(No Model.) 5 Sheets—Sheet 1.

C. W. BARNABY.

STEAM ENGINE INDICATOR.

No. 343,291. Patented June 8, 1886.

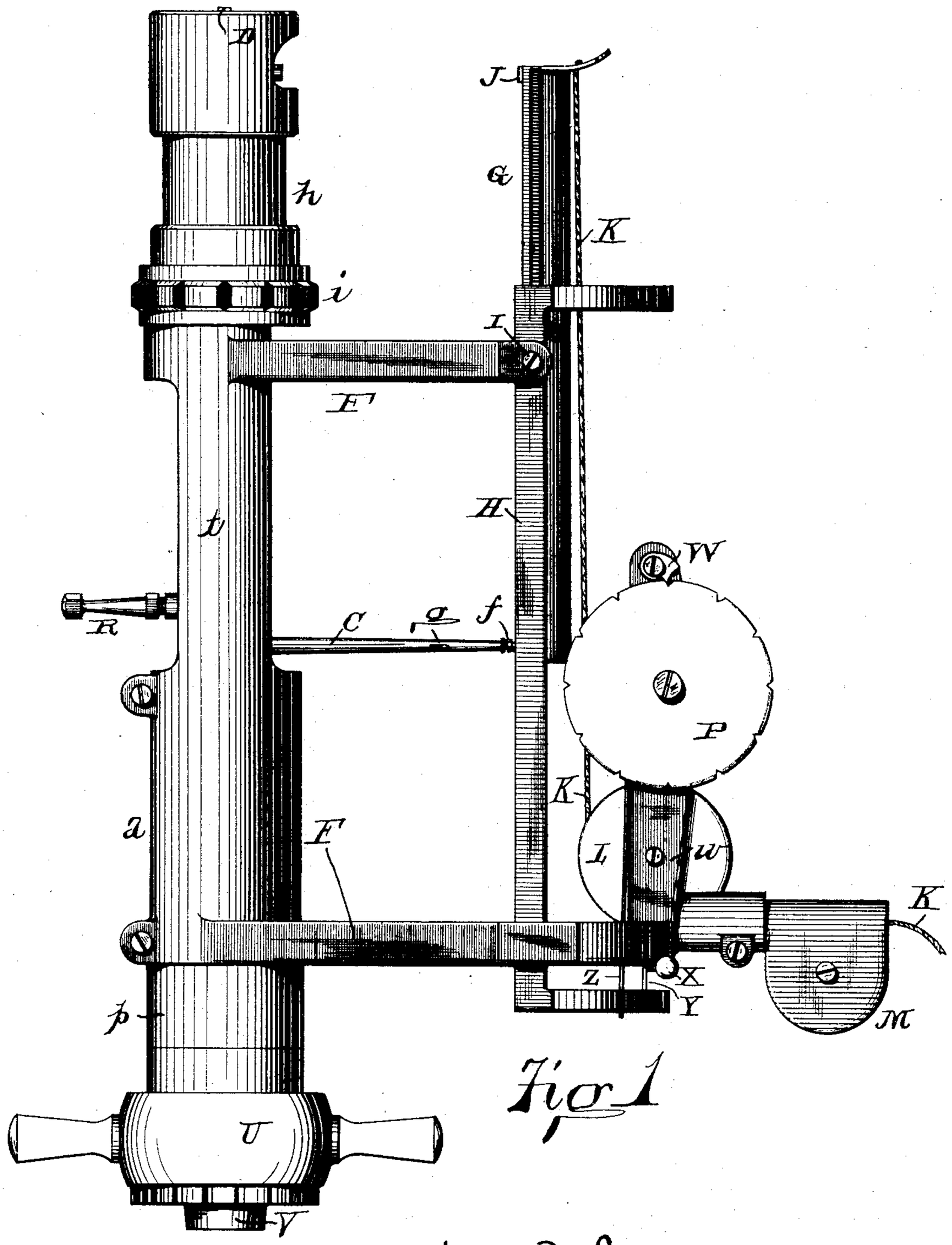

Fig 1

WITNESSES:
W. A. Seward
John R. Coode

Charles W. Barnaby INVENTOR
by James W. See
ATTORNEY

(No Model.) 5 Sheets—Sheet 2.

C. W. BARNABY.

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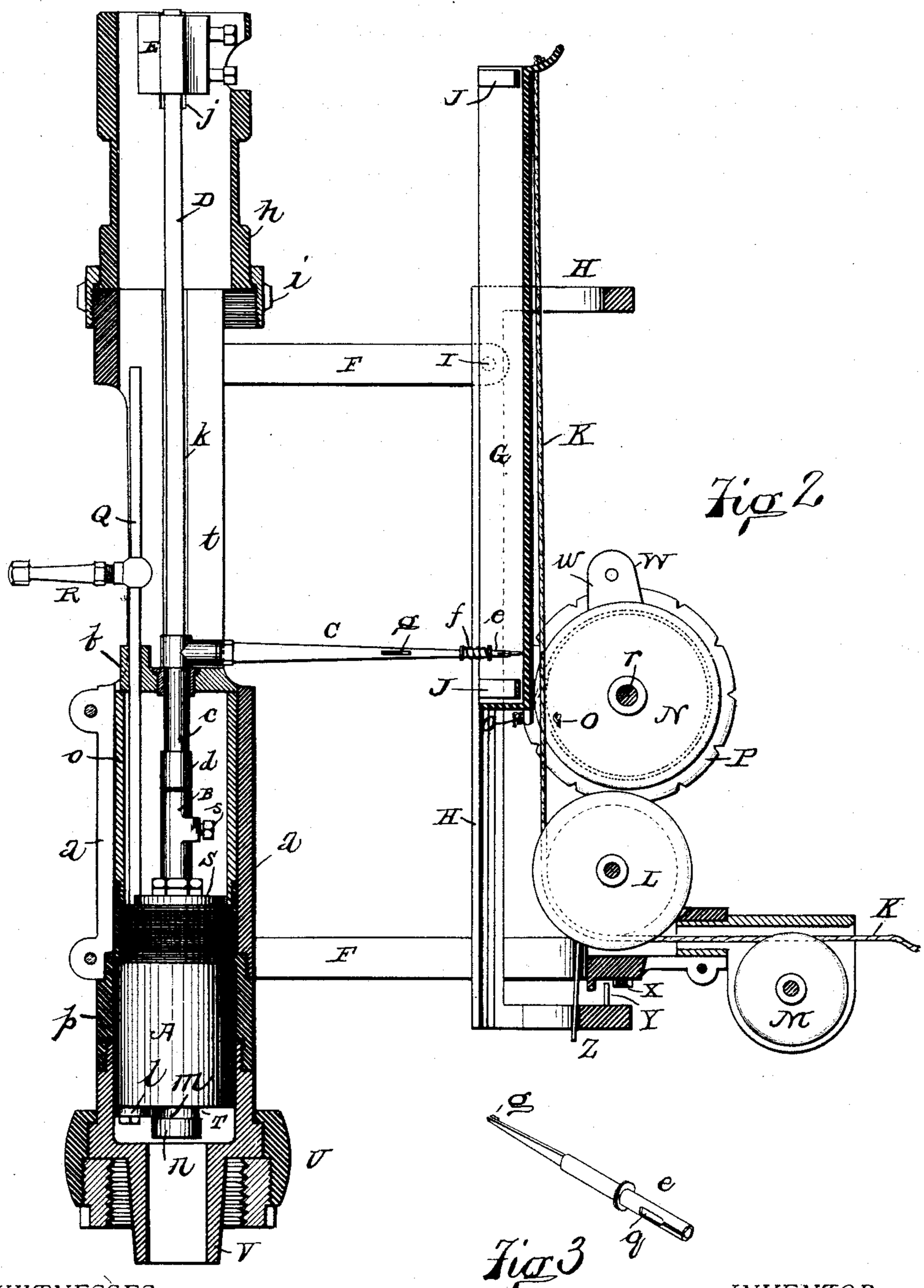

Fig 2.

Fig 3

WITNESSES:
W. D. Seward
John R. Woods

INVENTOR
Charles W. Barnaby
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(No Model.) 5 Sheets—Sheet 3.

C. W. BARNABY.

STEAM ENGINE INDICATOR.

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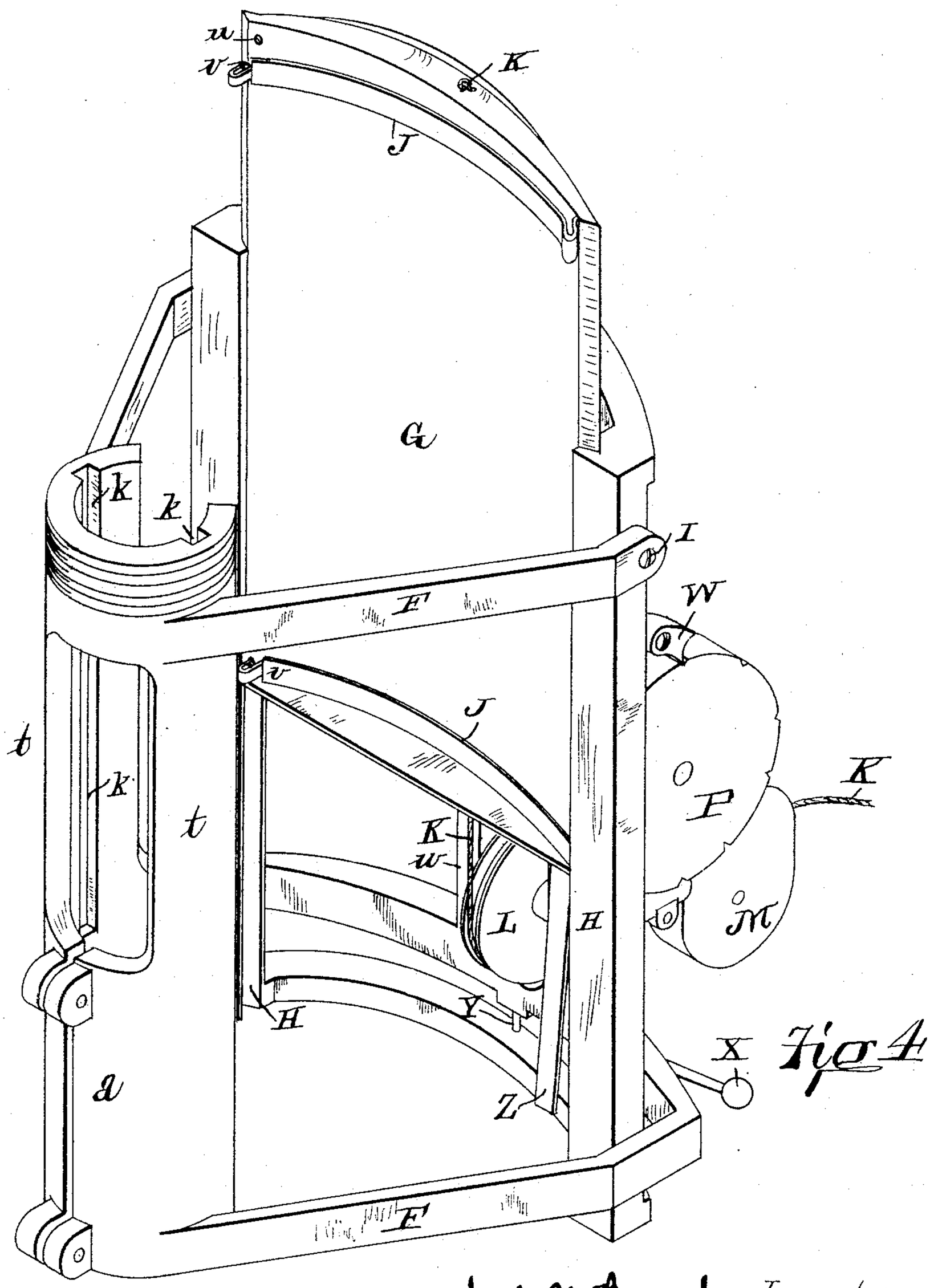

Fig 4

Witnesses.
W. Edward
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(No Model.) 5 Sheets—Sheet 4.

C. W. BARNABY.

STEAM ENGINE INDICATOR.

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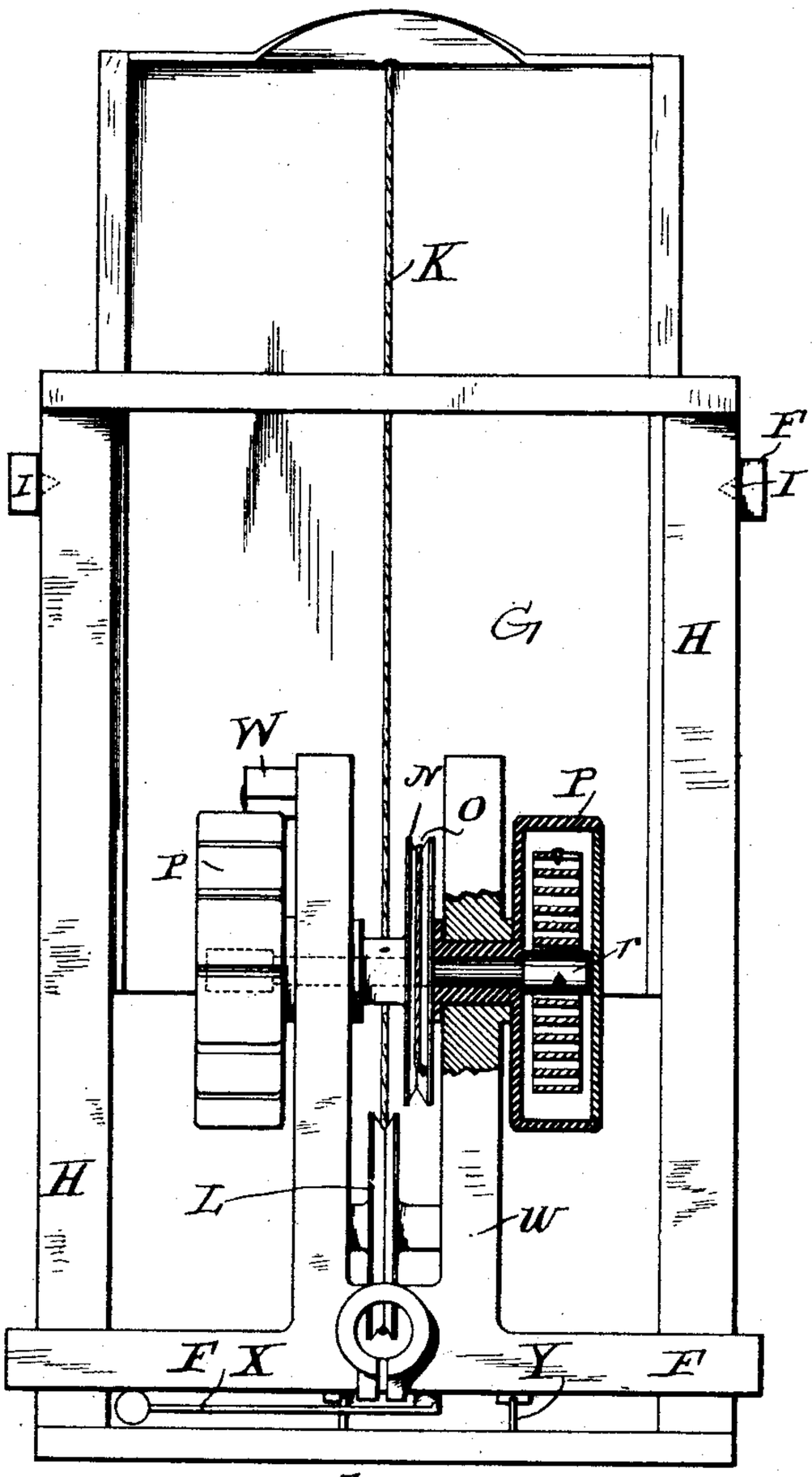

Fig 5

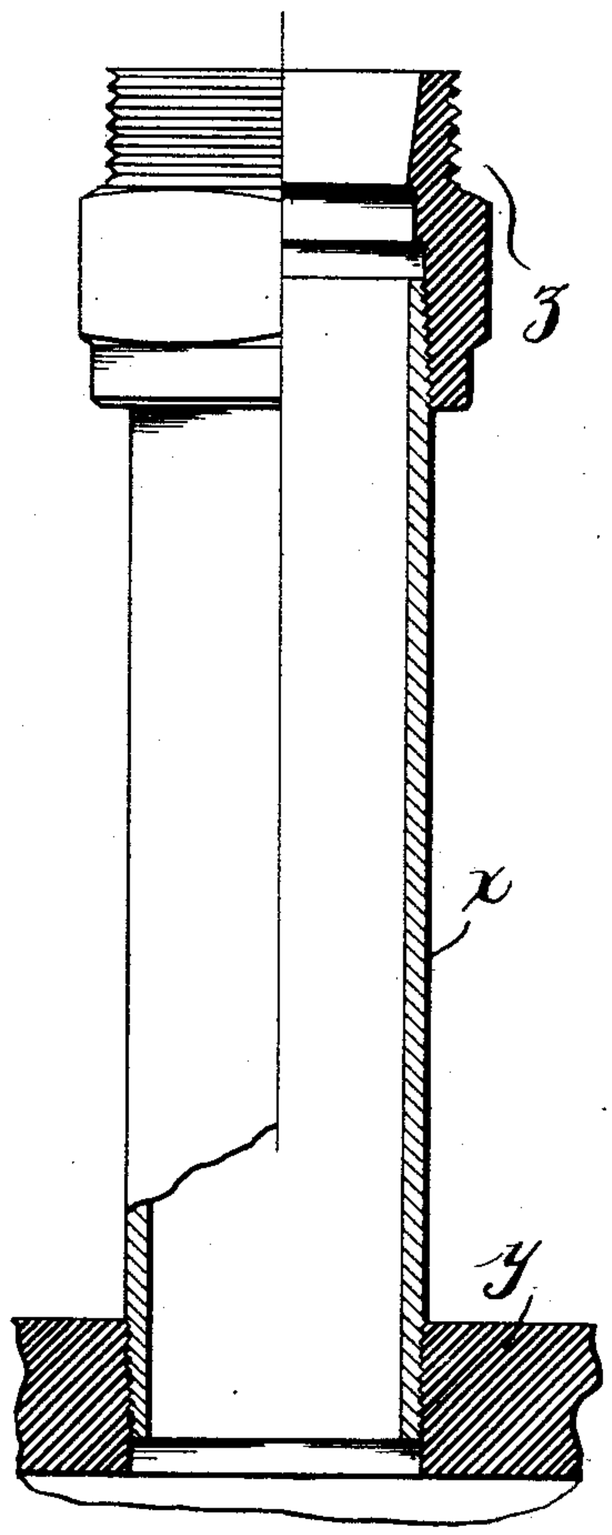

Fig 6

Witnesses:
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(No Model.)

5 Sheets—Sheet 5.

C. W. BARNABY.

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No. 343,291. Patented June 8, 1886.

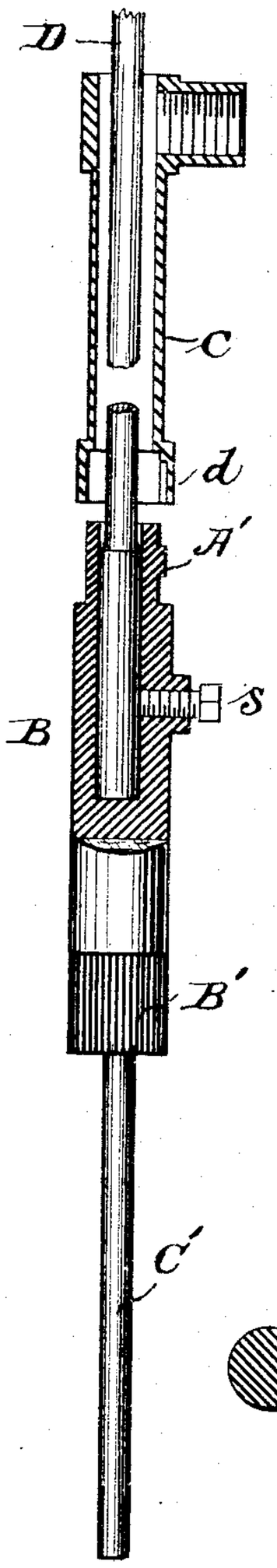

Fig 7

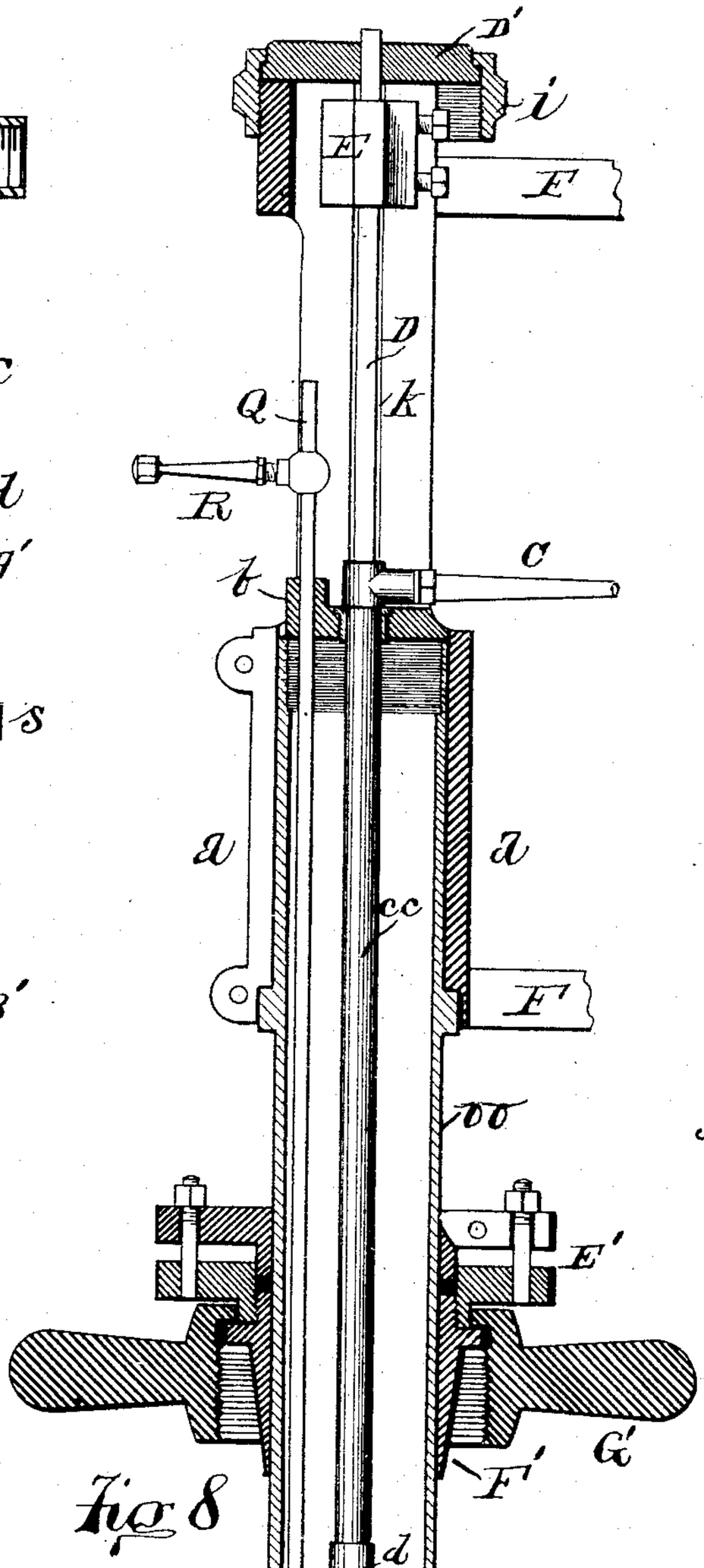

Fig 8

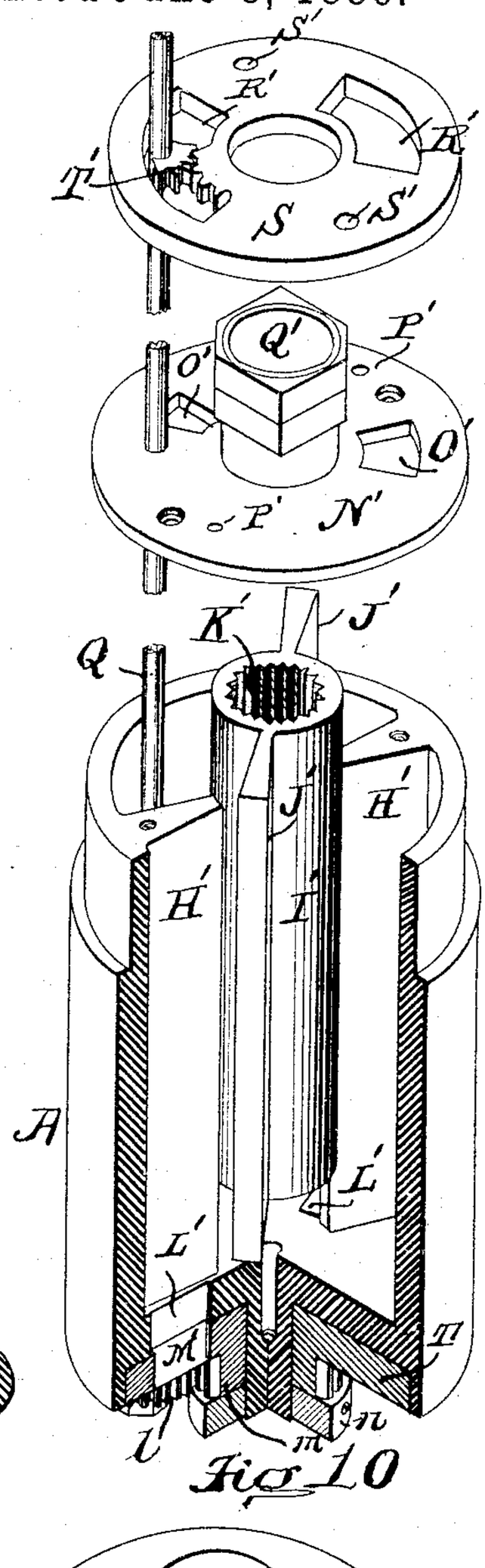

Fig 10

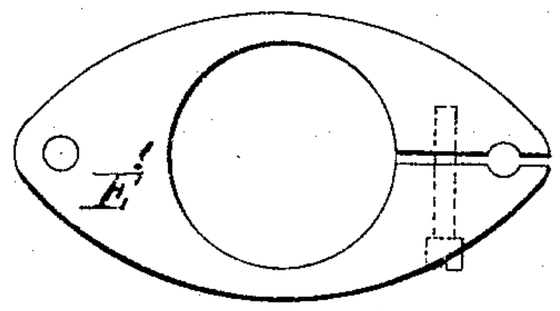

Fig 9

Witnesses:
Wadsworth
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Charles W. Barnaby Inventor.
by James W. See
Attorney.

UNITED STATES PATENT OFFICE.

CHARLES W. BARNABY, OF SALEM, OHIO, ASSIGNOR OF ONE-HALF TO THE BUCKEYE ENGINE COMPANY, OF SAME PLACE.

STEAM-ENGINE INDICATOR.

SPECIFICATION forming part of Letters Patent No. 343,291, dated June 8, 1886.

Application filed October 29, 1883. Serial No. 110,260. (No model.)

To all whom it may concern:

Be it known that I, CHARLES W. BARNABY, of Salem, Columbiana county, Ohio, have invented certain new and useful Improvements in Steam-Engine Indicators, of which the following is a specification.

This invention pertains to steam engine indicators, and the improvements are particularly adapted for indicators of that class employing an oscillating motor.

In the accompanying drawings, Figure 1 is a side elevation of an indicator embodying my improvements, the indicator being shown in its short connected form, (a term which will be hereinafter explained.) Fig 2 is a vertical section of the same in a plane coinciding with the axis of the body of the indicator; Fig. 3, a perspective view, much enlarged, of the pencil-holder; Fig. 4, a perspective view of the frame of the instrument which supports the paper-carrying mechanism; Fig. 5, a rear elevation of the frame-work and paper-carrying mechanism; Fig. 6, an elevation and part section of the receiver for the instrument when it is applied in long connected form; Fig. 7, a vertical section of the piston-axle, pencil-tube, and torsion-spring, shown much enlarged; Fig. 8, a vertical section of the indicator in long connected form; Fig. 9, a plan of the slip-gland; and Fig. 10 a dissected perspective, partly in section, of the motor.

In ordinary indicators a stop-cock is screwed into the engine-cylinder, and upon this stop-cock sets the indicator. Often considerable piping is interposed between the stop-cock and the cylinder. In all cases the length of the steam-conductor between the engine-cylinder and the indicator-cylinder is detrimental to accurate results by reason of its condensing and wire-drawing tendency. My improved indicator is adapted in like manner to be attached at a distance from the engine-cylinder, and the instrument arranged for this use I speak of in this specification as being in the short connected form. My indicator is convertible into what I call a "long connected" form, in which the cylinder of the indicator forms the extremity of the instrument, and is adapted to be inserted within a receiving-pipe attached to the cylinder of the engine to be indicated and pushed downward, in some cases even into the interior of the engine-cylinder.

In connection with the accompanying drawings, I will first describe my instrument in its short connected form, that is adapted for use outside of engine-cylinders, in the usual manner.

In the drawings, A represents the cylinder containing an oscillating piston or one which, under the action of the admitted steam, partakes of a partial revolution; B, the piston-axle or piston-rod; C, the oscillating pencil-lever, attached to the piston-rod so as to be oscillated by the movement of the piston; D, a torsion-spring having its lower end fixed to the piston and its upper end firmly secured to the body of the instrument; E, a block provided with set-screws for securing to the upper end of the torsion-spring, and having wings seated in longitudinal grooves in the body of the instrument, whereby the block is prevented from turning when urged by the torsion of the spring; F, two pairs of divergent arms projecting outward from the body of the instrument to support the paper-carrying device; G, a concave paper-holding tablet adapted to slide vertically and fitted to hold paper in a position to be swept by the end of the pencil-lever; H, the frame in which the paper tablet slides; I, pivot-screws in the framing of the instrument, on which is supported the tablet-frame H in such manner as to be capable of a slight oscillation at its lower end; J, paper-retaining clips attached to the paper tablet; K, the actuating-cord by which motion is transmitted to the paper tablet from the cross-head of the engine being indicated; L, an idle-sheave under which turns the cord K; M, a swiveling guide-pulley for holding the cord in proper relation to the sheave L; N, a sheave mounted in the rear of the paper tablet; O, a cord having one end attached to the paper tablet, and having its other end secured in the groove of the sheave N; P, a pair of spring-drums arranged to act upon the sheave N, as hereinafter set forth, and cause said sheave to tend to revolve in such direction as to wind upon itself the cord O, and thus draw the paper tablet backward to its upper limit of travel; Q, a valve-rod controlling the admission of steam to the cylinder

[redacted]

of the indicator, as hereinafter more fully explained; R, a handle by which the valve-rod is rotated so as to affect the cylinder-valves; S, a disk at the top of the cylinder, arranged to open and close orifices leading from the steam-spaces of the cylinder to the atmosphere, which has free access above the top of the cylinder; T, a disk-valve at the lower end of the cylinder, arranged to open and close orifices leading to the steam-spaces of the cylinder; U, the usual form of indicator coupling-nut for securing the instrument to an indicator cock or nipple; V, the usual tapering nose forming part of the coupling; W, pawls mounted near the rim of the spring-drums and adapted to engage in notches in the periphery of the spring-drums; X, a finger-lever pivoted to the frame F to the rear of the paper tablet; Y, a pin upon the foot portion of the tablet-frame H, arranged to be engaged by the lever X, whereby, when the lever is pushed toward the body of the instrument, the lower end of the tablet-frame H will be moved toward the body of the instrument, and Z a spring secured to the framing F and engaging with the tablet-frame in such manner as to press the bottom of the tablet-frame away from the body of the instrument.

By means of the above preliminary references a somewhat general description of the instrument and its operation in the short connected form may be given. The instrument is coupled to the cylinder of an engine in the usual manner by means of the common coupling shown. By means of the handle R and rod Q the disk-valves at the top and bottom of the cylinder are so turned as to admit steam freely from the cylinder of the engine being indicated to the steam-spaces of the cylinder of the indicator, and at the same time to close the orifices at the upper end of these steam-spaces. The piston is provided with radial wings, and the tendency of the steam-pressure within the indicator-cylinder is to oscillate the piston, and hence to oscillate in one direction the pencil-lever. The tendency of the torsion-spring D is to resist the oscillating motion of the piston. The resisting power of the spring D is predetermined or ascertained in a manner analogous to the treatment of other springs as used in indicators. The cord K is connected up with some reciprocating part of the engine in such a manner as to give to the paper tablet a motion, on a reduced scale, corresponding with the piston-motion of the engine, the upward motion of the paper tablet being produced, of course, by the retractile action of the spring-drums. The length of the oscillations of the pencil-lever will correspond in degree with the pressure of steam acting within the cylinder, the pencil-lever being oscillated in one direction by the steam-pressure against the resistance of the torsion-spring, and oscillated in the other direction by the action of the torsion-spring against the decreasing pressure of the steam. While the paper tablet is reciprocating past the oscillating pencil-lever, the pencil in the end of the pencil-lever is not in contact with the paper upon the tablet; but upon pressing the finger-lever X the tablet is swung inward until the paper tablet, or the paper, rather, occupies a position corresponding to the segment of the cylinder whose axis corresponds with that of the indicator-cylinder. The moving pencil will thus trace its lines upon the moving paper. In drawing the atmospheric line the cylinder-valves are so set, by means of the handle R, as to admit the atmosphere to both sides of the wings of the piston, which permits the pencil-lever to take a position corresponding to the zero of the torsion-spring.

Having thus described in a general way the mode of operation of the instrument, I will, before proceeding with a more detailed description of the parts, give a general description of the instrument in its long connected form. Instead of the usual indicator cock or nipple, with its small hole, there is screwed into the cylinder a piece of one-inch gas-pipe, or a similar tube. as represented in Fig. 6, in which *x* is the tube, *y* a portion of the engine-cylinder into which it is screwed, and *z* a portion of a coupling secured to its upper end. We thus have a free large opening into the interior of the engine-cylinder, the length of the tube being governed entirely by circumstances.

Referring to Fig. 8, A is again the cylinder of the indicator, but instead of being provided with a coupling-nut, heretofore referred to, it is secured to the end of a long tube, *o o*, whose upper end is secured to the body of the instrument. The piston-rod B remains the same, but a long tube, *c c*, connects this piston-rod with the pencil-lever, which is now far above the indicator-cylinder, and the spring D lowered with the cylinder has its upper end secured as before, but lower down, of course, whereby the function of the upper portion of the instrument remains substantially the same as in the short connected form.

G′ is a coupling-nut adapted to engage with the coupling-piece upon the tube which is secured in the engine cylinder, and this coupling-nut is provided with a tapering tail-piece, F′, to form a steam-tight coupling, the same as used before, except that the parts are very much enlarged, so as to permit the passage through them of the indicator-cylinder, with its attaching-tube *o o*. That part of this coupling which is attached to the indicator is not fixed upon this tube, but is arranged to be secured at any point in its length by means of a clamp-gland, as shown in plan in Fig. 9. By means of this arrangement the indicator may be coupled to the large pipe screwed into the engine-cylinder, and the cylinder may be pushed downward through the combined coupling and gland until the indicator-cylinder is as close to the bore of the engine-cylinder as circumstances will permit, and, under all circumstances, so close as to receive the full effect of the steam in the engine-cylinder. In case of an engine having excessive clearance the cylinder may even be intruded within the

engine-cylinder. The instrument is then used as before.

A more detailed description will now be made of the parts, taking in order, first, the parts pertaining to the paper-motion. The frame-arms F reach out from the body of the instrument and support all the parts pertaining to the paper motion, the upper pair of arms carrying the pivots on which rock the tablet-frame, as heretofore described. The lower arms are prolonged behind the tablet-frame to support the lever X, the guide-pulley M, and two uprights, *w*, which support the sheave L and the spring-drum mechanism. It should be mentioned that while the spring Z presses the tablet-frame away from the body of the instrument, and the lever X is adapted to press the tablet-frame toward the body of the instrument, a suitable stop engaging the pin Y prevents the tablet-frame being pressed too far by the lever.

In Fig. 5 is shown clearly the spring-drum arrangement. The sheave N is fastened to its axle. The spring-drums P are loose upon this axle, and contain the usual volute spring, one end of which is secured to the rim of the spring-drum, the other to the axle. The spring-drums, being revolved by hand, wind up the springs and bring a rotary strain upon the sheave N, as before mentioned, and the pawls W, of which there is one for each drum, retain the spring-drums after being wound up. The spring arrangement being in duplicate permits the use and disposition of two small and convenient sized springs, which I consider preferable to a single one of sufficient retractile power. The two comparatively weak springs permit of being wound up by hand, one at a time, while a single large spring of sufficient power cannot well be wound by hand. Owing to the strains not being concentrated upon one spring there is less liability of the breakage of springs, a matter of serious importance in indicators used in connection with very high-speed engines. On the concave face of the paper tablet the paper-retaining clips J are secured, being fixed by one end to one edge of the paper tablet and arranged to latch at the other end to the other edge of the paper tablet, as shown in Fig. 4. The latch consists of a barbed latch, *v*, on the end of the spring, engaging with a hole, *u*, in the edge of the tablet. The clip-springs J being flexible, conform neatly to the circle of the paper tablet, and thus hold the paper neatly. The barbed latch *v* is sharp pointed and somewhat flexible. The paper being pressed against the tablet, the latches are pressed home, puncturing the paper, if desired, and springing into engagement with the holes in the paper tablet. The paper tablet slides freely in V-engagements in the tablet-frame, as clearly shown.

The body of the frame, carrying the frame-arms F, consists of a tubular portion having a split-clamp arrangement at *a* to engage the indicator-cylinder or its attaching-tube. Its top is provided with a coupling-nut, *i*, to secure the spring-holding device hereinafter described. Between this coupling portion and the clamp portion *a* the body portion is cut away, leaving two side ribs, *t*, giving to the body an open skeleton form at about its center of length. Longitudinal grooves *k* are cut within the body from its top to about the top of the clamp portion.

In the short connected form of instrument, as shown in Figs. 1 and 2, an extension-tube, *h*, is coupled above the body of the instrument, this tube being of a very much greater length than indicated in the drawings, which has been necessarily contracted. In the upper end of this tube is fitted the block E, previously referred to, the block being capable of slight vertical motion, but prevented from any rotary motion by means of wings upon the block engaging in grooves *j*, cut in the sides of the tube. The block E is secured to the upper end of the spring before mentioned.

In the short connected instrument the torsion-spring D, which may be a simple round spring-wire, reaches from the indicator-piston rod to the block at the extreme upper end of the extension-tube *h*. In the long connected form of instrument, as shown in Fig. 8, the proper length of spring is secured without the use of the extension-tube. In this case the tube is removed and the block E takes its place in the top of the body-piece, a blank cap, D′, being used in connection with the coupling-nut *i* to form a respectable finish to the top of the body in the absence of the tube.

In Fig. 2, it is seen that a short tube, *o*, secured to the indicator-cylinder and reaching up into the body of the frame, and there clamped, serves as a means for securing the cylinder to the body of the instrument in its short connected form. In its long connected form the instrument employs a long tube *o o*, shown in Fig. 8.

In Fig. 8 the cylinder is seen to be screwed directly into the end of the connecting-tube, but in Fig. 2 the thread upon the upper end of the cylinder is utilized also for receiving indirectly the fixed part *p* of the coupling. In the long connected form there being no fixed coupling, this piece is omitted.

In Fig. 10 is shown the entire cylinder arrangement, A representing the shell of the cylinder; H′, abutment-wings projecting inward from the shell of the cylinder; I′, the cylindrical piston-core fitted to rotate in the center of the cylinder between these wings; J′, the piston-wings fitted to sweep steam-tight in the compartments of the cylinder; K′, a fluted socket in the piston-core; L′, ports through the floor of the cylinder from the two cylinder-compartments; T, the lower disk-valve fitted to rotate upon the stud projecting below the cylinder and against the bottom of the cylinder, and to open or close the ports L′ by means of suitable register-ports, M′; *m*, a pinion formed on the hub of the disk-valve T; *n*, a collar on the stud to retain the valve T in place; Q, the valve-operating rod, pre-

viously referred to, passing vertically entirely through the cylinder; *l*, a pinion on the lower end of this rod, engaging the pinion *m;* N′, the upper cylinder-head secured to the top of the cylinder by screws; O′, ports through this head, communicating with the cylinder-chambers at the rear of the piston-wings—that is, on that side of the piston-wings opposite to which the steam entering the bottom ports acts; P′, apertures through the cylinder-head communicating with that portion of the cylinder-chambers in which steam enters through the bottom ports; S, the top valve, arranged to rotate over the cylinder-head and open or close the apertures P′ without affecting the ports O′; T′, a rack-and-pinion arrangement by which the valve-rod Q rotates the top valve simultaneously with the bottom valve; S′, apertures through the top valve, which, when set to correspond with the apertures P′ in the cylinder-head, form the valve-opening; Q′, the bearing in the top cylinder-head for the piston-rod.

In Fig. 7 is seen the piston-rod B. Its stem C′ enters the core of the piston, and a fluted portion, B′, engages the fluted bore of the piston in such a manner as to permit of a slight shifting of the piston-rod in the piston endwise, but of no shifting rotatorily. In the top of the piston-rod is the socket for the foot of the torsion-spring, which is secured against rotary shifting by the set-screw *s*.

c is the tube for connecting the piston-rod with the pencil-lever, the pencil-lever being screwed transversely into its upper end, and its lower end being fitted to socket and feather upon the upper end of the piston-rod, as shown at A′ *d*.

In the body of the instrument at the top of the clamp portion *a* is provided the bearing-head *b*, which closes up the bore of the body at that point at the front of the body where the pencil-lever projects, the object being to prevent any steam blown upward through the body from the cylinder being blown outward upon the paper tablet. The steam is free to blow out around this head backward. This head furnishes a top bearing for the valve-operating rod Q and for the pencil-tube *c*. By removing handle R and loosening body-clamp *a* the lower portions of the instrument may be withdrawn from the body, the pencil-tube separating from the piston-rod at its clutch A′ *d*, and the spring coming with the piston-rod, it having been previously relieved from the block E.

In regard to the cylinder arrangement it should be understood that with the valves in one extreme position steam enters at the lower ports and acts upon one side of the piston-wings. The apertures P′ being closed in this condition, the piston is acted upon by the steam. Moving the valves to the other extreme closes the lower ports, and permits the steam to blow from the apertures P′. The ports O′ are always open, placing the back of the piston-wings in free communication with the atmosphere, and the fluted connection of the piston-rod with the piston permits of differential expansion of parts without causing end-binding of the piston. The block E, by sliding in the grooves *k* in the body of the instrument, permits a practical alteration in the torsional length of the spring, whereby, within certain limits, its torsional resisting power may be adjusted; but in practice the torsion-springs by proper proportioning of size will be adjusted to individual units of torsional resistance, whereby each spring may have its scale of pressures the same, as is usual with the springs of indicators.

In the end of the pencil-lever the pencil-holder *e* is fitted to move inward and outward a trifle. The front end of the pencil-holder has one side mortised and split, as at *q*, so as to nicely clasp a lead, and spiral spring *f*, located between a collar upon the end of the pencil-lever and a collar upon the pencil holder, tends to push the pencil-holder outward. A gib-head, *g*, upon a rearward extension of the pencil-holder, engages in a mortise in the side of the pencil-lever, and limits the outward motion of the pencil-holder. By this arrangement the pencil is held against the paper with an elastic pressure; but upon the swinging back of the paper tablet the pencil may not follow the paper up too far.

I have thus described my improved indicator, with which I am enabled to make close connection with the interior of a steam-cylinder, and in which I have reduced to a minimum the moments of momentum and inertia. I do not confine myself to the exact device set forth.

I have described the principle of my invention and the best manner in which I contemplate applying that principle, and I now claim as my invention, and seek to secure by Letters Patent—

1. The combination of a motor-cylinder, frame parts connected therewith, a paper-carrier supported thereby, a piston within the motor-cylinder, a pencil in connection with said piston, and a coupling attached to the frame parts at a point between the motor-cylinder and the pencil-lever, and adapted for coupling the instrument to an engine, substantially as and for the purpose set forth.

2. The combination of a motor-cylinder, a paper-carrier, a tubular frame part connected with the motor-cylinder, and a coupling fitted to slide on said tubular frame part and couple the instrument to an engine, substantially as and for the purpose set forth.

3. The combination of a motor-cylinder, a paper-carrier, a tubular frame part connected with the motor-cylinder, a coupling fitted to slide on said tubular frame part and couple the instrument to an engine, and a clamp-gland secured to the coupling, substantially as and for the purpose set forth.

4. The combination of a motor-cylinder, a frame part connected therewith, a coupling attached but removable from below the motor-

cylinder, a separable tubular extension of the frame part attached to the motor-cylinder, and a coupling upon such extension, both of said couplings being adapted for coupling the instrument to an engine, substantially as and for the purpose set forth.

5. In a steam-engine indicator, the combination of a paper-carrier, an oscillating pencil-lever, a sliding pencil-holder fitted to the end of the pencil-lever, a spring adapted to push the pencil and pencil-holder outward, and a stop adapted to limit the outward projection of the pencil when in use, substantially as and for the purpose set forth.

6. In a steam-engine indicator, the combination of a segmental or concave tablet adapted to receive a sheet of paper, and curved flexible paper-clips disposed across the curve of the tablet and secured at one end to the tablet, and provided with latchments at the other end, and adapted to press the paper against the tablet, substantially as and for the purpose set forth.

7. In a steam-engine indicator, the combination of a tablet adapted to receive a sheet of paper, and provided with perforations in its paper-receiving surfaces in a position to be covered by the paper, and curved flexible paper-clips secured at one end to the tablet and armed at the free end with barbed latches adapted to penetrate the paper and engage with said perforations, substantially as and for the purpose set forth.

8. In a steam-engine indicator, the combination, with an oscillating pencil-lever, of a paper-tablet frame and a paper tablet pivoted in such frame, substantially as and for the purpose set forth.

9. In a steam-engine indicator, the combination of a moving paper-carrier, a rotatory spring-axle fitted to be revolved as the paper-carrier moves in one direction, and to be revolved in the other direction by the recoil of the spring, a drum fitted to revolve on an axle, and provided with notches in its periphery, by means of which the drum may be revolved by the operator's grasping finger-motions, a spring coiled within the drum and attached to the axle and drum, and a detent-pawl engaging said notches and adapted to prevent the reverse rotation of the drum, substantially as and for the purpose set forth.

10. In a steam-engine indicator, the combination of a moving paper-carrier, a rotatory spring-axle fitted to be revolved in one direction by the paper-carrier, two winding-drums provided with peripheral notches, by means of which the drums may be separately revolved by the operator's finger-grasp, detents engaging said notches and adapted to prevent the reverse rotation of the drum, and a separate spring coiled within each drum, and each spring secured to its drum and both springs to the axle, substantially as and for the purpose set forth.

11. In a steam-engine indicator, the combination of an oscillating motor-cylinder, an oscillating piston therein, an oscillating pencil-lever connected with the piston, a tubular body or frame projecting upward from the cylinder and slotted for the play of the pencil-lever, frame-arms projecting at right angles from such frame or body, and paper-carrier mechanism supported by such arms, substantially as and for the purpose set forth.

12. In a steam-engine indicator, the combination of a body-piece, paper-carrier supports connected thereto, a changeable tubular extension below the body-piece, a motor-cylinder secured to such extension, a torsion-spring reaching upward from the motor-cylinder through the body, a removable extension-piece attached above the body around the spring, and a retaining-block for the spring, adapted to seat in the top of said upper extension-piece or in the top of the body at the foot of said extension-piece, substantially as and for the purpose set forth.

13. In a steam-engine indicator, the combination of an oscillating motor-cylinder, a tubular body portion projecting axially therefrom, a torsion-spring reaching upward from the motor-cylinder within the body portion, and a block firmly but adjustably secured to the spring and adapted to slide within said body portion, substantially as and for the purpose set forth.

14. In a steam-engine indicator, the combination of a motor-cylinder, a piston adapted for oscillating motion therein and having a serrated central bore, and a serrated spring-grasping piston-rod fitted to the bore of said piston, substantially as and for the purpose set forth.

15. In a steam-engine indicator, the combination of the motor-cylinder, a piston adapted for oscillating motion therein, cylinder-heads provided with ports, disk-valves engaging the cylinder-heads, and a valve-operating rod geared to said valves and disposed parallel to the axis of the cylinder, substantially as and for the purpose set forth.

16. In a steam-engine indicator, the combination of a motor-cylinder, a piston fitted for oscillating motion therein, cylinder-heads provided with ports, disk-valves engaging the cylinder-heads, and a valve-operating rod geared to said valves and disposed within the motor-cylinder parallel to its axis, substantially as and for the purpose set forth.

CHARLES W. BARNABY.

Witnesses:

SEHEN GEE,

B. S. AMBLER.