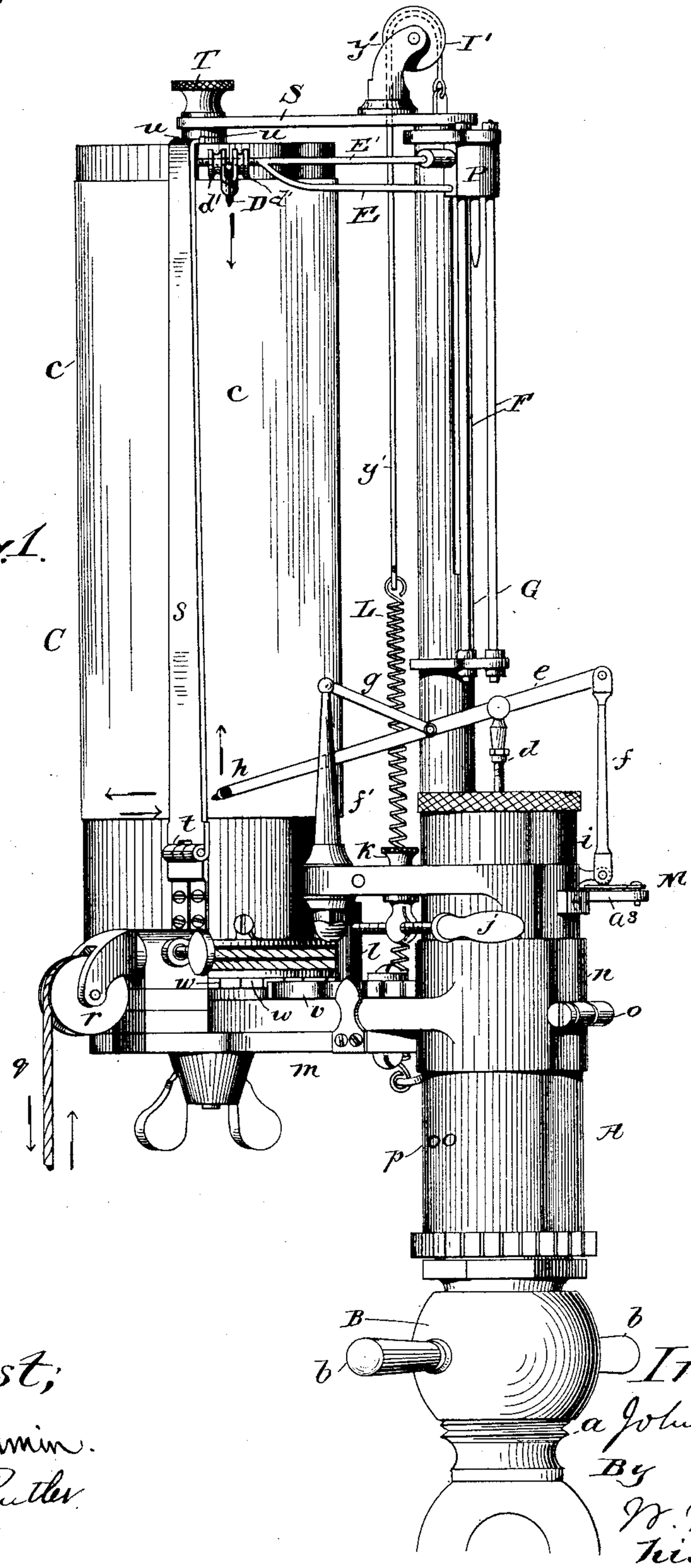
(No Model.) 3 Sheets—Sheet 1.

J. MILLIS.

VALVE MOTION INDICATOR FOR STEAM ENGINES.

No. 481,671. Patented Aug. 30, 1892.

Fig. 1.



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H. G. Butler.

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John Millis
By
W. P. Preble Jr
His Att'y

(No Model.) 3 Sheets—Sheet 2.

J. MILLIS.

VALVE MOTION INDICATOR FOR STEAM ENGINES.

No. 481,671. Patented Aug. 30, 1892.

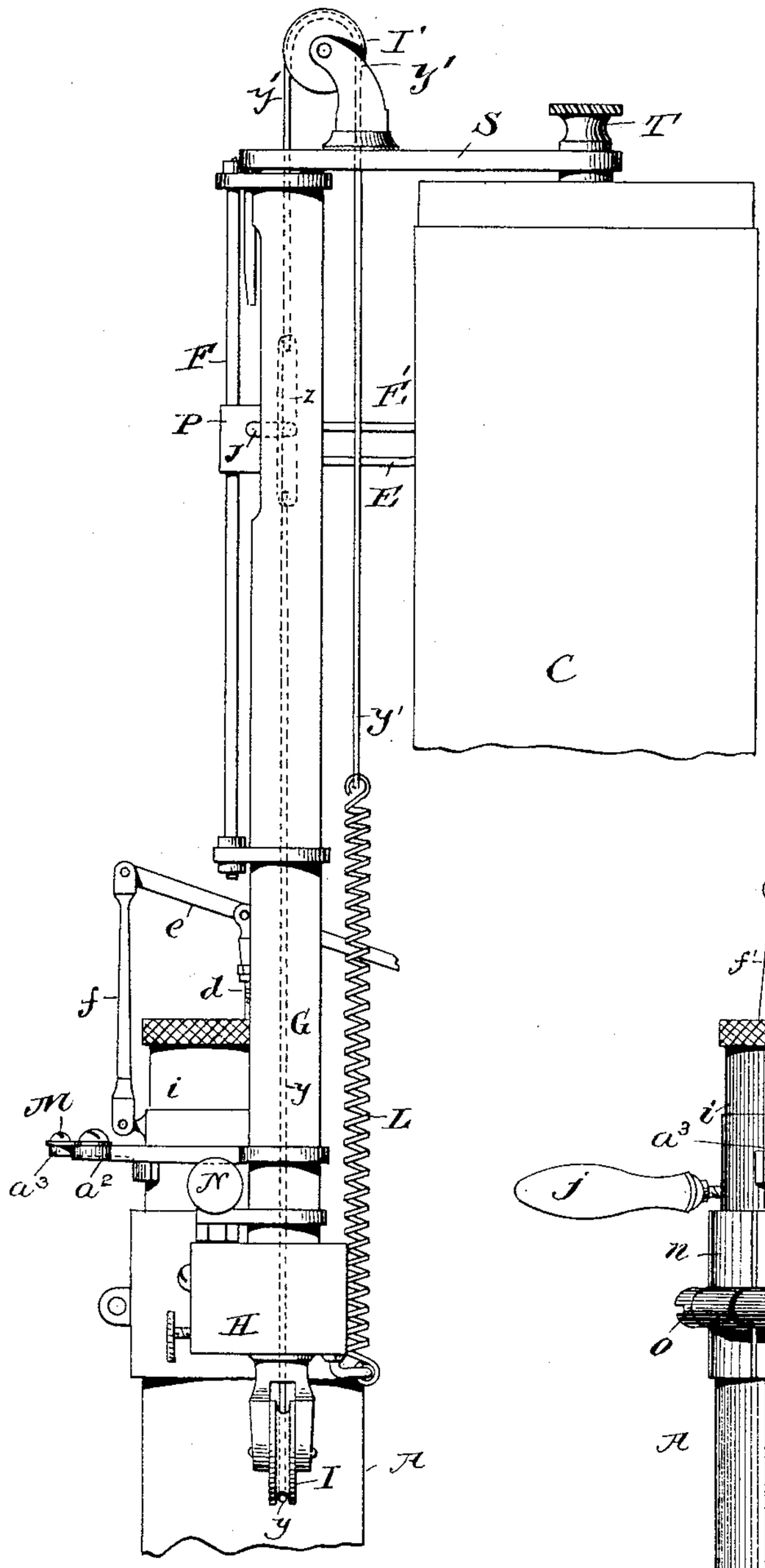


Fig. 3.

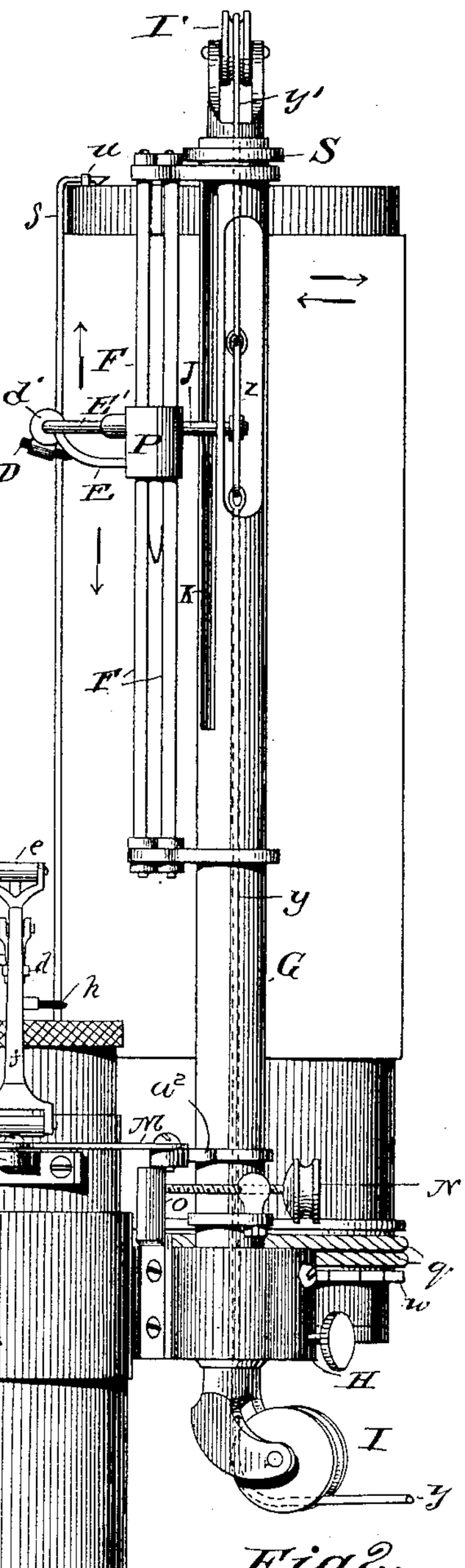
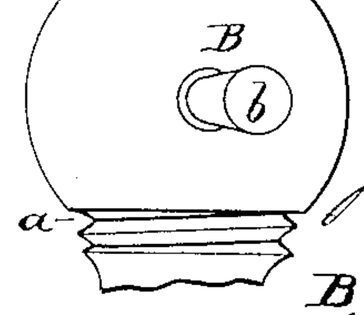


Fig. 2.



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(No Model.) 3 Sheets—Sheet 3.

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VALVE MOTION INDICATOR FOR STEAM ENGINES.

No. 481,671. Patented Aug. 30, 1892.

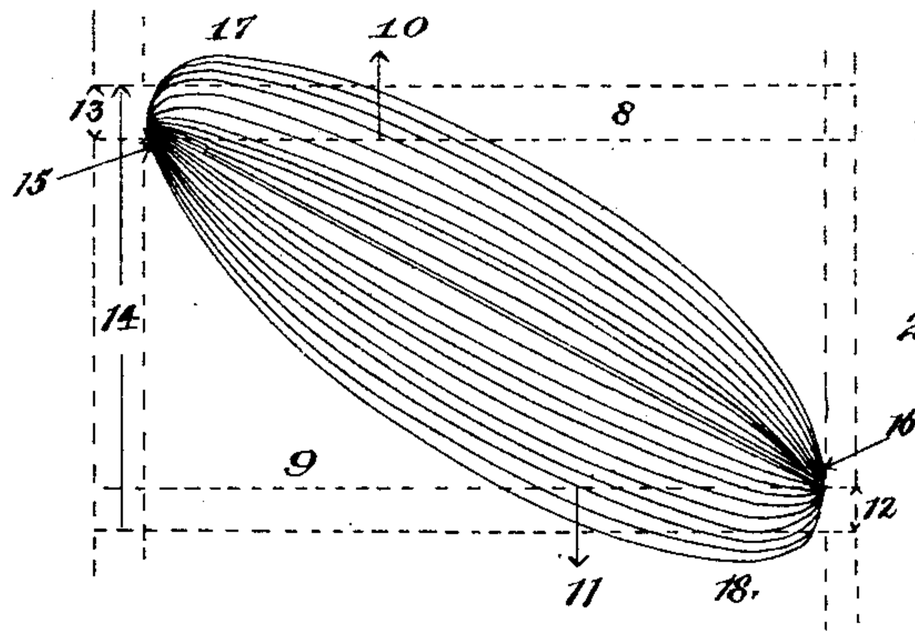

Fig. 6.

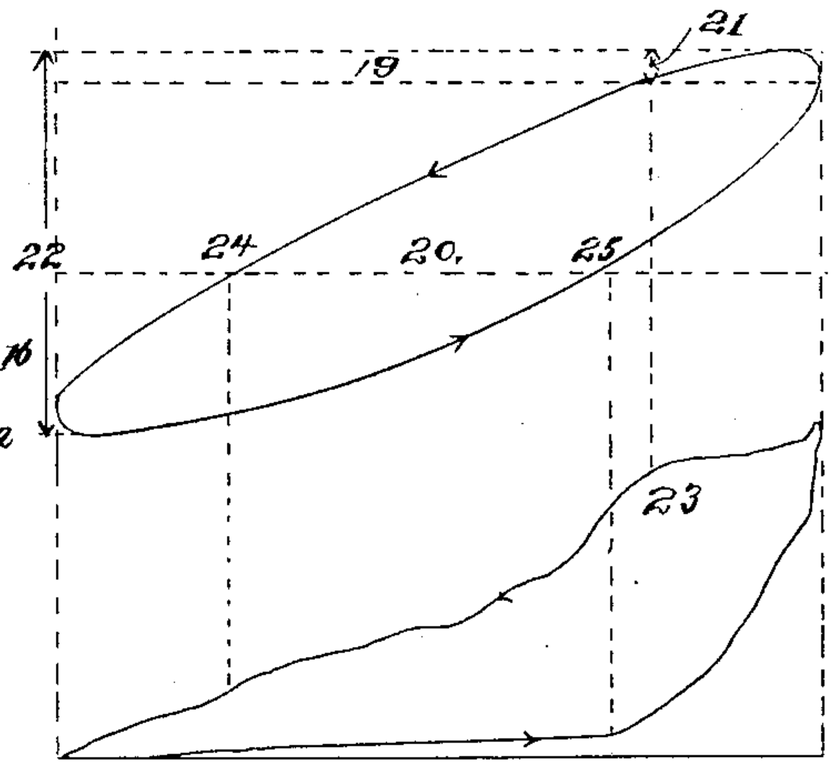

Fig. 7.

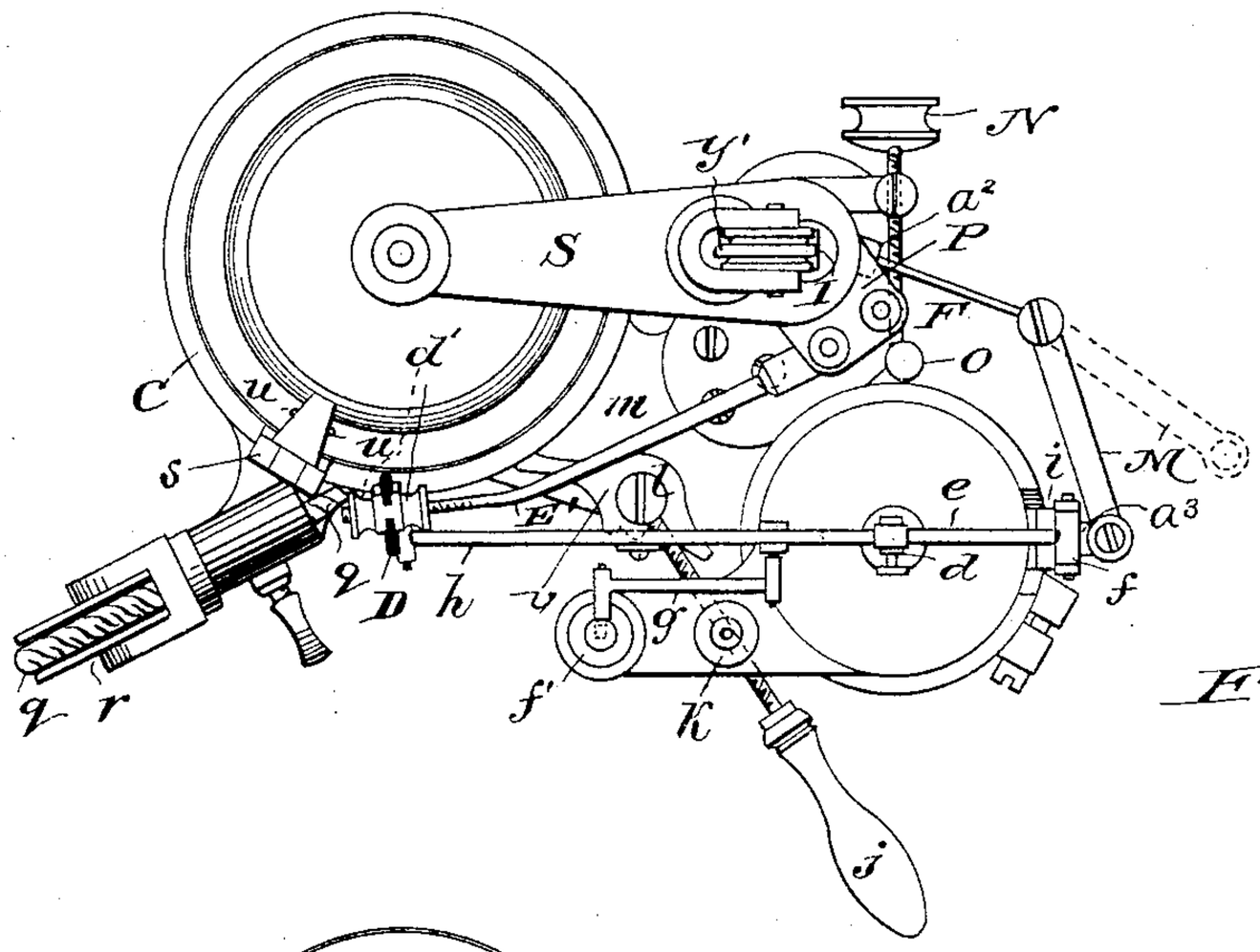

Fig. 4.

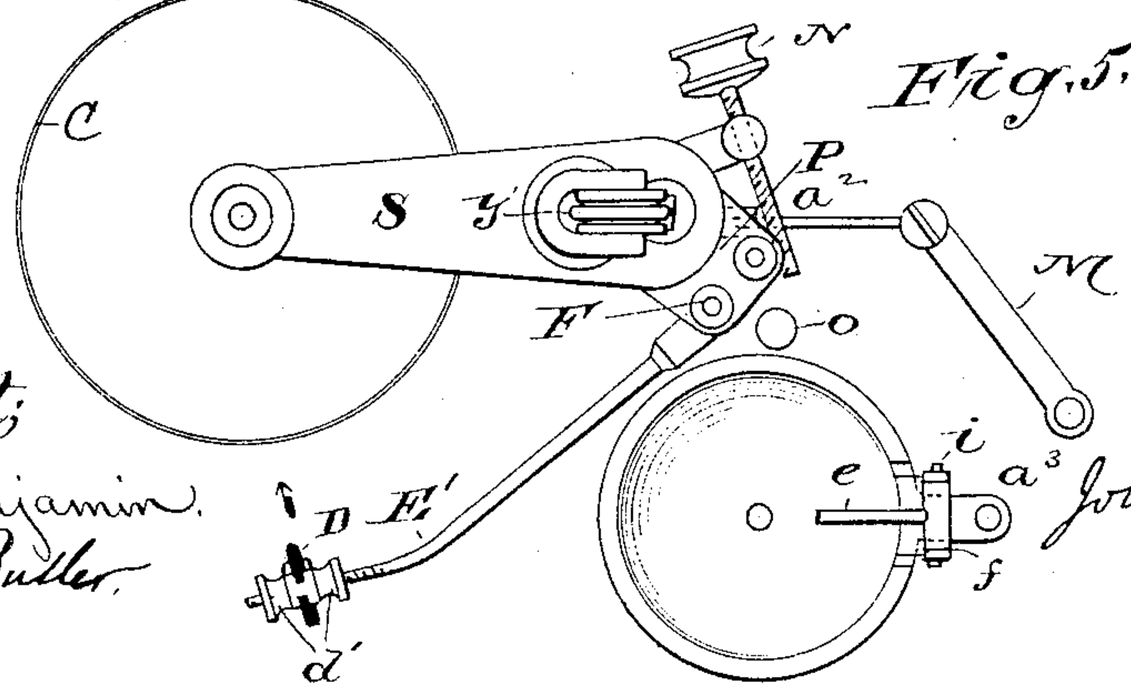

Fig. 5.

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UNITED STATES PATENT OFFICE.

JOHN MILLIS, OF THE UNITED STATES ARMY.

VALVE-MOTION INDICATOR FOR STEAM-ENGINES.

SPECIFICATION forming part of Letters Patent No. 481,671, dated August 30, 1892.

Application filed May 9, 1891. Serial No. 392,217. (No model.)

To all whom it may concern:

Be it known that I, JOHN MILLIS, a citizen of the United States, and an officer in the United States Army, now stationed at New Orleans, Louisiana, have made certain new and useful Improvements in Valve-Motion Indicators for Steam-Engines and other Machines, of which the following is a specification.

Heretofore various forms of steam-engine indicators have been employed, by which the varying pressure and action of the steam in the engine-cylinder has been shown by means of a diagram traced by a pencil on a sheet of paper carried upon a small rotating cylinder or barrel, which forms a part of the indicator, the instrument being so attached to and connected with the engine that the motion of the barrel of the indicator corresponds to the motion of the piston of the engine, while the movement of the pencil which traces the diagram is effected by the motion of a small piston in the indicator, whose motion corresponds to the varying pressure in the engine-cylinder. So far as I know, however, the action of the valve-gear and valves which control the admission and exhaust of the steam has heretofore only been obtained theoretically by models, drawings, or calculations, or by certain crude devices applied to the engine which can be used only in special cases, and which give only approximate results.

The object of my invention is to provide a valve-motion indicator for steam-engines or other machinery by means of which an automatically-drawn diagram is produced which shows the movements of the valve-gear and valves relatively to the motion of the piston when the engine is working under the conditions of actual service and which enables the exact relative motion and action of the valves and any portion of the valve-gear or other moving parts to be shown with great precision and to be readily studied. Preferably the valve-motion diagram should be drawn on the same card and at the same time as the regular steam-diagram, so that the two diagrams may be readily compared from point to point. This is particularly desirable in the case of engines having an "automatic cut-off" form of valve-gear, where the steam-diagram and the action of the valves are constantly changing with variations of load. My valve-motion indicator is therefore preferably constructed as an attachment to a steam-indicator. When so constructed, the cylinder or barrel of the steam-indicator which carries the paper or card on which the diagrams are traced is longer than usual, so that the valve-motion diagram may be traced vertically over the steam-diagram, or vice versa. The valve-motion indicator may be constructed and employed as an independent instrument.

In the accompanying drawings my invention is shown applied as an attachment to a regular form of steam-indicator now in the market.

Figure 1 is a front elevation of the combined steam-indicator and valve-motion indicator, the pencil of the valve-motion indicator being shown in its uppermost position. Fig. 2 is a side elevation, the pencil of the valve-motion indicator being shown in a lower position. Fig. 3 is a rear view, the barrel and steam-indicator being partly broken away. Fig. 4 is a top plan of the entire apparatus. Fig. 5 is a detail showing the valve-indicator disconnected from the steam-indicator, as it is used when the valve-motion diagram only is to be drawn. Figs. 6 and 7 are reproductions of diagrams made by the instrument.

The same letters and numerals indicate the same or similar parts in the different figures.

A is the chamber of the steam-indicator, into which the steam is admitted from the engine-cylinder, to which it is removably attached by the threaded union B, working upon the thread *a* of the steam-cock below. By turning the union by means of the handles *b b* the indicator and all its attachments are disconnected from the engine and readily removed therefrom.

C is the card-bearing cylinder or barrel carrying the card *c*, upon which both steam and valve-motion diagrams are drawn.

The steam-indicator is of ordinary construction, being provided with a piston and spring in the cylindrical chamber A, a piston-rod *d*, and a pencil-carrying device with parallel motion *e f f' g*, the pencil-point *h* being carried at the extreme outer end of the bar *e*. The post *f'* and link *f* are mounted upon projections from a sleeve *i*, which surrounds the chamber A and which is turned into the position shown in Fig. 1, where the pencil *h*

comes in contact with the card *c* or away from the card, as desired, by the adjustable screw-handle *j* passing through post *k*, mounted on and extending through one of the projections of said sleeve, as shown more particularly in Figs. 1 and 4. The handle *j* is turned or fed through said post *k* by means of the screw-thread on said handle to such a distance that when the pencil-carrying device is moved toward the card enough to touch the same the extreme end of said screw-threaded handle *j* comes against the stop *l*, which is provided on the arm *m*, which supports the card-carrying cylinder and which is in turn supported by being made integral with the clamp *n*, which surrounds the chamber A below the movable sleeve *i* and is held immovable and tightly grasping said chamber A by the screw and socket *o*. Of course as the pencil wears away the adjustable handle *j* is turned outward proportionately, so as to allow the pencil-carrying device to swing in far enough to have the pencil-point continue to touch the card.

The chamber A is provided with the usual drip-openings *p*.

The card-carrying cylinder or barrel C is of ordinary construction, except that it is preferably made somewhat longer than usual. It is supported by the arm *m* of the clamping-sleeve *n*.

The card *c* consists, as usual, of a piece of paper wrapped around the cylinder and held by means of the clamp-strip *s*, hinged at *t* and extending up to the top of the cylinder, where it is engaged by the stops *u u*.

The catch *v*, Fig. 4, mounted upon the arm *m*, supporting the barrel, is provided to engage the teeth *w* around the base of the barrel and prevent any revolution of the barrel when it is desired to have the same remain inactive for the removal of the card or for any other purpose.

Persons skilled in the art know without further explanation that the pencil-point *h* as it moves up and down in the direction of the vertical arrow shown in Fig. 1 in accordance with the varying pressure of the steam upon the piston and spring in the chamber A of the indicator, while the card *c* is alternately rotated in the direction of the horizontal arrows by a cord *q*, which is connected by suitable devices to some part of the engine whose motion corresponds to that of the engine-piston, and by a retractile spring, will indicate the action of the steam in the engine-cylinder.

As before stated, there is nothing peculiar in the construction described, the steam-indicator shown and described being one of the many well-known forms in the market, to any of which my invention of a valve-motion indicator could be readily applied.

I now come to the description of my valve-motion indicator, which, as I before stated, may be used independent of the steam-indicator or as an attachment thereto, as shown in the drawings. The valve-motion diagram is traced by a pencil-point D, moving parallel to the axis of the indicator-barrel similarly as in the case of the steam-diagram. Preferably this pencil-point D should be so placed with reference to the pencil-point *h* of the steam-indicator that both move in the same vertical line when bearing on the card *c*, and to accurately effect this adjusting jam-nuts *d'* are provided on each side of the holder P of the pencil-point D, as shown. The pencil-point D of the valve-motion indicator is thus adjustably mounted near the end of an arm E', which is stiffened and supported by the brace E. The arm and brace are attached to a block or cross-head S, which slides freely in the rods F, these latter being parallel to the axis of the indicator-barrel. These rods are attached to a tube or sleeve G, which fits closely over an inner tube, but is sufficiently free to enable it to be easily turned about this inner tube. The inner tube is rigidly supported in a hub or base H, (see Fig. 2,) attached to the arm *m*, before spoken of as supporting the barrel C, and from the upper end of the inner tube projects an arm, on which the pulley I' is mounted, and the outer end of which arm supports the top bearing of the axis of the barrel C, as shown, being connected thereto by the thumb-screw T. Below the base H is a guide-pulley I, mounted on a swinging post loosely set in said base H and freely turning, as occasion requires, to allow the cord *y* to be brought from any direction and to be led perpendicularly up the axis of the tube G to its connection with the link *z*, which is attached to the pin J, projecting from the sliding cross-head through a longitudinal slot *k* in the outer tube G. This slot corresponds to a somewhat wider opening in the inner tube.

The downward motion of the cross-head S and pencil-point D is produced by the cord *y*, which is connected with the valve-rod, the motion of which is to be studied, using any one of the well-known devices to reduce the movement, if necessary, to bring it within the limits of the instrument.

The return motion of the cross-head and pencil-point D is produced by the spring L, one end of which is secured to a fixed part of the apparatus and the other end connected to the sliding cross-head by a cord *y'* passing over the pulley I'. Obviously the contractile force of the spring L, which was drawn out by the downward motion of the cross-head, will return the cross-head to its initial position as quickly as the tension on the lower end of the cord is diminished.

The pressure of the pencil-point D upon the paper or card C is regulated by the distance to which the screw N is turned in its supporting-post, which of course determines the distance through which the pencil D is allowed to move toward the card before its motion is arrested by the inner end of the screw N striking against the stud O. This

screw may also be used as a handle to bring the pencil-point into contact with the card or to remove it from contact at any time by revolving the outer tube G about the inner tube. This can be effected while the instrument is in operation, since the moving cord is in the axis of the tube G, so that the only effect of revolving the tube G is to slightly twist the the cords y and y', which evidently will in no way affect the operation of the instrument.

When it is desired to take the steam-pressure card and the valve-motion card simultaneously, connection is made between the steam and the valve-motion indicators by the link M, pivoted to a projection a^3 from the rotating sleeve i of the steam-indicator, and to an arm a^2, projecting from the tube G. Obviously both pencil-points will be brought to bear on the card and removed at the same instant by moving the handle j by grasping said handle with the hand and swinging the cylindrical chamber A and all its accompanying devices to the left and the right, respectively, when the link M is thus connected. With the link M disconnected, as shown in Fig. 5 and by dotted lines in Fig. 4, either the steam or the valve-motion diagram may be taken separately.

Many other devices for obtaining a reciprocating motion of the cross-head and the pencil-point D might be adopted in the place of the one shown in the drawings, the essential feature being that the motion should be such that the movement of the pencil-point shall correspond to the motion of the part whose action is to be studied and that the pencil-point may be brought into contact with the card at the desired moment.

The operation of my improved indicator is as follows: The cylinder C being held stationary by the catch v, a fresh card is wrapped around the cylinder and held in place by the clamp s, the pencil-points D and h being turned away from the card and the link M being attached, as shown in Fig. 4. The catch v being then released, the card-bearing barrel at once takes up an oscillating rotation corresponding to the movements of the engine-piston, and as soon as the motion becomes steady the pencil-points are moved gently up in contact with the oscillating card c by the operator by means of the handle j, both pencils meanwhile being moved up and down by reason of their connection with the indicator-piston and the engine-valve, respectively. As soon as the contact between the card and the points takes place the latter begin to describe diagrams, one of which may be used as the groundwork for studying the action of the steam in the engine-cylinder in the usual manner and the other of which can be used for studying the action of the valve with regard to actual points of admission, cut-off, exhaust, compression, wire-drawing, &c., and the departure of the actual movements of the valve relative to those of the piston from the theoretical motion. By making suitable connections the relative motion of all the valves or of other parts of the engine may be studied, and by disconnecting the link M either steam or valve-motion diagrams may be taken separately, as above described.

To explain more clearly the use and action of this device, exact reproductions of diagrams actually drawn by the instrument are shown in Figs. 6 and 7.

In Fig. 6 is shown a series of curves made by the valve-motion indicator alone when applied to a high-speed engine having an automatic cut-off steam-valve gear controlled by a centrifugal governor and independent exhaust-valves separately operated, (Porter-Allen.) The indicator-pencil was connected with the steam-valve gear. From what precedes it will be understood that the horizontal movement or component of any one of the curves at any point corresponds to the actual motion of the engine-piston, while the vertical movement or component corresponds to the actual motion of the steam-valve, and the curve itself therefore shows the relative motion of the valve with respect to the piston of the engine. The entire series of curves shows the changes in the action of the valve-gear and valves when the load on the engine is increased from no load (interior curve) to maximum load (exterior curve.) The horizontal line 8 corresponds to the position of the steam-valve when just opening or closing at one end of the cylinder, and the line 9 indicates similar conditions at the other end of the cylinder. For any particular load the points of admission and cut-off 10 11 and the amount of valve-opening for either end of the cylinder are clearly shown at 12 13, as well as the extreme travel of the valve at 14. These curves also show that the amount of "lead" in this case was very little at one end and practically nothing at the other, and that the form of valve-gear secures nearly a constant lead with great variations of load. The departure in the general shape of the curves from true ellipses shows the effect of "angularity of connecting-rod" or of connecting parts of the valve-gear, and the slight flattening of the curves at 17 and 18 indicates lost motion in the valve-gear.

In Fig. 7 are shown steam and valve-motion diagrams taken simultaneously from an automatic cut-off high-speed engine of the slide-valve type, in which the valve is operated by a shifting eccentric and the cut-off is controlled by a fly-wheel governor, (New York Safety.) The intersections of the valve-motion diagram with the horizontal line 19 correspond to the points of admission and cut-off, and its intersections with the horizontal line 20 show the points of exhaust and compression. As in the previous case, the amount of steam opening 21 and the extreme throw of the valve 22 are shown.

The fall of the steam-line and the rounded form of the steam-diagram at point of cut-off 23 are at once explained by the too-small steam-opening of the valve and its slow closure.

The latter is shown by the very oblique direction of the valve-motion curve with respect to the horizontal line at the point of intersection 21. The opening of the exhaust 24 was fairly prompt and its closure 25 was even more so. The shape of the valve-motion curve shows clearly, as in the former case, the effects of angularity of connecting and eccentric rods, as well as the irregularities produced by the action of gravity on the weights of a centrifugal governing-valve gear revolving in a vertical plane. These causes in this case have increased the curvature of the lower half of the curve and flattened the upper part, producing corresponding changes in the points of cut-off, exhaust, and compression.

It is obvious that the instrument may be applied to any other form of engine or valve-gear and that it may be used in connection with a variety of other machines besides steam-engines.

Persons skilled in the art will readily appreciate the advantages which will arise from the use of the apparatus as above indicated.

I claim as follows:

A valve motion indicating attachment for steam-engines, which comprises a reciprocating pencil-carrying device, a revolving tube upon which said device is mounted, the valve, devices which connect said pencil-carrying device with the valve of the engine, which said valve communicates motion in one direction to the pencil-carrying device, a spring which communicates motion in the opposite direction to said pencil-carrying device, and devices which turn said tube and bring said pencil-carrying device into or away from contact with the card on which diagrams are to be drawn, substantially as shown, and for the purposes specified.

JOHN MILLIS.

Witnesses:
J. D. SCHMIDT,
R. L. PRESTON.