(No Model.) 2 Sheets—Sheet 1.

W. F. BROWN.

STEAM ENGINE INDICATOR.

No. 377,601. Patented Feb. 7, 1888.

FIG. 4.

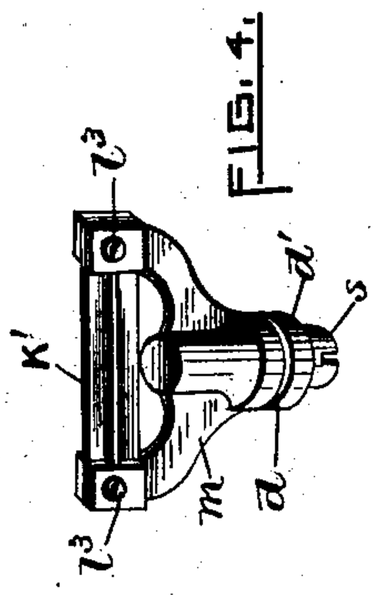

FIG. 2.

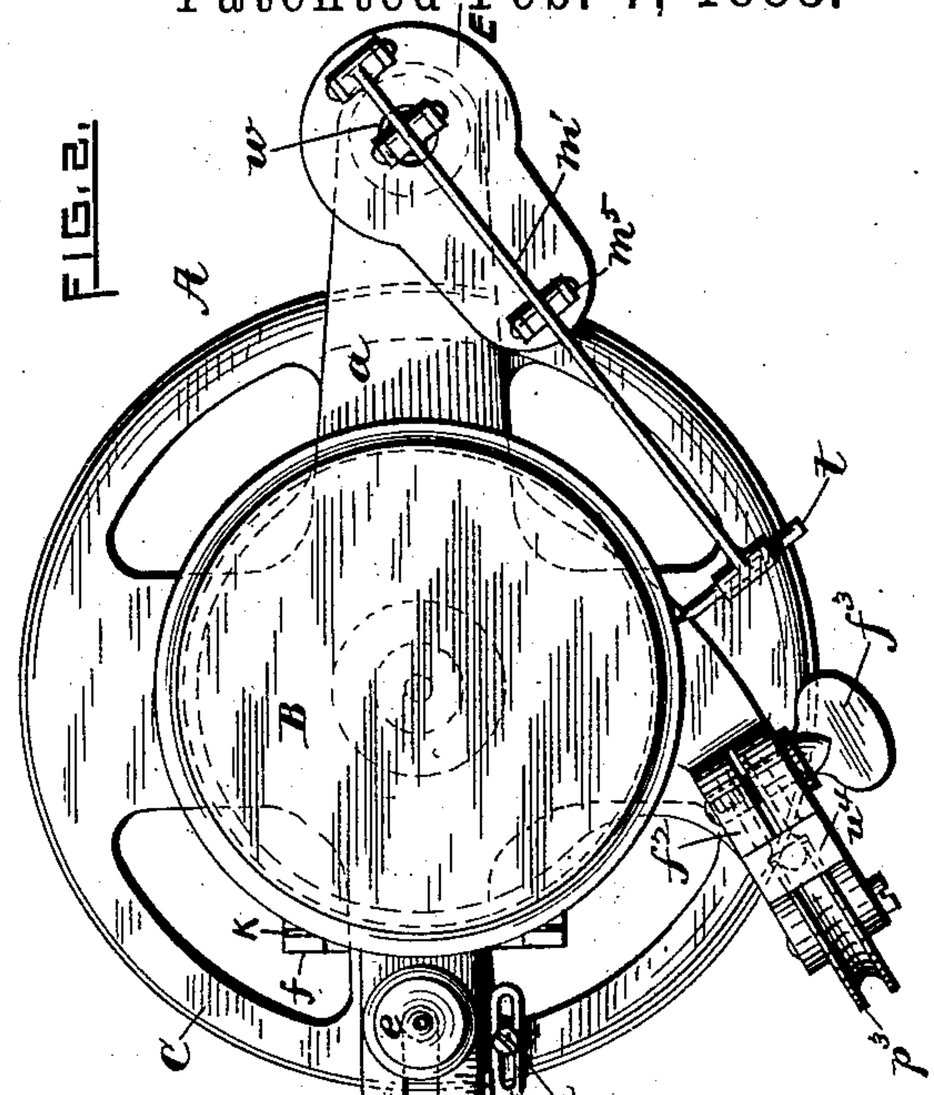

FIG. 5.

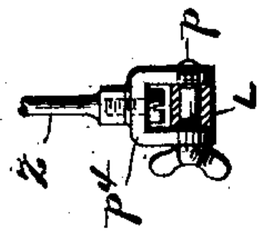

FIG. 1.

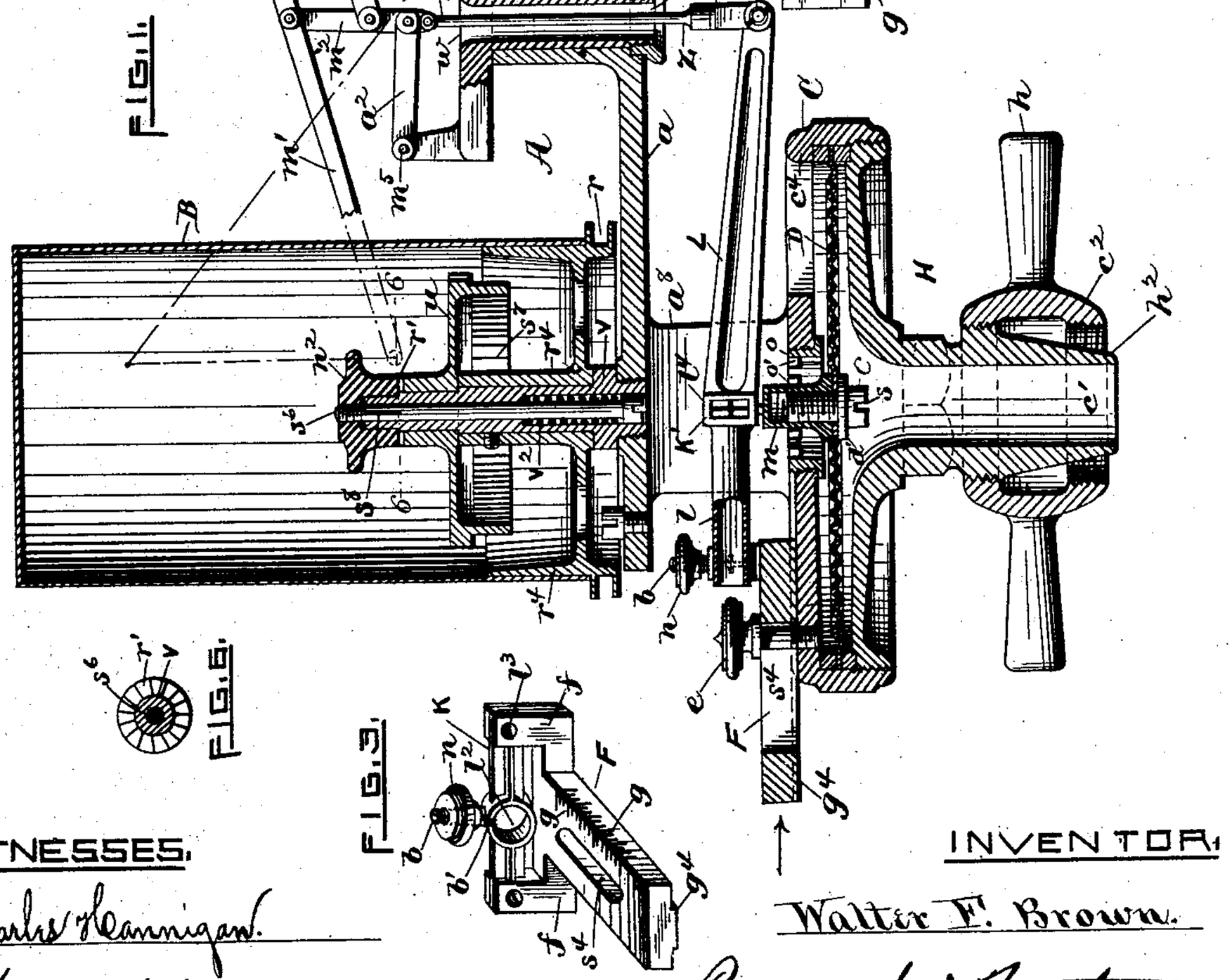

FIG. 6.

FIG. 3.

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(No Model.) 2 Sheets—Sheet 2.

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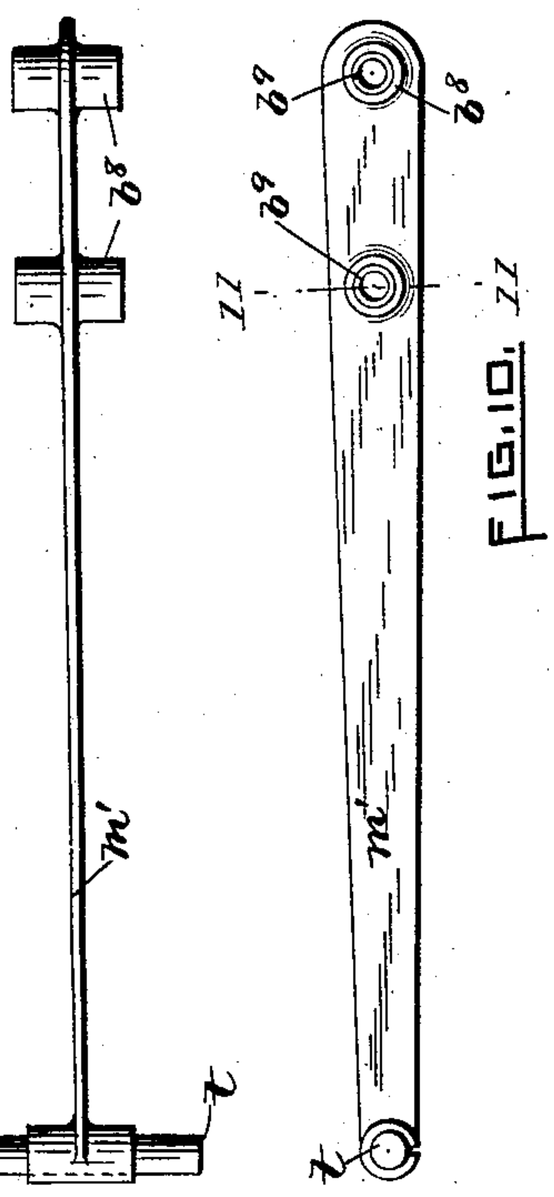

FIG. 9.

FIG. 10.

FIG. 11.

FIG. 7.

FIG. 8.

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UNITED STATES PATENT OFFICE.

WALTER F. BROWN, OF PROVIDENCE, RHODE ISLAND.

STEAM-ENGINE INDICATOR.

SPECIFICATION forming part of Letters Patent No. 377,601, dated February 7, 1888.

Application filed July 7, 1887. Serial No. 243,618. (No model.)

To all whom it may concern:

Be it known that I, WALTER F. BROWN, a citizen of the United States, residing at Providence, in the county of Providence and State of Rhode Island, have invented certain new and useful Improvements in Steam-Engine Indicators; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same, reference being had to the accompanying drawings, and to letters or figures of reference marked thereon, which form a part of this specification.

My present invention relates to steam-engine indicators; and it consists, essentially, in the combination, with a spring-diaphragm, against which the pressure to be recorded is imparted, of a lever actuated by the diaphragm, an adjustable fulcrum for the lever, and mechanism connected with said lever adapted to vibrate a pencil-point or tracer in a true vertical line.

The object of my invention is to simplify the construction of steam-engine indicators, thereby at the same time reducing the weight of the reciprocating parts and making the machine more compact and symmetrical.

Another object attained by the use of the present invention is that "quick-speed" engines of the present day may be readily and accurately indicated, the "card" produced thereby being smooth and free from the wavy or zigzag line usually produced in making the "expansion-curve."

Still another advantage possessed by my improved indicator is that the same spring-diaphragm, in connection with the adjustable fulcrum of the connected lever, is used both for high and low pressures, as well as for intermediate pressures, all as will be more fully hereinafter set forth and claimed.

This invention is an improvement upon the steam-engine indicator which was granted to me August 10, 1886, and numbered 347,088.

In the accompanying two sheets of drawings, Figure 1 represents a vertical sectional view taken through the center of the indicator, showing the several parts in the normal position. Fig. 2 is a top view of the same. Fig. 3 is a perspective view of the movable fulcrum detached. Fig. 4 is a similar view of the device for connecting the spring-diaphragm with the main operating-lever. Fig. 5 is a detached view of the lower portion of the link which connects the free end of the operating-lever. Fig. 6 is a horizontal sectional view taken through the driving-spindle, &c., on line 6 6 of Fig. 1. Fig. 7, Sheet 2, is a side elevation of the indicator. Fig. 8 is a detached side view, in partial section, showing the guide-pulley for the cord, &c. Fig. 9 is an enlarged plan view of the pencil-carrying lever, the same being made preferably of aluminum and having its bearings lined with steel bushings. Fig. 10 is a side view thereof, and Fig. 11 is a transverse sectional view taken on line 11 11 and showing the steel bushing.

A detailed description of the invention is as follows:

A, referring to the drawings, designates the improved indicator complete.

H indicates the pressure-head as a whole, adapted, by means of a screw-threaded tubular end portion, c', and coupling c^2, with handles h, to be secured to a cylinder-cock, as usual. The upper portion of said head H is enlarged, and also screw-threaded, and to which is secured the indicator-frame C, the latter having an inwardly-projecting rim or flange, c^4, adapted to bear against packing rings or collars, between which is packed and secured a metallic spring-diaphragm, D, said diaphragm being constructed substantially as shown and claimed in my United States patent hereinbefore referred to. To the center of the diaphragm is secured a fixed fulcrum, m, provided with a bar, K′, secured thereto by screws l^3. (See Fig. 4.) The lower portion of said fulcrum is made cylindrical, terminating in an enlargement, the same being centrally tapped to receive a screw, s, which passes through a hole formed in the center of the diaphragm. By means of said screw and an interposed collar, d', the diaphragm is rigidly secured to the fulcrum m, and at the same time producing a steam-tight joint. A comparatively large opening is made through the top of the frame C at its center, the said opening being tapped and fitted with an annular nut, o, adapted, by means of lugs o', to be adjustably mounted in the frame. This nut o serves to limit the movement of the diaphragm in case an excessive pressure be present in the

pressure-chamber *c*. Extending upwardly from and forming a part of the frame C are oppositely-located uprights a^8, which support the base *a*, on which are mounted the drum B and pencil-carrying mechanism. At one side the base is extended horizontally and terminates at its outer end in a vertical hollow hub, *a'*, which is bored out to receive a depending hollow spindle, *w*, secured to or forming a part of the pencil-carrying frame E. An annular nut screwed to the lower end of said hollow spindle serves to prevent the latter from vertical movement, but at the same time permits the frame E to turn freely in its axial direction.

F indicates the lever-support, mounted upon the main frame or cap C at right angles to the axis of the drum, &c., and at the opposite side of the indicator from the frame E, a groove being formed in the said cap, into which a tongue, g^4, of the support is fitted. A binding-screw, *e*, tapped into the frame C and passing through an elongated opening, s^4, serves to adjustably secure the support in position. The latter at its inner end is extended laterally, as at *f*, from which project short vertical arms, which are slotted to receive a light metallic clamping-tie, K, Fig. 3, the center portion, l^2, of which, transversely, is made to serve as an annular clamp, the same being bored out to receive the short arm *l* of the operating-lever L, about to be described.

The upper portion of the annular clamp is provided with a taper-threaded stem, *b*, which is divided throughout its length and across the face of the clamp, as at *b'*, (see Fig. 3,) thereby, in connection with the nut *n*, producing a spring clamping device adapted to firmly and adjustably retain the lever L. A scale or series of spaces, *g*, is formed on the side of the sliding support F. An index or pointer, *i*, is adjustably secured to the frame C, adjacent to said scale, by means of a clamping-screw, i^2, which passes through a slotted opening, *i'*, and is tapped into said frame.

L indicates the main operating-lever, mounted at the enlargement l^4 upon the bar K' of the fulcrum *m*, the latter being secured to the diaphragm, as before described. The outer or free end of the lever L is connected to a forked link end, p^4, by means of the thumb-screw *p*, Fig. 5, &c. A link or rod, *z*, is mounted to swivel in the link end p^4. Said rod passes up through the hollow spindle *w*, and is jointed to and forms a part of the parallel mechanism which imparts movement to the tracer or pencil *t*. The arrangement of the levers, &c., to produce a parallel movement is well known. As drawn, m^4 and m^5 designate fixed pivots secured to the pencil-carrying frame E. (See Fig. 1.) A horizontal link, a^2, jointed to the pivot m^5, is connected at its opposite end with the vertical link m^2, which in turn is jointed to the link Z. A vertical link, m^3, is jointed to the other pivot, m^4. The upper ends of these links m^2 m^3 connect with the long arm or pencil-carrying lever *m'*, the parts being so arranged that the centers of the pivots m^4, the upper joint of the link *z*, and the pencil *t* are always in line. As drawn, also, the proportions of the links are such as to produce a ratio of seven to one—that is to say, the free end of the lever L will produce a travel of the pencil equal to seven times its own movement. At the same time the positions of the fulcrums of the lever L, Fig. 1, are such as to produce a relative movement of about three to one, so that if the center of the diaphragm rises one-sixteenth of an inch the pencil will be correspondingly raised twenty-one sixteenths. It is obvious now that by loosening the screw *e* and nut *n*, and moving the lever-support F toward the center, and then resecuring the parts in position, the leverage is directly increased, thereby adapting the indicator to be used under different pressures without changing the diaphragm. By means, also, of this device I am enabled to dispense with a series of springs, thereby saving their cost and the necessary time in changing them, as common to piston-indicators.

The paper-carrying drum B is actuated substantially as usual. A stationary hollow stud, V, is tapped into the center of the base-plate *a*, directly over the center of the diaphragm. A drum head, r^4, is provided with a hub which is fitted to turn freely on said stud, the outer rim of said head being turned to receive and fit the lower portion of the drum B. A circumferential groove, *r*, is formed in the base of said head to receive a cord, c^4, (see dotted lines, Fig. 8,) one end of which is secured to the head r^4 and the other adapted to be attached to reducing and reciprocating mechanism connected with the cross-head or other suitable parts of an engine, as usual. A guide-pulley, p^3, is mounted in a holder, u^4, having a hollow stem, u^5, through which said cord passes and leading to the groove *r*. The stem portion u^5 is mounted in fixed split ears f^2, a thumb-screw tapped therein serving to adjustably secure and clamp the holder in position.

An upper or circular head, *u*, is secured to the stationary stud V, said head having a downwardly-extending flange to which one end of a spiral spring, s^7, is attached, as usual, the other end of the spring being secured to the hub of the drum-head r^4. The upper face of the hub of the head *u* is provided with ratchets *r'*, which engage similar ratchets formed on the adjacent face of the nut n^2, the latter being fitted to the thread of a screw, s^6, which passes freely up through the hollow stud V surmounting the same. The lower portion of the hole in said hollow stud is enlarged to receive a coiled spring, v^2, and the head of the screw. By means of this arrangement (see Fig. 1) the spring serves to automatically keep the nut in engagement with the upper head.

To adjust the tension of the main spring s^7, the nut n^2 and its screw are lifted against the tension of the spring v^2 from engagement with the ratchets *r'*. The drum-head is then turned

to the right or left, as desired, thereby expanding or contracting the spring, when by releasing the nut it immediately re-engages the ratchet in a new position.

I would add in this connection that the screw s^6 is prevented from axial movement by means of a key, s^8, although freely permitting endwise motion.

Another feature of the present invention resides in the construction of the links and joints constituting the "parallel motion." The several reciprocating levers or links thereof, as m', m^2, m^3, a^2, and z, I propose making of aluminum, the hubs b^8 of the several joints to be lined with a thin sleeve or bushing of hardened steel. By means of this arrangement the weight of the reciprocating parts is greatly reduced, yet at the same time possessing ample strength and stiffness for the work, the advantage being that, owing to the diminished weight, the levers may be operated at a much greater velocity without serious vibrations than the recording mechanism of indicators as usually constructed. The steel bushings form very durable bearings for the steel pins at the several joints.

The operation is as follows: The indicator is assumed to be properly connected to the steam-engine cylinder, the cord c^4 being attached to a reducing mechanism actuated by the cross-head or other suitable reciprocating part of the engine. Now, upon admitting steam from the cylinder into the pressure-chamber c, the force of the steam, acting against the under surface of the spring-diaphragm, forces the center portion of the latter in a vertical direction, thereby slightly elevating the lever L and causing the pencil-lever m' to move an increased distance corresponding to the leverage of the parallel mechanism and the position of the adjustably-mounted fulcrum K. A piece of paper is attached to the drum B, as usual. Now, by vibrating the pencil-carrying frame E in its hollow socket a', so as to engage the point of the pencil t with the surface of the paper, the combined movement of the drum and diaphragm produces a card or "diagram" which may be computed as usual after the removal of the paper from the drum.

It will be noticed that the lever L in its upward movement is opposed by the torsion of the steel supporting-bar K', thereby dispensing with a loose joint, the short arm of the lever at the same time being a fixed fulcrum, which is also provided with a torsion-bar, K, in lieu of a joint.

By means of the adjustable stop o the diaphragm is prevented from excessive upward movement, which otherwise might injuriously affect the recording mechanism.

By first approximately knowing the several extreme pressures to be recorded, the fulcrum-carrier F may be successively adjusted so as to produce cards having substantially equal height, the position of the parts as drawn corresponding to the higher pressures, the extreme lower pressures being usually recorded after the fulcrum is adjustably secured in the opposite position, thereby producing the greatest leverage.

It will be seen from the foregoing that the one spring-diaphragm used answers the purpose of the several tension-springs necessitated by piston-indicators in recording like pressures.

Having thus described my invention, I claim—

1. The combination, with a mounted metallic spring-diaphragm having a main lever, as L, attached thereto and an adjustable fulcrum for the lever, of recording mechanism actuated by the said main lever, and a paper-carrying spring retractile drum adapted to revolve by means of a flexible connection attached to a reciprocating part of the engine.

2. The combination, with a pressure-chamber, a metallic spring-diaphragm mounted therein, and an adjustably-mounted stop for limiting the motion of the diaphragm, of an adjustably-fulcrumed lever, as L, attached to and moving with the diaphragm, a recording mechanism jointed to the free end of the lever, and a spring retractile drum adapted to carry a paper upon which the diagram is made by said recording mechanism, substantially as hereinbefore described.

3. A steam-engine indicator having a mounted metallic spring-diaphragm, a paper-carrying drum mounted above the diaphragm, an adjustably-fulcrumed lever attached to said diaphragm and located intermediate thereof and the drum, a recording device or multiplying mechanism jointed to the diaphragm-lever, and a mounted hollow spindle vertically supporting said multiplying mechanism, all combined and operating substantially as hereinbefore described, and for the purpose specified.

4. In a steam-engine indicator, the combination of a mounted metallic spring-diaphragm, a multiplying mechanism connected therewith, and an adjustable stop for limiting the movement of the diaphragm, substantially as hereinbefore described.

In testimony whereof I have affixed my signature in presence of two witnesses.

WALTER F. BROWN.

Witnesses:

CHARLES HANNIGAN,

GEO. H. REMINGTON.