(No Model.)

5 Sheets—Sheet 1.

C. T. PORTER.

STEAM ENGINE.

No. 517,983. Patented Apr. 10, 1894.

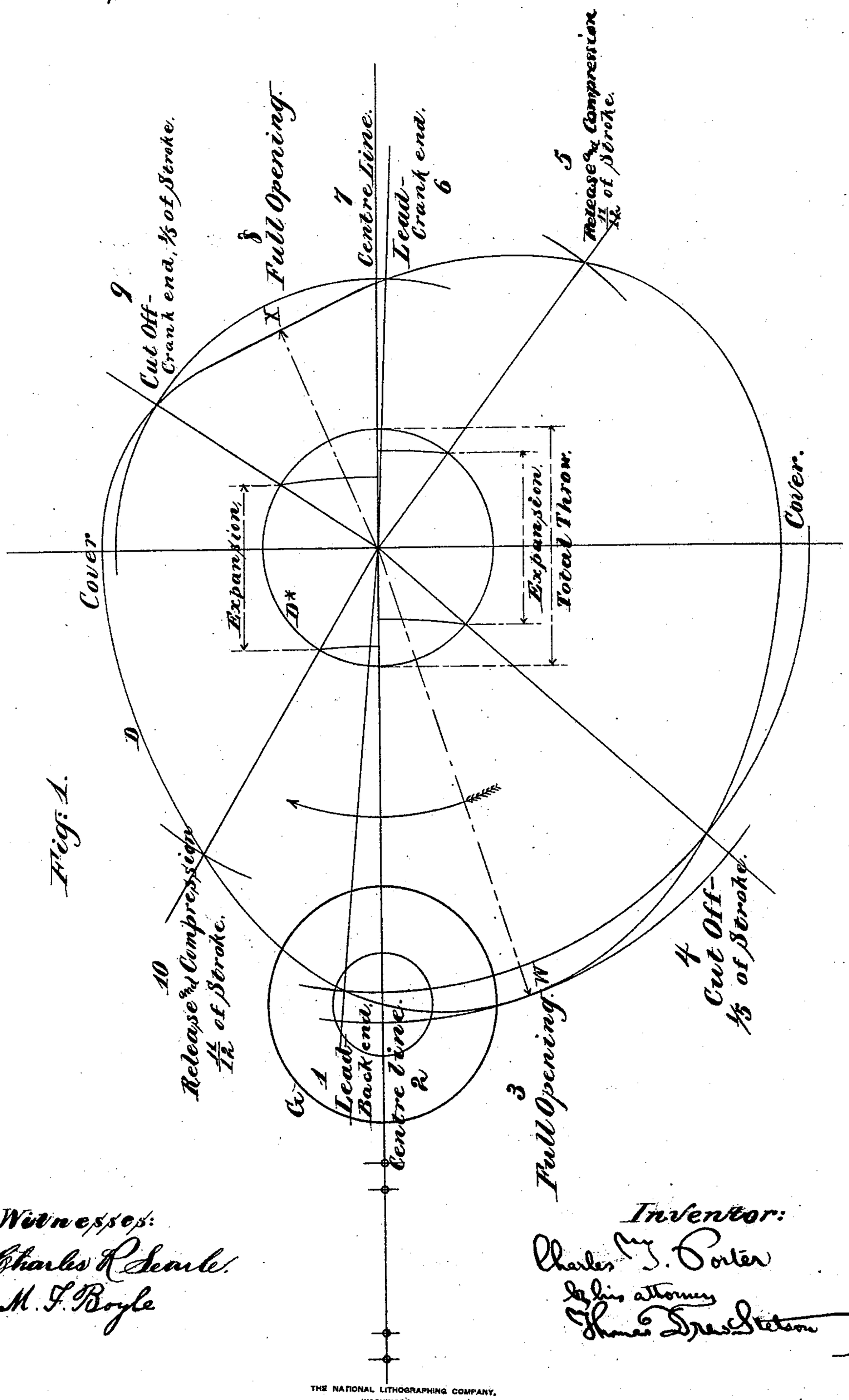

Fig: 1.

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by his attorney
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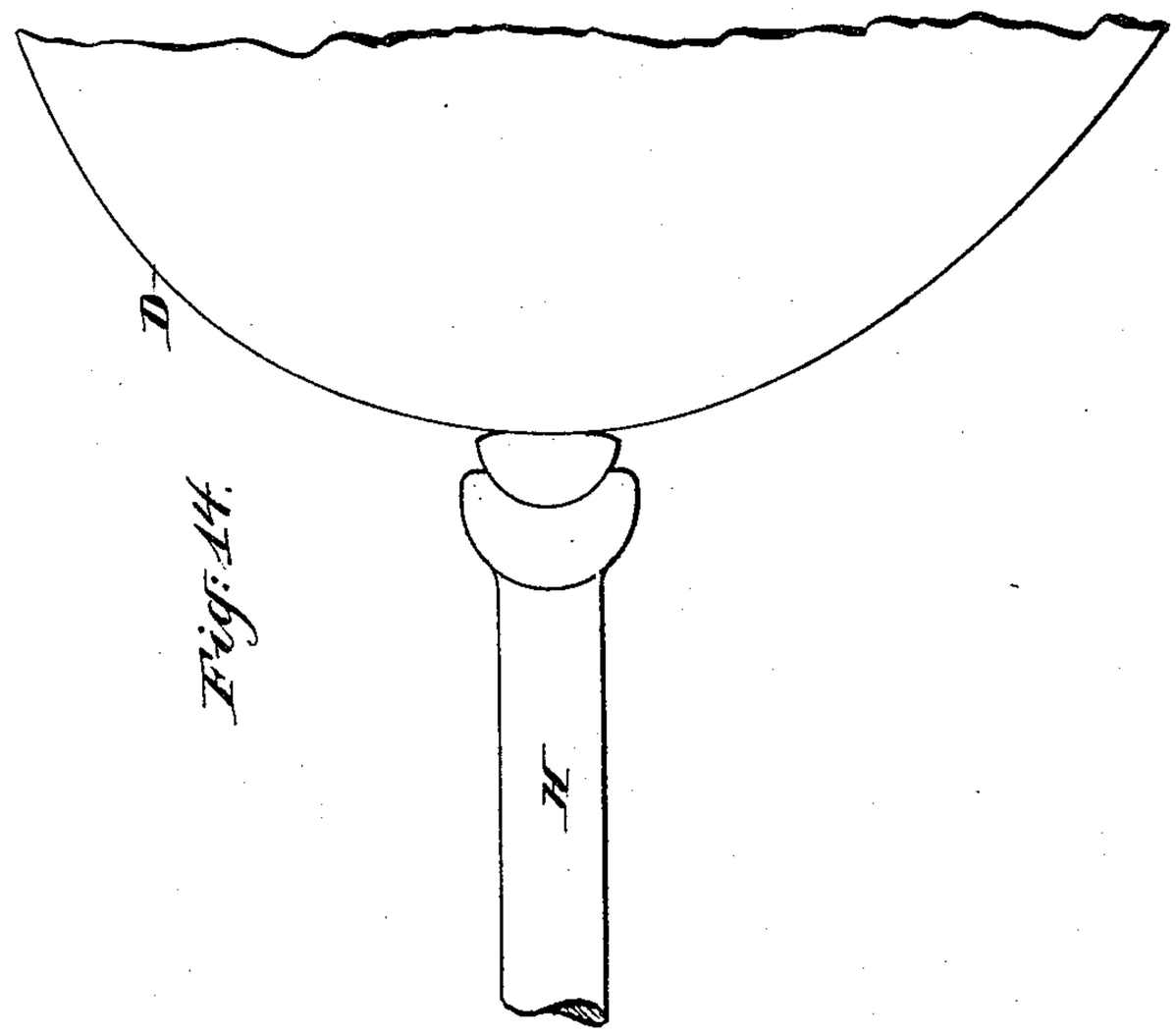
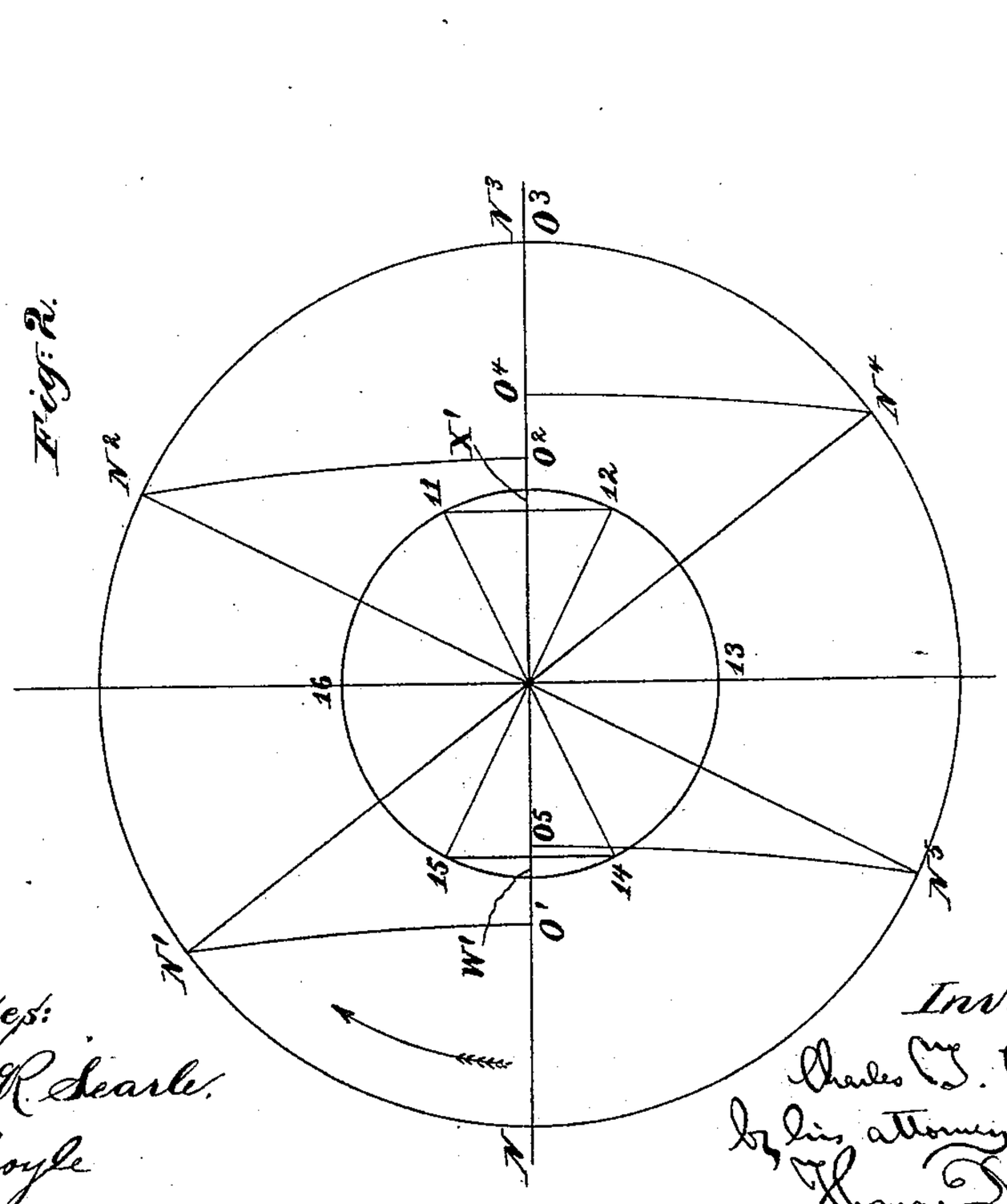
C. T. PORTER.

STEAM ENGINE.

No. 517,983. Patented Apr. 10, 1894.





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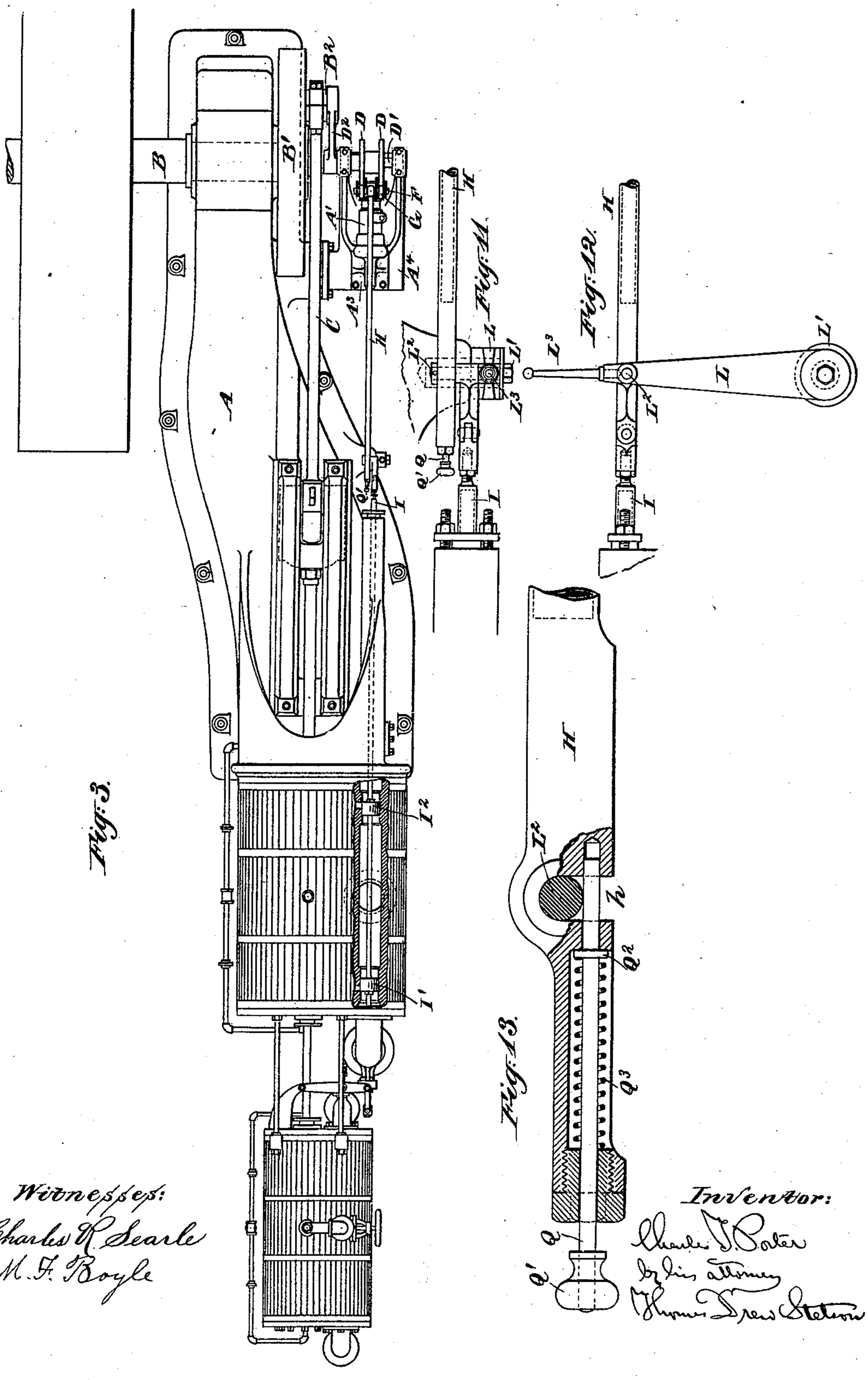
C. T. PORTER.

STEAM ENGINE.

No. 517,983. Patented Apr. 10, 1894.



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C. T. PORTER.

STEAM ENGINE.

No. 517,983. Patented Apr. 10, 1894.

Fig. 4.

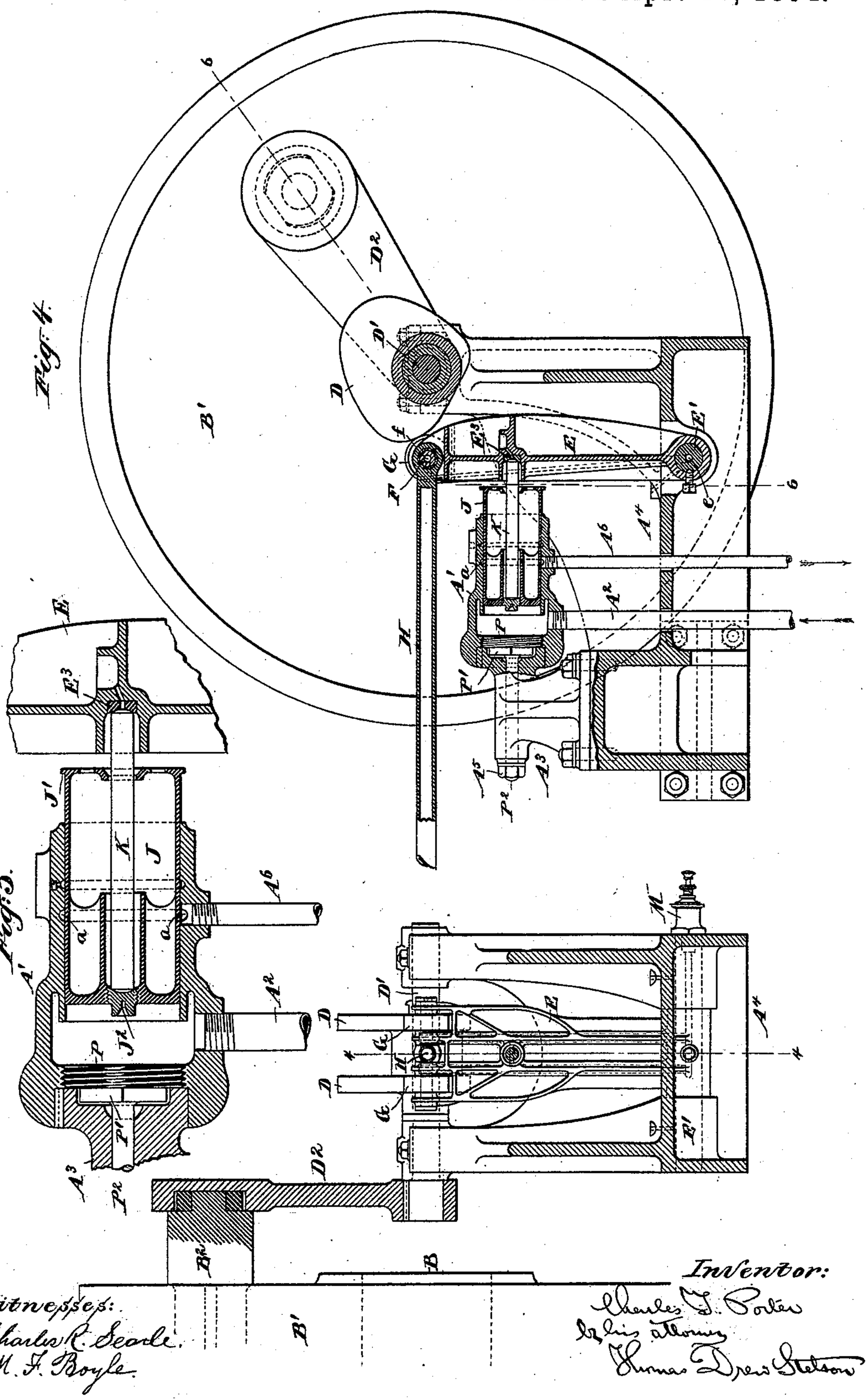

Fig. 5.

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(No Model.) 5 Sheets—Sheet 5.

C. T. PORTER.

STEAM ENGINE.

No. 517,983. Patented Apr. 10, 1894.

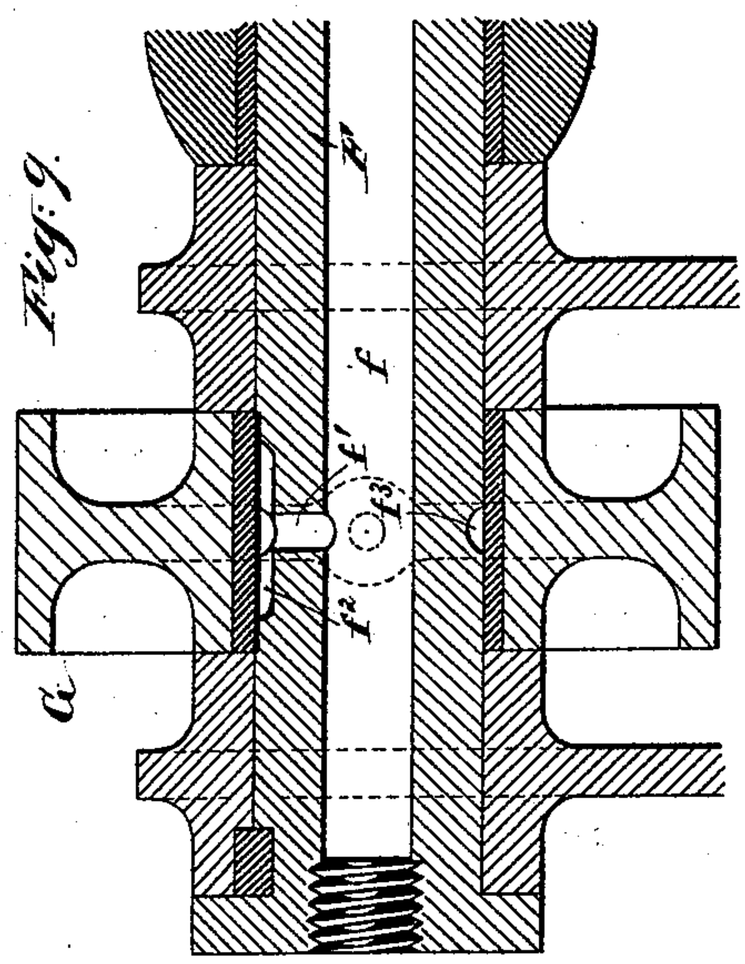

Fig. 9.

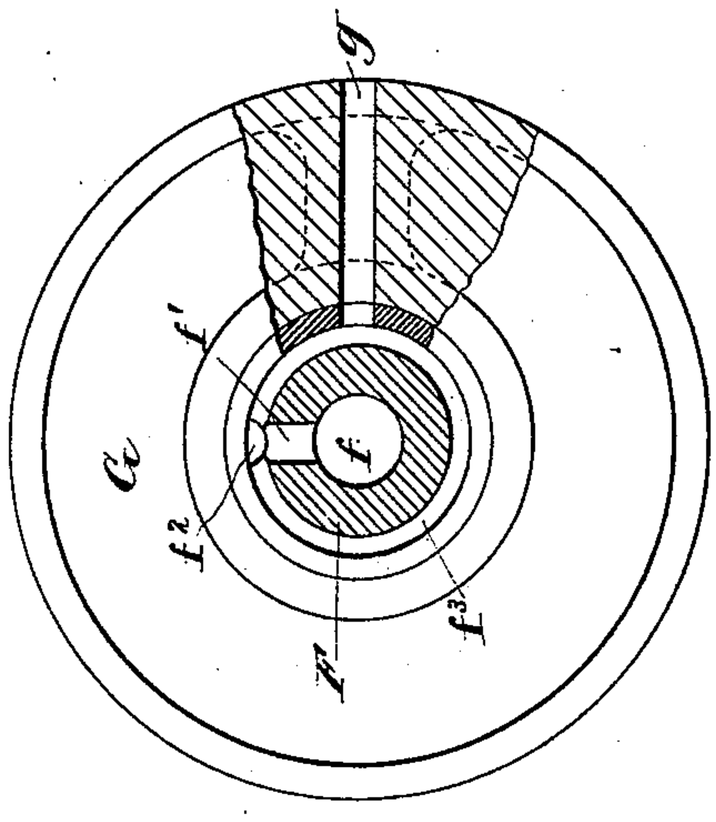

Fig. 10.

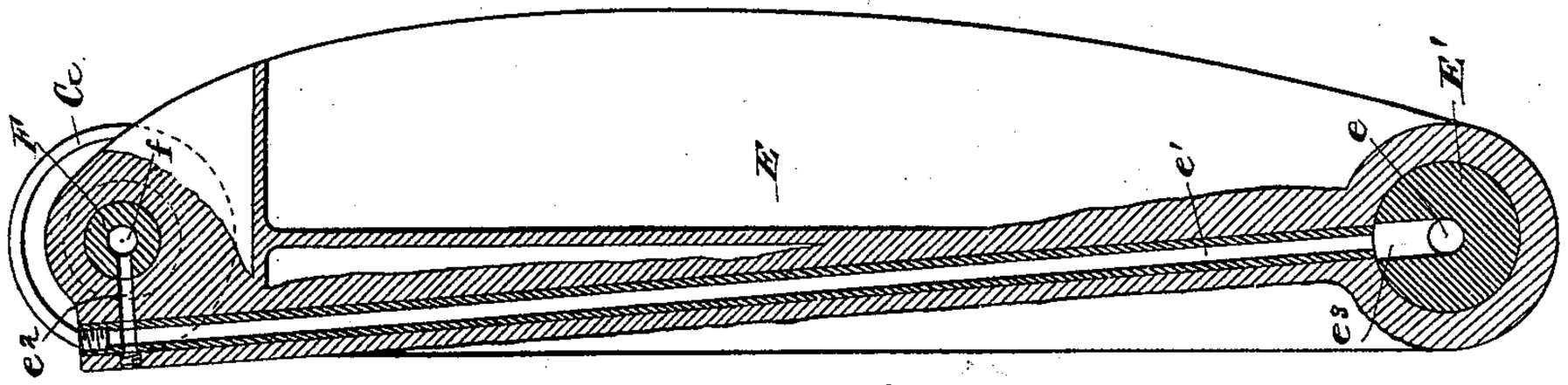

Fig. 8.

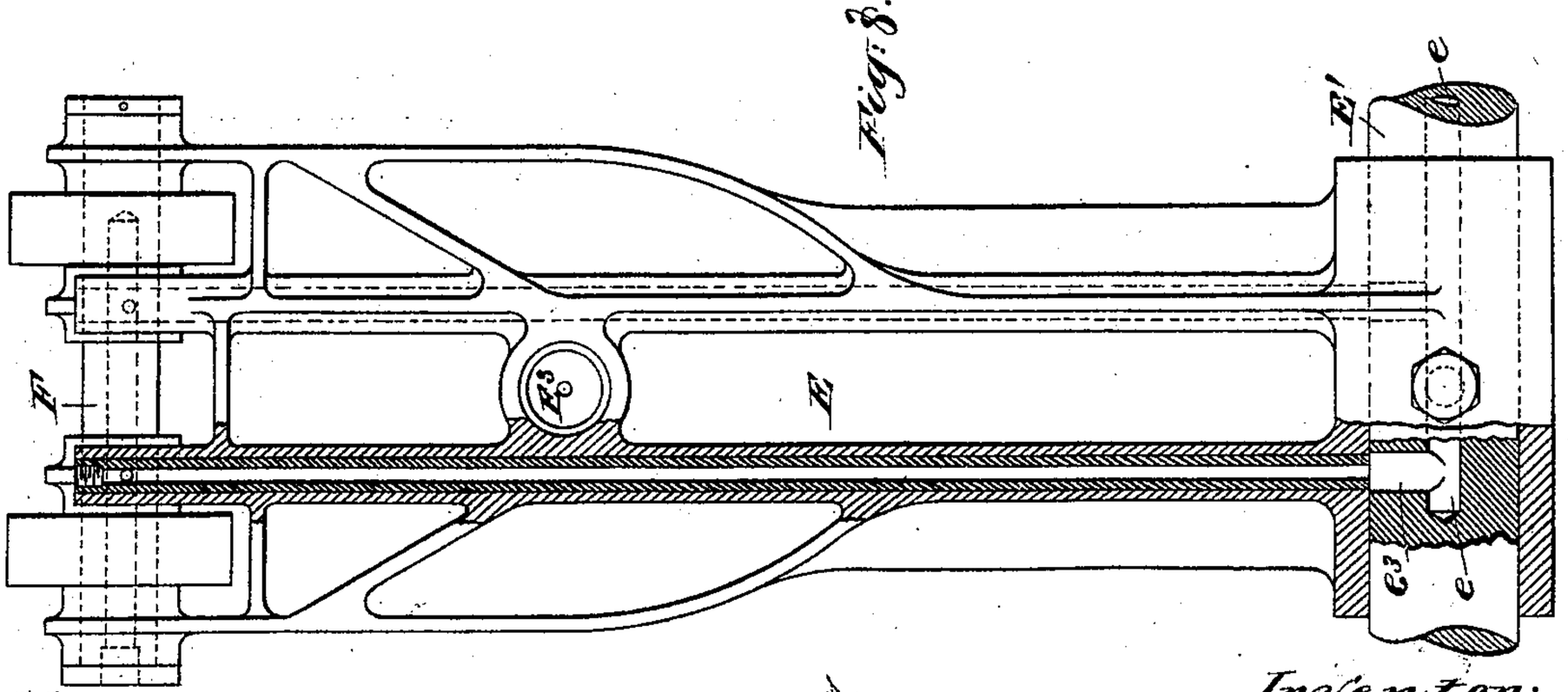

Fig. 7.

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UNITED STATES PATENT OFFICE.

CHARLES T. PORTER, OF MONTCLAIR, NEW JERSEY.

STEAM-ENGINE.

SPECIFICATION forming part of Letters Patent No. 517,983, dated April 10, 1894.

Application filed May 5, 1893. Serial No. 473,113. (No model.)

To all whom it may concern:

Be it known that I, CHARLES T. PORTER, a citizen of the United States, residing at Montclair, in the county of Essex and State of New Jersey, have invented a certain new and useful Improvement in Steam-Engines, of which the following is a specification.

The object of this invention is to give a practical solution to the problem, "How shall a perfect expansion diagram be produced by a steam-engine, running at any desired speed, with a single valve of moderate size, having positive movements, working in equilibrium and so adapted to work without resistance under any desired pressure, making only one opening for admission and one opening for release of the steam, and with a very small percentage of space added to the piston displacement for clearance and port?" In other words, "How, with a simple construction, shall all the well-known causes of waste be avoided, and the equally well-known economic features be realized, in the steam-engine?" The objection presents itself at once, that with an equilibrium valve, which cannot be lifted from its seat, large waste room in clearance and port is a necessity, to prevent breakdown from water in the cylinder. This objection I have removed by a construction of cylinder and arrangement of steam-pipe, which are made the subject of Letters Patent of even date therewith, and by which water in the cylinder, in more than a very trifling amount, is made impossible. The question can therefore be considered, quite freed from this difficulty. It is well understood that this object cannot be attained if an eccentric is employed as the means of actuating the valve. I have succeeded in devising for this purpose a cam, which possesses the following features:

First,—it cuts off the steam at a fixed point in the early part of the stroke. The point which I have selected, as the most economical point of cut-off, is one-fifth of the stroke. Second,—it opens a width of port about two and one-half times greater than is opened by an eccentric of the same throw, and cutting off at the same point, the velocity of the opening and closing movements being increased in about the same ratio. Third,—it delays the release of the steam, if neither exhaust lap or lead be given to the valve, until eleven-twelfths of the stroke, thus permitting the expansion to continue practically to the end of the stroke; and it closes the exhaust at the same point of the return stroke, giving, in the small waste room space, a good compression, while the exhaust is ample to avoid any appreciable back pressure, above that of the atmosphere, or in the condenser. Fourth,—it compensates for the inequalities of piston motion on the opposite strokes produced by the angular vibration of the connecting-rod; giving a difference in lead proportionate to the difference in piston velocity near the opposite centers, and equalizing the points of cut-off and of release. Fifth,—it is so designed that, while accomplishing these four objects, the acceleration or retardation of the valve-motion which it produces or allows, in the opposite directions alternatey, shall, at every point, bear a known relation to the acceleration imparted by gravity to a falling body, and shall be so moderate in amount that at ordinary high speeds contact can easily be maintained between the cam and the actuated parts. Sixth,—it permits the employment of piston valves of moderate size, so as to require, for proper admision and release of the steam, with a piston travel of six hundred feet per minute and ordinary length of stroke, only an addition of about two per cent. to the piston displacement for clearance and port. Seventh,—it exhibits the advantages, in simplicity of construction and operation, in closeness of regulation, and in economy of steam, which, with suitable construction, are attainable by the system of cutting off at an early fixed point in the stroke, and regulating the speed of the engine by throttling the steam, when already dry. As, in order to produce these results, different movements must be imparted to the valve on the opposite strokes, the cam cannot be made of a form capable of working in a yoke; and, indeed, at high speed, such a construction would be inadmissible, on account of the inevitable lost motion and shock on each reversal. I have selected as the basis of my improvements, and as free from all practical objections, the style of cam here shown, working against a roller which I hold in contact by the pressure of steam, or other elastic fluid. In a single-crank engine,

the location of the cam outside the crank, as here shown, possesses controlling advantages. It can be made small and is very accessible, the connection to the valve is direct, the solidity of the engine bed is not impaired by the requirements of this connection, the shaft may be shortened, and, except to supply oil to the outer bearing, the engineer has no occasion to go on the belt and fly-wheel side of the engine for any purpose. As a construction which seems, on several accounts to be preferable, I employ two identical cams, working against two identical rollers, one on either side of the cam-rod, by which motion is communicated to the valve. These are in effect one cam, and will be designated as "the cam" in this specification. I make one pin to serve as a bearing pin for the rollers and a joint pin for the cam-rod. This pin is supported securely in the vibrating end of a lever, which is pivoted at its opposite end, and is of such length relatively to the throw of the cam, that the angular vibration of the rod shall be trifling. This lever, in addition to carrying the rollers and cam-rod, and determining their position, performs two other important functions. It acts as the medium through which the elastic pressure of the steam or other fluid employed is applied to the rollers to hold them in contact with the face of the cam, and through which also the rollers and cam receive their lubrication. I support the cam-shaft in line with the main shaft of the engine, the lever, and the cylinder in which the elastic pressure is exerted, on a single bracket, which is firmly bolted to the main-framing or bed-plate of the engine, by which means the relations between these parts are effectually preserved. At the end of the cam-rod nearest the cylinder I provide a light and simple but secure disengaging hook, which enables the engine to be started from any position except on the dead-centers, and to be run forward or backward by hand, by means of the starting-bar inserted in the end of the lever. I form the valve of two connected pistons and locate one of these at each end of the cylinder, and, except in small engines, I provide two such valves arranged side by side, connected through their stems and moving together as one valve. In compound engines the cam enables me to cut off at one-fifth of the stroke in each cylinder. I can proportion the area of these cylinders as one to five, and so obtain twenty-five expansions of the steam. In tandem compounds I derive the motion of the valves for both cylinders from the same cam, employing a reducing lever between the cylinders for communicating its motion to the valve of the high pressure cylinder.

The accompanying drawings form a part of this specification.

Figure 1 is a diagram on a large scale, showing the outline of the true cam. Fig. 2 is a diagram showing the action of a corresponding eccentric. Fig. 3 is a plan view of a tandem compound engine according to my invention. Fig. 4 is a vertical section on the line 4—4 in Fig. 6. Fig. 5 is a corresponding section showing a portion on a larger scale. Fig. 6 is a section on the line 6—6 in Fig. 4. It will be observed that this line is vertical in the lower part of the figure, and inclined at about forty-five degrees in the upper portion. Fig. 7 is a plan view, and Fig. 8 a corresponding side elevation of certain parts. Fig. 9 is a side elevation partly in vertical section showing on a large scale the hook and provisions for locking it by which the valve motion is engaged and disengaged when required. Fig. 10 is an outline giving a side view of a modification.

Similar letters and numerals of reference indicate corresponding parts in all the figures where they appear.

Referring to the figures and to letters and numerals of reference marked thereon, A is the fixed framing or bed of the engine.

B is the shaft, B′ the crank, and B^2 the crank-pin.

C is the connecting-rod leading from the cross-head, and through which are transmitted the strong alternate thrusting and pulling forces due to the action of the steam on the piston.

D is a double cam carried on a cam-shaft D′ in line with the shaft B, and having the form which enables it to perform all the functions which have been described by imparting movements to the valve in one direction and limiting the movements imparted to it by the constant counteracting force in the opposite direction. It is connected by a lever D^2 to the main crank pin so as to be revolved with the shaft B. The arm D^2 should not be connected with absolute rigidity to the crank-pin. Its junction with the cam shaft D′ should be absolutely firm, and its connection to the crank-pin B^2 should have a little liberty to come and go, to compensate for the possibility of the shafts B and D′ being slightly out of line.

E is a lever actuated by the cam, and transmitting its motion to the valve. It turns on a center at E′. The contact with the cam is effected through the roller G. The motion is communicated to the cam-rod or link H, through the joint-pin F which serves also as the bearing-pin for the rollers G. This link H is formed with a hook *h* which engages with a pin L^2 carried in an idle lever L turning on a fixed center L′.

Q is a rod adapted to move endwise in the link H, and with a handle or knob Q′ on its outer end by which it may be grasped and either lifted or moved endwise, or both, as required.

Q^3 is a spiral spring encircling the pin Q, and exerting a gentle force against a collar Q^2 thereon to urge the pin Q into its locked position, where it will hold the hook *h* engaged with the pin L^2. So long as the parts are allowed to remain thus engaged the mo-

tion of the rollers G is communicated to the valves. When in starting or at any other period it is required to work the valve by hand, the knob Q′ is grasped and the pin Q drawn endwise sufficiently to liberate the pin L′, and then the rod H is lifted so as to disengage the hook *h*. Then a detachable handle L^3 being inserted in a socket in the upper end of the lever L, that lever may be moved at will, to shift the valve rod and the attached valves I′, I^2 into any required positions to turn the engine forward or backward. When it is desired to again engage the parts the knob Q′ is again pulled to draw the pin Q out of the notch *h* and that notch is again engaged with the pin L′, and the pin Q is again allowed to move endwise by the force of the spring Q^3 and lock the notch *h* into engagement.

A′ is a hollow cylinder fixed on the bed A, and in communication through the pipe A^2, with the steam-boiler, not shown. This cylinder is truly bored and receives a deep hollow piston J, having its open end partially covered and flanged, as shown by J′. The center of the bottom of the piston is formed by a removable plug J^2 tapped into place, and having its inner end finished concave.

K is a thrust-connection or toggle, serving as a connecting-rod for this piston, one rounded end bearing against the plug J^2 and the other end, also rounded, bearing in a correspondingly finished concave box E^3 held in a pocket in the lever E. In the use of this mechanism, steam from the boiler exerts its pressure against the piston J, and through the toggle K on the lever E. The yielding force due to this pressure urges the lever E forward so that the roller G is kept in contact with the surface of the cam D, in all parts of its revolution. Any leakage of steam or water past the piston J is received in the circular groove *a* and escapes into the atmosphere by the pipe A^6. The piston J should be of such size that the pressure of the steam against it will act on the lever E with sufficient force to keep the bearing roller G always in contact with the surface of the cam.

The cam is the chief feature of this invention. It will be seen that the design of the cam is a comprehensive one. I have discovered that it is practicable by this means to avoid the defects which are inherent in the eccentric when employed as the means for working steam expansively, and which become more serious the further the expansion is carried, and at the same time to avoid excessive acceleration or retardation of the actuated parts at any point of its revolution; thus adapting the cam for use on high speed engines.

Fig. 1 presents an outline of one of my cams. A circle, D*, of a diameter equal to the throw of this cam is described about its center. This circle may be taken to represent on a small scale the path of the crank of the engine, when the diameter of the circle will represent the stroke of the piston. It should be mentioned that in any cam working against a roller the real periphery of the cam is an ideal line passing through the axis of the roller, and the material cam must be of such form that, however the angle of its impingement against the roller may vary, the real periphery will always intersect this axis. This periphery is, of course, always meant in this description. In Fig. 1 this periphery is shown intersecting the axis of the roller G. The cam is shown in the position it occupies when the piston is at the end of the cylinder farthest from the crank or when the engine is on the back center. The engine is supposed to be rotating in the direction indicated by the arrow. The events numbered from 1 to 10 occur as the points of the periphery so numbered come successively to coincide with the axis of the roller G. The four principal events are numbered also on the interior circle D*. The points of cut-off and release and compression on each stroke are here shown, both in the path of the crank and in the stroke of the piston. The cam equalizes each of these latter on the opposite strokes, compensating for the inequality produced by the angular vibration of a connecting rod six cranks in length.

W and X represent the widths of the openings made for the admission of the steam.

Fig. 2 represents the movements of an eccentric of the same throw and advanced so as to cut off the steam at the same point as my cam. The engine is in each case supposed to be rotating in the direction indicated by the arrow. The inner circle is the path of the center of the eccentric. The outer circle may be taken to represent the path of the crank, when its diameter will represent the stroke of the piston. The eccentric has been advanced so that when the crank is on the center line at N the center of the eccentric is at the point of opening 11. When the eccentric has arrived at the point of cut-off 12, the crank is at N′, and the piston is at O′. When the eccentric has arrived at the point of release and compression 13, the crank is at N^2, and the piston is at O^2. When at the commencement of the return stroke, the crank is on the center line at N^3 and the piston at the corresponding end O^3 of its stroke, the eccentric is at the point of opening 14. When the eccentric has arrived at the point of cut-off 15, the crank is at N^4, and the piston is at O^4. Finally, when the eccentric has reached the point of release and compression 16, the crank is at N^5 and the piston is at O^5. In this diagram W′ and X′ show the width of the openings made by the eccentric for the admission of the steam. This figure shows what renders the eccentric objectionable, when employed to effect an early cut-off. The obvious defects are, first, a too narrow opening for admission; second, early release and compression, and third, inequality of cut-off and of release and compression on the opposite strokes. Com-

parison of the two diagrams will show the complete manner in which these are remedied by my cam.

Attention needs to be called to another defect which is not obvious on inspection but which is serious. The velocity of the piston, with a connecting rod six cranks in length, is forty per cent. greater at the end of its stroke farthest from the crank than it is at the end of its stroke nearest the crank. This difference in piston velocity calls for a very considerable difference in the lead given to the valve on the opposite strokes. With the eccentric the greater lead required at the back end can be given only by adding less lap to that end of the valve. This, however, causes it to close later, and so increases the already greater length of the admission. This defect also is seen to be remedied by my cam.

The cylinder A′ is secured to the block A^3, which is, in turn, stiffly supported upon the same bracket A^4 which carries the bearings for the cam shaft D′ and for the center E′. This bracket is stiffly bolted to the bed of the engine and the block A^3 is bolted upon the bracket.

To effect the detachable union of the cylinder A′ with the block A^3, I form a female screw thread in the cylinder and fit therein a plug P having a corresponding male thread, and a large square head P′ by which it can be strongly inserted. The extension P^2 from this plug, of much smaller diameter, is extended through a hole bored in the block A^3 and secured by a nut A^5.

I attach importance to the provisions for supporting the cam-shaft D′, lever E, cylinder A′ and their several attachments on the single bracket A^4 which can be removed and replaced at will. The considerable strain exerted on the piston J urging the rollers G into contact with the cam, is received and supported by the deep web of this bracket. Its removable character allows the work thereon to be executed by ordinary tools entirely disconnected from the heavy bed-plate. The connection of this bracket to the bed-plate, and again the connection of the block, A^3 to this bracket, are maintained stiffly in position by keys or tongues fitted in grooves.

Modifications may be made without departing from the principle or sacrificing the advantages of the invention.

Parts of the invention can be used without the whole.

I can substitute a half-round rolling or swiveling pin in place of the roller G, when the real cam will be employed bearing against the flat surface of said pin, to give the required motions.

I consider compressed air or other fluid as the equivalent of steam, and any chamber containing vapor or gas under tension of sufficient capacity to maintain a practically uniform pressure in all positions of the piston, an equivalent of the boiler. It is important that the fluid be light and elastic, and of sufficient pressure.

In engines with an overhanging pulley at each end of the shaft, the cam will be placed on a short extension of the shaft at one end, of reduced diameter, but requiring no supporting bearings, and the connection to the valve will be through levers on a rock-shaft behind the pulley. I have indicated one-fifth as the preferable point of cut-off, and the cam shown is adapted to attain that degree, and I have shown five to one as the relative volumes of the two cylinders, but these points may be varied within wide limits.

I am aware that steam-pressure has heretofore been employed to hold the valve connections in contact with a cam, such pressure being exerted in the valve-chamber itself, and transmitted through the valve connections. My construction differs in that I employ a separate cylinder, in which either steam or compressed air or any other elastic fluid may be used, and locate this cylinder close to the cam, and provide a special connection between them. By this arrangement the great pressure required, often amounting to several thousand pounds, is transmitted through a rigid connection, and the valve connections are free from such pressure and strain.

I claim as my invention—

1. As a means of applying the pressure of steam or other elastic fluid to maintain contact between the cam and the valve connections, the cylinder A′, piston J, and thrust-rod K, in combination with the lever E, all arranged for joint operation substantially as herein specified.

2. In the valve motion of a steam-engine, the connecting link H, reciprocated as shown, having a hook *h*, and the axial rod Q and means as the knob Q′ for both moving it axially and raising and lowering it, and the spring Q^3 urging it into the locked position, in combination with each other and with the pin L^2 and the valve rod I, all arranged for joint operation substantially as herein specified.

3. In a steam-engine having the valves actuated by a cam, the detachable bracket A^4 supporting the cam-shaft D′, lever E and cylinder A′, with a web extending between the cam-shaft and the cylinder support, adapted to serve as herein specified.

In testimony that I claim the invention above set forth I affix my signature in presence of two witnesses.

CHAS. T. PORTER.

Witnesses:
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M. F. BOYLE.