(No Model.) 4 Sheets—Sheet 1.

A. B. CALKINS.

STEAM ENGINE INDICATOR.

No. 442,102. Patented Dec. 9, 1890.

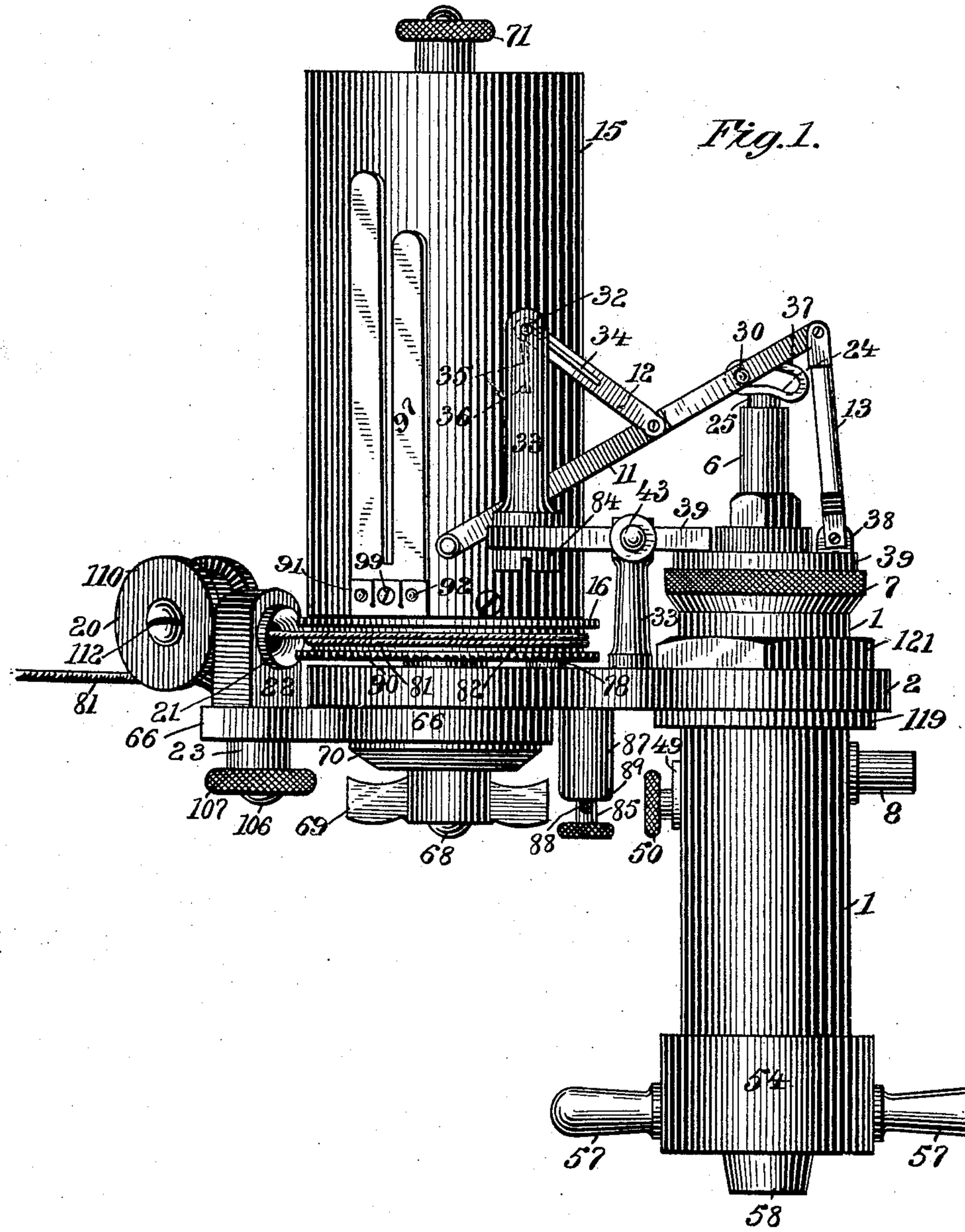

Fig. 1.

Witnesses
Wm. J. Tanner
A. J. Tanner.

Inventor
Almon B. Calkins.

By Geo. D Phillips. Atty.

(No Model.) 4 Sheets—Sheet 2.

A. B. CALKINS.

STEAM ENGINE INDICATOR.

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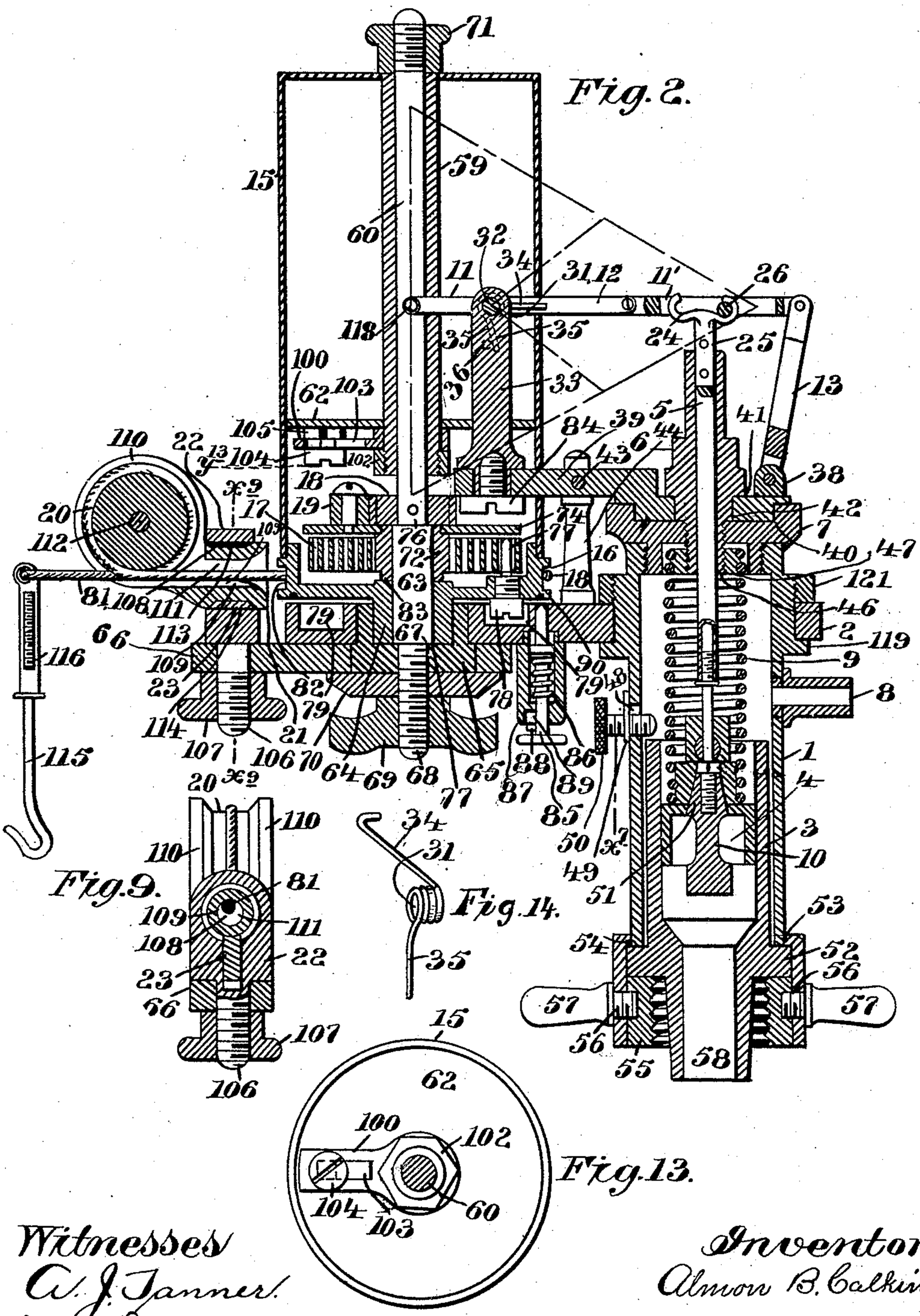
Fig. 2.



Witnesses
A. J. Tanner.
C. H. Gallaher.

Inventor
Almon B. Calkins.

By Geo. A. Phillips.
Attorney.

(No Model.) 4 Sheets—Sheet 3.

A. B. CALKINS.

STEAM ENGINE INDICATOR.

No. 442,102. Patented Dec. 9, 1890.

Fig. 3.

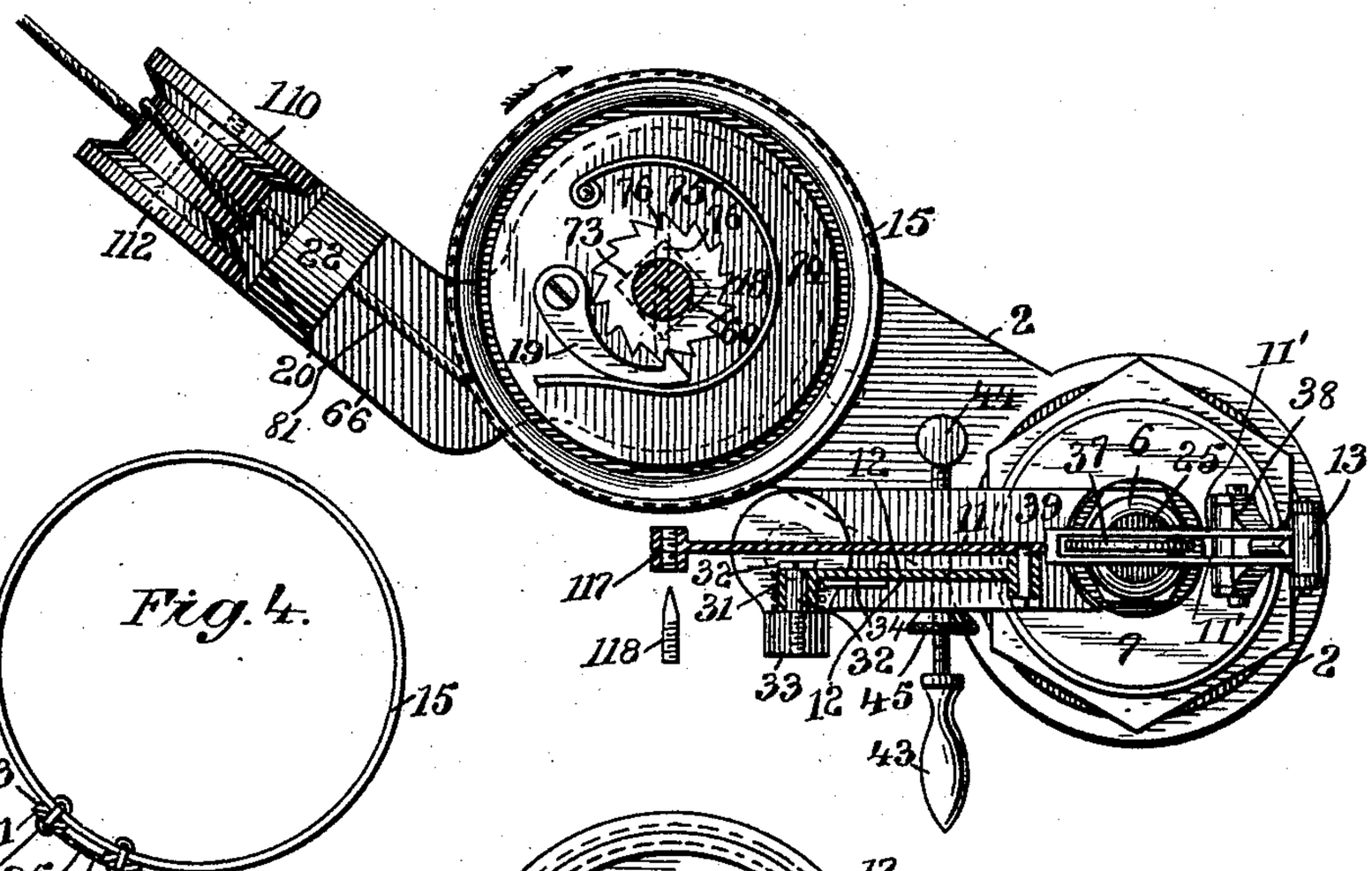


Fig. 4.

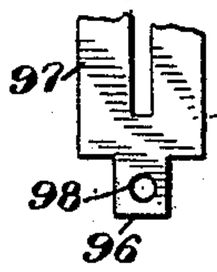


Fig. 6.

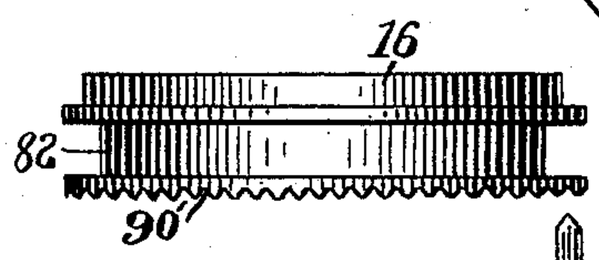


Fig. 8.

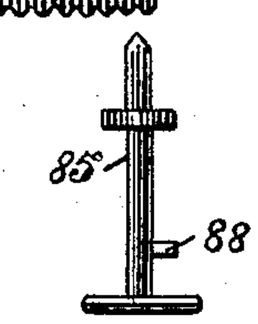
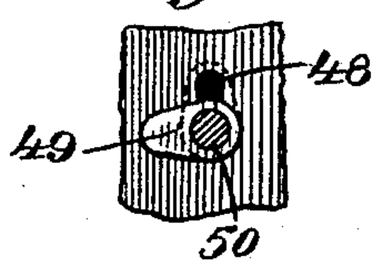


Fig. 5.

Fig. 7.



Witnesses
Wm. F. Tanner
A. J. Tanner

Inventor
Almon B. Calkins.

By. Geo. D. Phillips. Atty.

(No Model.) 4 Sheets—Sheet 4.

A. B. CALKINS.

STEAM ENGINE INDICATOR.

No. 442,102. Patented Dec. 9, 1890.

Fig. 11.

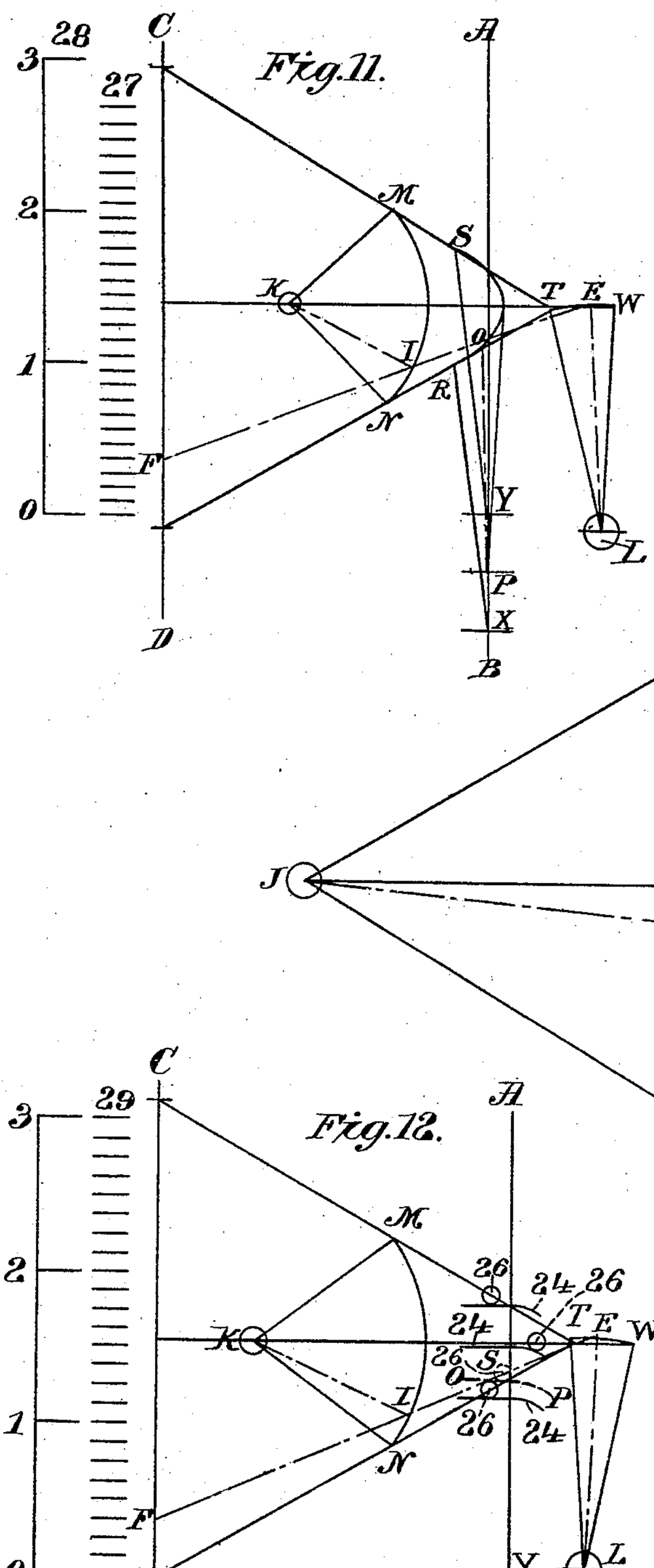


Fig. 10.

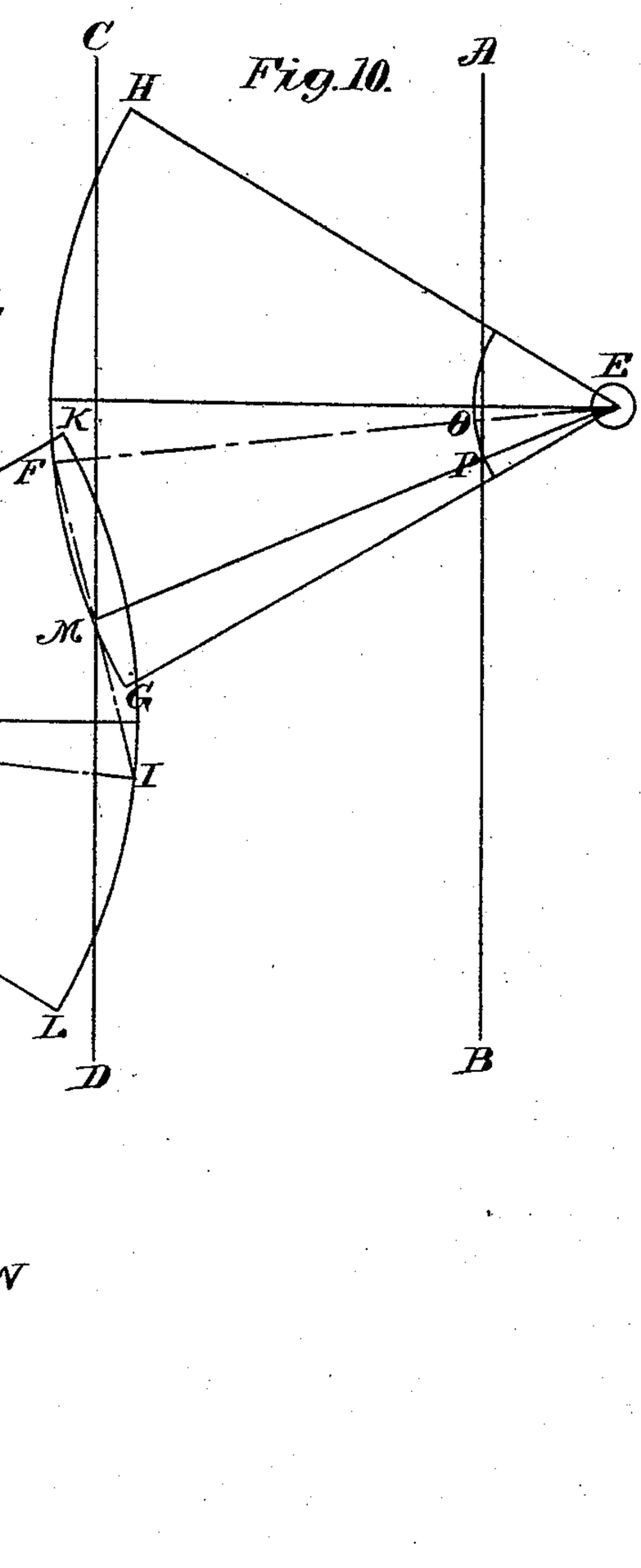


Fig. 12.

Witnesses
Wm. J. Tanner
A. J. Tanner

Inventor
Almon B. Calkins,

By Geo. D. Phillips. Atty

UNITED STATES PATENT OFFICE.

ALMON B. CALKINS, OF BRIDGEPORT, CONNECTICUT.

STEAM-ENGINE INDICATOR.

SPECIFICATION forming part of Letters Patent No. 442,102, dated December 9, 1890.

Application filed January 6, 1890. Serial No. 366,018. (No model.)

To all whom it may concern:

Be it known that I, ALMON B. CALKINS, a citizen of the United States, residing at Bridgeport, in the county of Fairfield and State of Connecticut, have invented certain new and useful Improvements in Steam-Engine Indicators; and I do 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 the letters and figures of reference marked thereon, which form a part of this specification.

My invention relates to steam-engine indicators.

Among the objects of my invention is the improvement of the parallel movement, perfecting thereby the ratio of movement of the pencil to the piston; also, to improve the indicator in many other respects that will add greatly to its efficiency as well as to simplify and cheapen its construction.

To this end my invention consists, first, in mounting rigidly or forming at the upper end of the indicator piston-rod a compensating curved surface or guide to engage with the pencil-carrying bar of the parallel movement, such curved surface or guide projecting laterally from the piston-rod and in the direction or path described by the forward and backward movement of the pencil-carrying bar, and, second, a spring to preserve the contact or engagement of such pencil-carrying bar with the curved surface or guide of the piston-rod.

My invention further consists in providing the hub of the swivel-plate, which plate supports the levers of the parallel movement, with a hub or projection, which hub operates in a recess of the cylinder-cap and is held in place by means of a flanged projection on the piston-rod guide-sleeve; also, to provide a nipple in the outer casing or shell of the cylinder and above the piston, to which a hose or pipe may be attached to provide an outlet for the steam escaping by the piston; further, to provide means whereby the piston may be lubricated from the exterior of the cylinder-casing, such means preferably consisting of an oil-hole through such casing and a cover for such hole to exclude the dust; further, to provide the paper-carrying drum with a long sleeve mounted on the drum-stud, such sleeve being rigidly attached to the top of such drum, a web rigidly attached to the lower end of such sleeve to assist in strengthening such drum in its position on the carriage; further, to regulate the tension of the drum-carriage spring by means of a ratchet-wheel rigidly attached to the drum-stud, a horizontally-placed disk attached to a sleeve of the drum-carriage spring, a pawl mounted on such disk to engage with the ratchet-wheel, the carriage-spring arranged to be reversed that the instrument may be used either right or left handed, and, further, to provide the drum-carriage with a stop-pin whose head projects below such carriage and engages a stop adjacent to said carriage, and by means of which stop the maximum travel of the carriage is limited.

My invention further consists in providing the paper-carrying drum with a compensating balance or weight, which balance or weight is placed eccentrically with the axis of such drum, such balance arranged to be shifted in any position about such axis, thus balancing such drum in its reciprocating movement, and thereby causing it at the instant or commencement of its reverse action to be identical or in time with the reverse action of the piston of a steam-engine, to which engine the indicator is connected; further, to hold the drum-carriage and its paper-carrying drum in any position required by means of a stop-pin actuated by a spring, said pin and spring located, preferably, in the frame of the indicator, the projecting end of such pin engaging with the drum-carriage, and, further, in attaching a support to the paper-carrying drum in such a manner that sufficient space is left between such support and drum to receive the tongue of the paper-spring, which spring by means of said tongue is attached directly to the support instead of the drum, as heretofore constructed, all of which improvements will be more fully described in the specification, and particularly pointed out in the claims.

To more fully understand my invention, reference is had to the accompanying drawings, forming a part of this specification.

Figure 1 represents a side elevation of my improved indicator. Fig. 2 represents a sectional view of the device shown in Fig. 1. Fig. 3 represents a top plan view. Figs. 4, 5, 6, 7, 8, and 9 represent detail views. Figs. 10, 11, and 12 are diagrams representing the result or effect of the different constructions of the parallel movement. Figs. 13 and 14 also represent detail views.

Its construction and operation are as follows:

1 represents the cylinder casing or shell; 2, the frame to which said casing is attached; 3, the cylinder proper, situated within the casing; 4, the piston; 5, the piston-rod; 6, the guide-sleeve for said rod; 7, the cylinder-cap; 8, the nipple attached to the cylinder for an outlet for the steam escaping by the piston; 9, the pressure-spring overlying the piston; 10, the taper-shank thumb-nut to prevent leakage of steam through the piston; 11, the pencil-bar; 12, the vibrating arm loosely engaging with the pencil-bar and standard 33; 13, the link loosely engaging the pencil-bar and its connection on the swivel-plate 39; 15, the paper-drum; 16, the paper-drum carriage; 17, the drum-carriage spring; 18, the ratchet-wheel; 19, the pawl for same; 20, the cord-pulley; 21, the cord-guide sleeve; 22, the housing overlying the same; 23, the tightening-key for said sleeve.

As before mentioned, one of the objects sought to be obtained by this invention is the improvement of the parallel motion for indicators, it being a well-known fact that an imperfection exists in such motion, which consists in the variable ratio of motion of the piston to the pencil—*i. e.*, the pencil does not move in time at all points of its elevation with the piston. This defect bears upon the accuracy of the diagram, and for correct delineations is unreliable. The movement of the pencil situated at the end of the pencil-bar is in practice four times faster than the piston. Now, if the piston should be moved one-sixteenth of an inch the pencil should move four-sixteenths of an inch, and for each succeeding one-sixteenth of an inch movement of the piston four times that distance or four-sixteenths of an inch should be shown or recorded by the pencil, and this ratio should be represented and maintained throughout the entire movement of the piston and pencil-bar. As the travel of the piston is necessarily limited within a small compass, the multiplied movement at the end of the pencil-bar is necessary in order to enlarge the diagram sufficient to obtain a clear and correct reading.

In order to transmit to the pencil a movement exactly in time with the piston, I provide the curved surface 24 to the top of the piston-rod 5, (see Figs. 1 and 2,) and this curved surface may be a part of the piston-rod proper; or it may be formed on the separate piece 25 and attached to said rod. The roll 26, which is attached to the pencil-bar, travels on the curved surface 24.

In order to give a clear idea of the object sought to be obtained by the use of this curved surface on the piston-rod and its proper relation to the motion of the pencil and piston, it will be necessary to refer to some of the features of both the Richards and Thompson indicators bearing on this point of the equality of ratios.

The Thompson invention shows an improvement of the Richards parallel motion in the matter of reducing the weight and number of parts. In the effort to do this a very important feature was necessarily sacrificed, and this was the equal ratio of movement of the pencil to the piston in any desired multiplication.

By reference to the outline diagram, Fig. 10, the Richards parallel motion is described. A B represent the line of motion of the piston, and C D that of the pencil. The dotted lines E F and J I represent levers. Line F I represents a link connecting such levers. M represents the pencil-point. The line A B represents the path through which the indicator-piston moves. O P represents a link connecting the line A B with the line E F. Now, as the line E F from E as a pivot moves through the arc G H and the line J I from J as a pivot through the arc K L it will carry the point M of the line F I through the straight line C D, which line is parallel with line A B. It follows therefore that the line O P and F I if parallel in one position will be parallel in every position. A straight line will always connect E P M, and M, moving in the line C D, will be parallel with P, moving through the line A B.

The diagram in Fig. 11 represents the Thompson parallel motion. A B represents the piston-rod, and C D the line through which the pencil moves. The dotted line E F represents the pencil-bar swinging from E of the dotted line E L, which dotted line represents a link. The dotted line O P represents a link connecting E F with A B. Now, as P of the line O P moves through the line A B it will cause I of the line I K to move through the arc M N, and will also carry F of the line E F through the line C D, and E of the line E L through the arc T W. O will also move through the angular curve R S. Now, as the arcs M N and T W are fixed and constant, the position of F, by means of the versed sine of the arc T W, will cause the position of F to vary with each of the several positions occupied by P, moving through the line A B. This is made apparent in a practical manner by the following operation: A model of this parallel motion having been made, a micrometer-screw cut forty to the inch, with a graduating-sleeve reading to thousandths, is fitted under the piston in the line A B with the screw just touching the piston. A paper is placed on the drum of the indicator and the pencil in the end of the pencil-bar is brought into contact with the paper. The drum is turned slightly and the first or lower

mark of the series of graduations 27 at the left of Fig. 11 is traced, one turn of the micrometer-screw is made and the second line of the series is traced, and each succeeding turn of the screw a corresponding line of the scale is made. As the multiplication of movement was four to one, the lines drawn in the scale 27 should be exactly one-tenth of an inch apart for every one-fortieth-of-an-inch movement of the piston. A falling off in the graduating-scale is very apparent when the scale of inches 28 is consulted; a shortening of the scale is very perceptible in the lower graduations. An examination of the diagram in Fig. 11 will show why these errors occur. When the lower mark of the graduating-scale 27 was made, the line O P at O was in the irregular curve R S, nearly to the arc M N; but as motion was given the piston the point O moved in a line drawing rapidly away from arc M N, and at the same time the point E moved rapidly through the elevation represented by the versed sine of the arc T W, causing by this counteraction the pencil to fall, and thus record irregular graduations.

To rectify these errors, I have devised a compensating medium in the curved upper surface 24 of the piston-rod.

By referring to diagram in Fig. 12 will be shown the principle on which curve 24 operates to correct the errors above described. A B represent the line of motion of the piston, C D that of the pencil. The dotted lines represent the moving parts, line E F representing the pencil-bar, which turns at E on the fulcrum-link E L, substantially as in the Thompson.

I K represent the vibrating arm pivoted at I to the pencil-bar E F. This arm moves about the fulcrum K in the arc M N. Through the medium of such arm the point F of the bar on line E F is caused to move in the line C D and the point E in the arc T W. The pencil-bar or line E F has the roll 26 connected thereto, as before described, which engages with the line O P, which line represents the curved surface 24 of the upper part of the piston-rod, as the same law governs the action of the pencil under the influence of the vibrating links I K and E L in this case as in the Thompson invention.

The curved surface 24 (represented by line O P) is so formed or adjusted that while the piston is being moved in the line A B the point S (which is the center of the circle described by the roll 26, whose periphery touches the line O P) moves on the left-hand side of line A B and at right angles to such line and on the right-hand side through an arc, the relative combination of these surfaces compensating for the variations represented at this point by the Thompson parallel motion.

The same practical test of the micrometer-screw applied under the piston of my improved device resulted in producing the uniform scale 29. (Seen to the left of the diagram in Fig. 12.) As the multiplication of the power of the levers in this device is five to one, the scale will be, as represented, in one-eighth of an inch. The inch-scale to the left of graduating-scale 29 shows the value of my improvement in obtaining the exact subdivision of the inch into equal parts. It will be observed on referring to the drawings, Figs. 1 and 2, that the curved surface is an irregular one, which curve is the path of the roll 26, thus compensating for the variations above alluded to. The pencil-bar 11 has the forked end 11′ (see Fig. 3, Fig. 2 showing one of such forks removed) to admit the upper curved top 37 of the piston-rod, the roll 26 being supported on pin 30, passing transversely through such forks, as seen at Fig. 1.

To keep the roll always in contact with the surface 24, the spring 31 (see Fig. 14, which represents a perspective view of such spring, a sectional view being also shown in Fig. 3) is coiled around the hub of the vibrating lever 12, which hub is secured by the screw 32 to the standard 33, one arm 34 of such spring engaging with the vibrating lever 12, and the other arm 35 engaging with pin 36 of the standard 33. Thus a downward pressure is always exerted on the pencil-bar through such lever. This pencil-bar spring keeps such bar steady, and prevents undue oscillation or fling, and would be an important feature on any parallel motion, even if not used in connection with the upper curved surface of the piston-rod. It will be observed that in appearance the upper portion or top of the piston-rod is an irregular-shaped slot; but it must be distinctly understood that the upper portion 37 has no reference to the compensating-curve 24. Such upper portion 37 may be removed entirely, as shown in Fig. 2. Therefore it does not operate in any manner to assist such curve in performing its part in establishing the equality of ratios. It simply prevents the dislodgment of the roll 26 in shipping or rough handling of the instrument.

The standard 33 and the lug 38, to which the link 13 is hinged, are both mounted on the swivel-plate 39. This plate is provided on the swivel with the boss 40, which fits a recess in the cap 7. This plate is held in position by the piston-rod guide-sleeve 6, which sleeve is double-shouldered at 41 and 42, one of which shoulders abuts firmly against the cap 7, and the other holds the swivel-plate sufficiently firm to enable the latter to turn or swing to and from the drum. The proper relation of the pencil to said drum is regulated by means of the screw 43, (see Fig. 3,) which screw passes through said plate and engages with the pin or standard 44 of the frame 2. The jam-nut 45 on said screw locks it in any position required.

The piston-rod guide-sleeve 6 (see Fig. 2) serves a threefold purpose. It holds the swivel-plate in position, it serves as a guide for the piston-rod, and the threaded end 46, which projects through the cap 7, engages with the threaded mounting 47, to which the

pressure-spring 9 is secured. As more or less steam will leak by the piston and create back-pressure thereon, an outlet is provided for such leakage through the nipple 8, which nipple is screwed into the casing 1. The outer projecting end of such nipple is made sufficiently long to receive preferably a flexible tube, and this tube will carry the steam far enough away from the instrument so as to avoid soiling the card.

The oil-hole 48 is provided through the casing just above the cylinder 3, so that the piston may be lubricated without removing the same. When not used and to prevent the escape of steam, said hole is closed by the guard 49, controlled by stud 50. A clearer view of this feature may be seen in the section detail view in Fig. 7, representing a section of the stud through line x^7 of Fig. 2. The thumb-nut 10, (see Fig. 2,) which engages with the lower threaded end of the piston-rod 5 and connects the piston and rod, is provided with the taper head 51, which fits closely a taper seat provided in the upper part of said piston. This ground taper joint prevents the steam escaping through the piston-rod opening in the piston.

As an improvement in the manner of attaching the instrument to the engine-cylinder, the lower end of the cylinder is provided with the flange 52. The flange 53 of the shell 54 engages therewith. The internal-threaded ring 55 is placed within the shell 54 and held there by means of the screwed ends 56 of handles 57, passing through the shell 54 and into threaded holes in the ring 55. The cock (not shown) to which the indicator is supposed to be attached is provided with a taper mouth to receive the taper end 58 of the cylinder. The threaded ring 55 engages with a thread formed on the cock, so that by means of the flanges of the cylinder and shell, together with the threaded ring and the handles, a firm connection is made to the cock. Formerly the connection between the indicator and the cock was too frail. As the whole weight of the instrument must be supported on the cock a firm connection is very essential, in order to prevent undue vibration of the moving parts. Another advantage of this connection aside from its importance as a rigid connection, is the simplicity of construction. All the parts are susceptible of being duplicated by means of the proper tools and at small cost.

To preserve the alignment of the drum and take the strain from the drum-carriage, the long central sleeve 59, mounted on the drum-stud, is attached to the top or cap of the drum and also to the flange or web 62, which web and sleeve by their rigid connection with each other practically form one piece. This arrangement thoroughly braces the drum and steadies it in its rotating movement. This internal support also enables the drum to withstand such outward pressure or blow as would otherwise dent or distort its surface.

The central bearing of the drum-carriage 16 (see Fig. 2) engages with the enlarged portion 63 of the drum-stud. The hub 64 of said carriage also fits a recess in the bushing 65, a reduced portion of which bushing enters the frame 2. An enlarged portion of the bushing 65 also enters plate 66. The shoulder 67 of the drum-stud is also seated in the bottom of the recess in the bushing 65 and held there by means of the lower threaded end 68. A thumb-nut 69 and washer 70 hold the cord-guide plate 66 in any position required. The inner end of the coiled clock-spring 17 within the drum-carriage is attached to sleeve 72, mounted on the drum-stud 60. Each end of such sleeve is squared. One of such squared ends 73 can be seen more readily in Fig. 5, which represents a plan of the frame 2 and drum-carriage mounted thereon with drum and disk 74 removed, showing an interior view of the carriage.

Mounted on the drum-stud 60 and just over the disk 74, but not in contact therewith, is the ratchet-wheel 18, its pawl 19 and pawl-spring 75 being attached to the disk 74. A pin 76 passing transversely through the ratchet- and drum-stud rigidly secures said wheel to the stud. The object of the ratchet-wheel is to wind up the clock-spring in the drum-carriage to the proper tension required to return the drum back to its normal position. When the drum is being revolved, the disk 74, sleeve 72, and pawl 19 remain stationary.

The outer end of the clock-spring 17 is provided with the loop or eye *a*, which eye engages with the stud 77. (See Fig. 5.) This stud has an intermediate thread, which is fitted to a hole, which hole passes through the base of the drum-carriage. (See Fig. 2.) The head 78 of such stud enters the circular groove 79, which groove is formed in the upper surface of the frame 2. This groove does not extend entirely around the circle, the narrow bridge or neck 80 (see Fig. 5) being left to form a stop for the head 78, so as to limit the travel of the drum-carriage.

The instrument is intended to be used right or left handed, the views all showing a right-hand construction. The cord 81, which passes around the outer circumference of the drum-carriage in groove 82, rotates the drum and carriage from right to left. To reverse this motion, the spring 17, together with its sleeve 72, is removed from the drum-stud and turned over. This brings the lower squared end 83 (see Fig. 2) of the sleeve 72 uppermost. This reverses the retractile power of the spring—*i. e.*, the spring unwinds in the opposite direction. The pawl is also turned over on the disk, so as to engage the ratchet in the opposite direction, said ratchet being also reversed. The lead of the cord 81 around the carriage-drum will also be reversed. The position of the spring-stud 77 will be at the right side of the bridge 80, instead of the left, as shown in Fig. 5.

In changing from right to left hand the pencil-bar 11 is placed on the opposite side

of the standard from what it now occupies in the different views. The stop-pin will also be entered from the opposite side of swivel-plate 39. Said plate will then be turned around, bringing the pencil in contact with the opposite side of the drum The standard 33 in the above operation is also turned on its axis simply by loosening screw 84.

Heretofore it has been customary to detach or unhook the indicator-cord from its engine-connection in order to stop the drum, to remove the card after a diagram has been taken. The rapid movement of the cord under high speeds renders this a difficult operation. To overcome this difficulty, I propose to stop the drum at the point of its forward completed stroke. This I accomplish by means of a spring stop-pin in the following manner: This stop-pin 85, which projects through frame 2, (see Fig. 2,) is actuated by the spring 86 in the pocket 87, which pocket projects downward from said frame. The pin 85 has the projection 88, (see also Fig. 8,) which engages with the lower end of the pocket when the spring 86 is compressed and drops into the notch or slot 89 when said pin is released. When the drum by means of its connection with the engine has been carried or rotated to the proper point, then the stop-pin 85 is released and its conical-shaped point engages indentations 90, provided on the under side of the drum-carriage. In place of such indentations, as shown in Fig. 2, the bottom surface 90′ of the drum-carriage may be corrugated, as shown in Fig. 8. This will check the movement of the drum, so that the card or diagram-paper may be removed and replaced by a new one. In the meantime the cord-connection between the indicator and the engine is unbroken. As the drum was stopped when the slack of the cord was all taken up, said cord will merely vibrate with the motion of the engine. Disengaging the stop-pin will instantly cause the drum to resume its rotating motion.

Another feature in my improved indicator is the manner of constructing the paper-spring which holds the card or diagram-paper to the face of the drum. Heretofore the spring has been screwed directly to the drum and the drum made thick enough to support the screw. To avoid this extra thickness of the drum, which should be as light as possible, I provide the support 91, (see Fig. 1,) which support is attached to the drum by the rivets 92, (see also Fig. 4,) which view represents a plan of the bottom of the drum and a section of the spring-support through the line of the rivets. The lugs 93 are formed on the inner face of such support, so as to form the bridge 94, thus leaving an open space between the drum and spring-support. The hole 95 (see Fig. 4) is also provided through the bridge. Within the open space between said drum and bridge is inserted the tongue 96. (See lower broken section of the paper-spring 97 in Fig. 6.) The tapped hole 98 is provided in the tongue to receive a screw 99 (see Fig. 1) and hold it rigid to the bridge of the support. By this method of attaching the spring it is rendered more flexible and even in its action and less liable to break.

A further improvement in connection with the drum consists in providing a compensating balance thereon for the purpose of causing the oscillations of said drum to be more equally in time in its relative positions with the positions of the piston of the engine during its stroke. In other words, this compensating balance placed eccentrically with the axis of the drum will preserve the equilibrium of such drum in its reciprocative action and prevent undue fling or throw of the drum, so that the steam-engine at the beginning of its return-stroke and the reverse or return motion of the drum shall be identical, both movements occurring simultaneously. I accomplish this by means of the adjustable radial arm 100, (see Figs. 2 and 13, Fig. 13 being an inverted sectional plan of the drum through line Y^{13} of Fig. 2,) which arm is attached to the end of the central sleeve 59, which projects below the web 62. The hub of the arm abuts against said web, and is held there rigidly by means of the threaded nut 102. The slot 103 is provided in said arm for the weight. Such weight is provided with the slotted head 104 and a threaded body, which passes through the slot of the arm and engages the threaded nut 105, the whole forming the counter balance or weight.

The compensating feature of this balance lies in the ability with which it can be adjusted to any angle of any fixed positions of the drum. These fixed positions relate to the different positions of said drum under the different tensions of the drum-carriage spring 17. This is accomplished by adjusting the weight in or out on the radial arm or turning said arm on its axis, or both. As the horizontal line drawn by the pencil on the drum represents in its length the stroke of the piston of the engine in reduced form, any position in this line must exactly represent the position of the piston of the engine in its stroke. To make the drum under the influence of the spring under various tensions at various speeds perform this duty, the counteracting influence of the weight has necessarily been called into play.

A further improvement of my device relates to the construction of the cord-guiding attachment, which attachment is mounted on the plate 66, a hole in said plate engaging with the enlarged portion of the bushing 65, and such plate held in any required position by the nut 69 and washer 70. The housing 22 has the threaded stud 106, which projects through said plate and is held there by nut 107. The hole 108 is provided through such housing to admit the hub or sleeve 21 of the pulley-hanger 110. (See also Fig. 9, which is a section through x^9 of Fig. 2.) Said hub has the hole 111, through which the cord passes

to the pulley 20. The object of this construction is, first, to carry the cord from the drum-carriage to the engine-connection through the medium of the pulley, with an equal tension between said pulley and the drum-carriage; second, insuring the positive turning of the pulley on its axis 112; third, that the cord shall be kept in position about the drum-carriage and not allowed to drop away. All these features are accomplished by widening the face of the pulley, so that the cord may be wound once or more times around the same.

The housing may be turned on its supporting-plate at any angle required, or said plate turned on its support on such bushing 65, or both, so that the cord may lead from either side of the drum-carriage for either a right or a left hand arrangement of the instrument.

I have provided a novel feature in clamping the cord attachment to its supporting-plate. The hub 21 of the pulley-hanger has the groove 113 formed around its face, and into such groove the projection 114 of the key 23 is forced when the housing is drawn downward by means of the nut 107, thus effectually clamping such hub firmly against the upper wall of the hole in such housing.

Heretofore a plain hook has been used to connect the indicator with the engine. This does not admit of the stretch of the cord being taken up. To overcome this, I have provided the adjustable hook 115, having its end threaded, which threaded end engages the threaded swivel 116, by means of which any stretch of the cord may be taken up without loss of time.

Heretofore a plain hole has been provided in the end of pencil-bar to admit the pencil, and much difficulty has been experienced in getting a nice adjustment of the point in its proper relation with the diagram-paper on the drum. I have provided the threaded hole 117 (see Fig. 3) in the end of the pencil-bar, and into which is screwed the threaded metallic pencil 118.

To further facilitate the construction of the device, the frame 2 (see Fig. 2) and the casing 1 are made separate. The shoulder 119 on such casing forms a seat for such frame. The hole 120 (see Fig. 5) is provided in the frame to engage with the body of the casing above the shoulder 119. The threaded nut 121 engages a thread on the exterior of the casing-body and holds said frame firmly on its seat.

It is evident that some of the details of construction in the above-described device may be modified or changed without departing from the spirit of my invention—such, for instance, as the position of the drum counter balance or weight, which would be equally as effective if placed on the drum-carriage instead of on the drum, as shown.

Having thus described my invention, what I claim, and wish to secure by Letters Patent, is as follows:

1. As an improvement in steam-engine indicators, as a compensating feature in the parallel motion to equalize the motion of the pencil to the motion of the piston, the combination, with the piston-rod and the pencil-carrying bar, of a contact-surface, preferably situated at the upper end of such rod and rigidly secured thereto and projecting laterally therefrom and in the direction of the forward and backward movement of the pencil-carrying bar, such surface to engage with said bar, and means to bring about such engagement, the contour of the face of such surface of the piston-rod engaging such pencil-carrying bar being so formed or shaped that the piston in its movements will cause the pencil at the end of the pencil-carrying bar to move throughout its full range in an equal ratio of time with the movement of the piston, substantially as and for the purpose set forth.

2. The combination, in a steam-engine indicator, of a pencil-carrying bar and a vibrating arm or link loosely connected by one of its ends to the pencil-carrying bar, its other end loosely journaled to a fixed standard, with a spring exerting a downward pressure to the pencil-carrying bar through the medium of the vibrating arm or link, so as to prevent undue vibrations while such pencil-bar is in motion, substantially as set forth.

3. The combination, in a steam-engine indicator, of the piston-rod 5, having at its upper end the laterally-projecting surface 24, pencil-carrying bar 11, having the roll 26 to engage with such upper surface of the piston-rod, and the spring 31, exerting a downward pressure to the pencil-carrying bar through the medium of the vibrating arm 12, so as to keep the roll of the pencil-carrying bar always in contact with such upper surface of the piston-rod, as described.

4. The combination, in a steam-engine indicator, of the swivel-plate 39, having standard 33 and lug 38 mounted thereon, which standard and lug support the several levers of the parallel movement, said plate having a circular hub or projection engaging with a recess in the cap of the cylinder shell or casing and arranged to revolve thereon, with the piston-rod guide-sleeve 6, having lower threaded end to engage a threaded hole in said cap, and a projecting shoulder on such sleeve to engage with and hold in place the swivel-plate, as set forth.

5. The combination, in a steam-engine indicator, of the piston-rod and the casing-cap with the long guide-sleeve mounted on such rod, said sleeve having a threaded end engaging a threaded hole in such cap, a portion of such threaded end projecting through said cap and engaging with the upper spring-mounting of the pressure-spring within such casing, as described.

6. The combination, in a steam-engine indicator, of the swivel-plate 39 with the standard 33, said standard arranged to be revolved upon its axis on such plate, and means to se-

cure such standard fixedly in any position required, as set forth.

7. In a steam-engine indicator, the outer casing or shell of the cylinder provided with the nipple 8, to which a hose or pipe may be attached to provide an outlet for steam escaping by the piston, substantially as set forth.

8. In a steam-engine indicator, the cylinder casing or shell having an oil-hole communicating with the interior of such shell and the cylinder, such hole situated in said casing at a point above the cylinder, and a cover to close such hole, so as to prevent the entrance of dust and escape of steam from the casing, as described.

9. The combination, in a steam-engine indicator, of the piston-rod 5, having its lower end threaded, piston 4, attached to such lower end, thumb-nut 10, having a threaded hole to engage the threaded end of said rod, and a taper head 51, which engages with a corresponding taper seat provided in the piston, so that by the engagement of such taper surfaces a close joint is formed to prevent the escaping of steam by the piston, as set forth.

10. The combination, in a steam-engine indicator, of the drum-carriage, drum-stud, frame 2 to support such stud with the drum, having the long sleeve journaled on said stud, said sleeve rigidly attached to the upper portion or cap of said drum, and a web radiating from the lower end of said sleeve and rigidly secured to the internal surface of the drum, whereby the same is braced and strengthened on its support, as set forth.

11. The combination, in a steam-engine indicator, of the drum-carriage, the coiled drum-carriage spring mounted thereon, the outer end of such spring attached to said carriage, the drum-stud, a sleeve journaled on such stud, said sleeve attached to the inner end of the coiled drum-carriage spring, a ratchet-wheel rigidly attached to the drum-stud, a horizontally-placed disk attached to the spring-sleeve, and a pawl mounted on such disk to engage the ratchet-wheel, so that the tension of the drum-carriage spring may be regulated.

12. The combination, in a steam-engine indicator, of the drum-stud, a frame to support such stud, the drum-carriage journaled on said stud, a spring mounted on such carriage, the inner end of such spring attached to a sleeve journaled on the drum-stud, the outer end of such spring attached to the drum-carriage, a ratchet-wheel rigidly attached to the drum-stud, and a disk carrying a pawl, which pawl engages said wheel, said disk mounted on one end of the sleeve of the drum-carriage spring, said sleeve so constructed that it may be reversed and either end engage with such disk, and by such construction the indicator may be used either as a right or left hand instrument, as described and set forth.

13. The combination, in a steam-engine indicator, of the drum-stud, the drum-carriage journaled on such stud, and the coiled drum-carriage spring having its outer end attached to said carriage and its inner end attached to a sleeve journaled on such drum-carriage, as set forth.

14. The combination, in a steam-engine indicator, of the drum-stud 60, the drum-carriage 15, journaled thereon, the drum-carriage spring 17, and sleeve 72, to which the inner end of such spring is rigidly attached, such sleeve journaled on the drum-stud, the outer end of such spring provided with a ring to engage the stud 77 of said drum-carriage, head 78 of such stud projecting below said carriage to engage a stop adjacent to such carriage, and by means of which stop the maximum travel of the drum-carriage is limited, substantially as described.

15. The combination, in a steam-engine indicator, of the drum-carriage, the paper-carrying drum mounted thereon, drum-stud on which said carriage is journaled, drum-carriage spring, drum-carriage-spring sleeve journaled on said stud, stud 77, attached to said drum-carriage to engage with the outer end of said drum-carriage, spring-head 78 of such stud projecting below such carriage, groove 79, formed in the frame 2 to admit such head, and a stop provided in such groove to act as a stop against which said head may engage to limit the maximum travel of the drum-carriage, substantially as set forth.

16. The combination, in a steam-engine indicator, of the drum-stud 60, the drum-carriage 17 journaled thereon, drum 15 mounted on such carriage, with a stop-pin 85 of frame 2, spring 86 actuating such pin, and means provided on said drum-carriage to engage with the point of said stop-pin to hold said carriage in any position required, as set forth.

17. The combination, in a steam-engine indicator, of a rotating drum-carriage, a paper-carrying drum mounted on such carriage, a compensating balance or weight attached to such drum or carriage, such balance placed eccentrically with the axis of such drum or carriage, such balance arranged to be shifted in any position about such axis, thus causing the moment of the reverse action of said drum and carriage to be in exact time with the moment of reverse action of the piston of the engine, as set forth.

18. The combination, in a steam-engine indicator, of the wide-faced cord-guiding pulley 20, its pulley-hanger 110, on which such pulley is journaled, housing 22, within which is journaled hub 21 of such frame, said housing mounted on plate 66 and arranged to turn in a horizontal plane thereon, so as to guide the cord from either side of the drum-carriage, key 23, to clamp against said hub of the pulley-frame, and nut 107, to hold such cord-guiding attachment firmly on said supporting-plate in any position required, as described and set forth.

19. The combination, in a steam-engine indicator, of the casing 1, having the projecting shoulder or flange 119, frame 2, situated on

such flange projection, and threaded nut 121, engaging a threaded portion of the casing to hold such frame firmly on its seat, all substantially as described, and for the purpose set forth.

20. The combination, with the paper-carrying drum of a steam-engine indicator, of the spring-support 91, lugs 93, projecting from the inner face of such support, said lugs arranged to rest upon the outer surface of the drum, thereby forming an open space between such drum and the inner face of the support, means, substantially as shown, to secure said support to the face of the drum, the paper-holding spring having the tongue 96, which tongue is inserted within the said open space between the support and drum, and means, substantially as shown, for holding such spring through the medium of its tongue rigidly to the support, all substantially as set forth.

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

ALMON B. CALKINS.

Witnesses:
SIGMUND LOEWITH,
GEO. D. PHILLIPS.