut-off has been effected, should the cut-off take place near the commencement of the stroke of the piston—that is, should the cut-off be very short.

In case a governor be fitted to the engine, it may be connected to the cut-off lever *d*, in which case no clamping device for said lever would be required.

Having thus fully described this my said invention, I claim—

1. In a valve-gear for steam or other engines, an adjustable rotary cam mounted upon and driven by an eccentric, said parts being so arranged that said valve-gear is adapted to impart to the main valve of the engine the ordinary functions of an actuating-valve and the additional function of a cut-off valve, substantially as set forth.

2. In a valve-gear for steam or other engines, in combination with an eccentric provided with driving-teeth thereon, a rotary cam and an interposed train of gearing, whereby said eccentric is caused to act as a driving-wheel for said cam, substantially as set forth.

3. In a valve-gear for steam or other engines, in combination with an eccentric, a rotary cam and an interposed train of gearing, whereby said cam is driven by said eccentric at a less number of revolutions than that of the eccentric itself, substantially as and for the purpose set forth.

4. In a valve-gear for steam or other engines, in combination with a driving-shaft, a rotary cam provided with an annular journal or journals, and connected to a yoke by means of side bars or suspension-rods, whereby the relative alignment of said yoke and cam are maintained, substantially as set forth.

5. In a valve-gear for steam or other engines, in combination with a driving-shaft provided with a cam, a yoke provided with an arm or offset and suspension rods or bars for connecting said driving-shaft and arm or offset, whereby said yoke is supported in position, substantially as set forth.

6. In a valve-gear for steam or other engines, in combination with a cam-shaft, a yoke having an arm or offset supported by suspension rods or bars, and provided with means of adjustment therewith, whereby the proper alignment of said yoke relatively to said shaft is maintained, substantially as set forth.

7. In a valve-gear for steam or other engines, in combination with a cam-shaft, a yoke having an arm or offset connected through a journal-bearing therein to suspension rods or bars by a shaft or bolt passing through said journal-bearing and through slots in said bars, whereby said yoke is adjusted and allowed to oscillate upon said shaft or bolt, substantially as set forth.

8. In a valve-gear for steam or other engines, in combination with an eccentric and a yoke, an adjustable cam rotated by said eccentric and connected to said yoke, substantially as described, whereby said cam is adjusted at will for variable cut-off without moving the eccentric, substantially as set forth.

9. In a valve-gear for steam or other engines, in combination with a driving-shaft, a rotary cam provided with an epicyclic train of gearing, one wheel of said gearing being fitted with an adjusting arm or lever, whereby the position of said cam is changed relatively to any assumed point in the circumference of the driving-shaft, for effecting variable cut-off movements of the valve-gear, substantially as set forth.

10. In a valve-gear for steam or other engines, in combination with a rotary cam and its yoke, an adjusting mechanism provided with an adjusting-lever connected to said yoke, whereby the revolution of the cam is permitted while the adjusting-lever remains at rest relatively to said yoke, substantially as set forth.

11. In a valve-gear for steam or other engines, in combination with an eccentric and a rotary cam having its adjusting mechanism operated by an arm or lever attached to said mechanism, a fastening arc or sector for said arm or lever secured to any part partaking of the motion of the eccentric, whereby the revolutions of the eccentric and cam are respectively effected without change of position relatively to each other, substantially as set forth.

12. In a valve-gear for steam or other engines, in combination with a rotary cam and its yoke, an adjusting mechanism provided with an adjusting-lever connected to said

yoke through the intervention of a sector or arc and a vibratory bar or link, whereby the point of cut-off is varied at will, and the revolution of the cam permitted while the adjusting-lever is held at rest relatively to said yoke, substantially as set forth.

13. In a valve-gear for steam or other engines, in combination with a driving-shaft, a rotary cam having a recessed interior, and provided therein with gearing for rotating said cam, whereby its operative forces are brought to act centrally within the said cam, and space upon the driving-shaft is economized, substantially as set forth.

GEO. E. TOWER.

Witnesses:
AMOS HUNT,
WM. P. O'CONNOR.