No. 624,151. Patented May 2, 1899.

G. F. ATWOOD.

MEAN EFFECTIVE PRESSURE INDICATOR.

(Application filed July 2, 1898.)

(No Model.) 4 Sheets—Sheet 1.

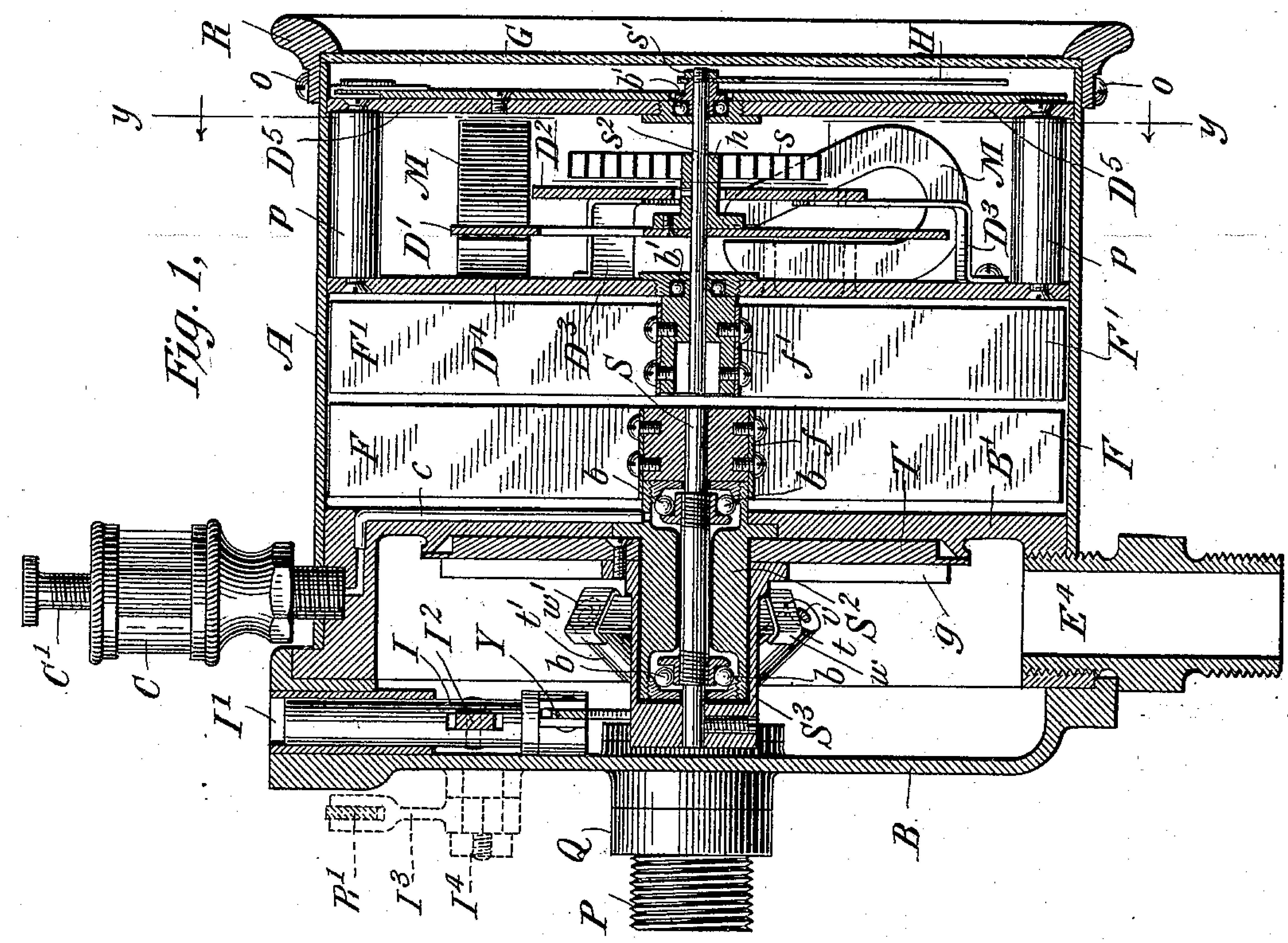

Fig. 1,

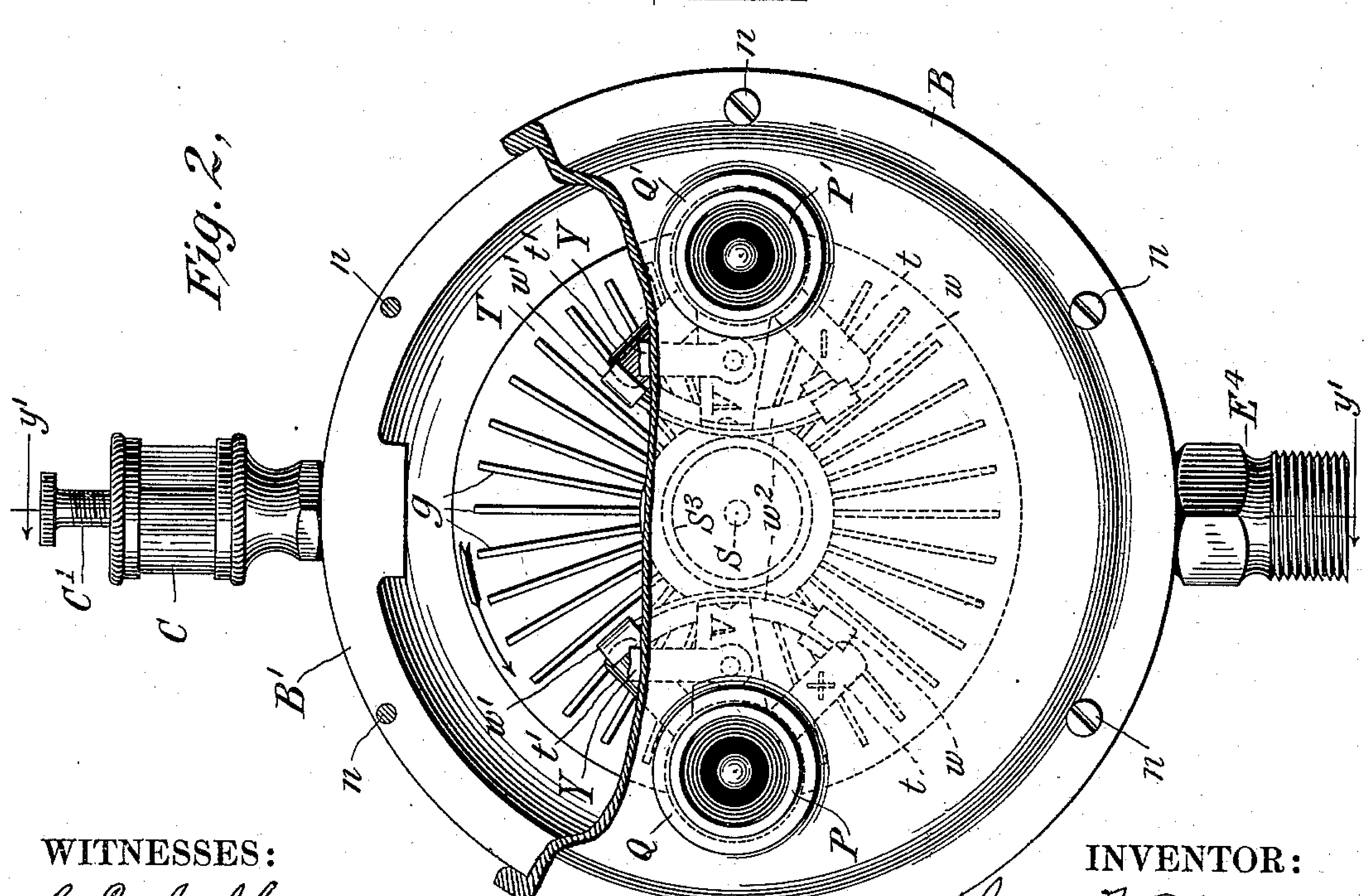

Fig. 2,

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THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

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(No Model.) 4 Sheets—Sheet 2.

Fig. 3,

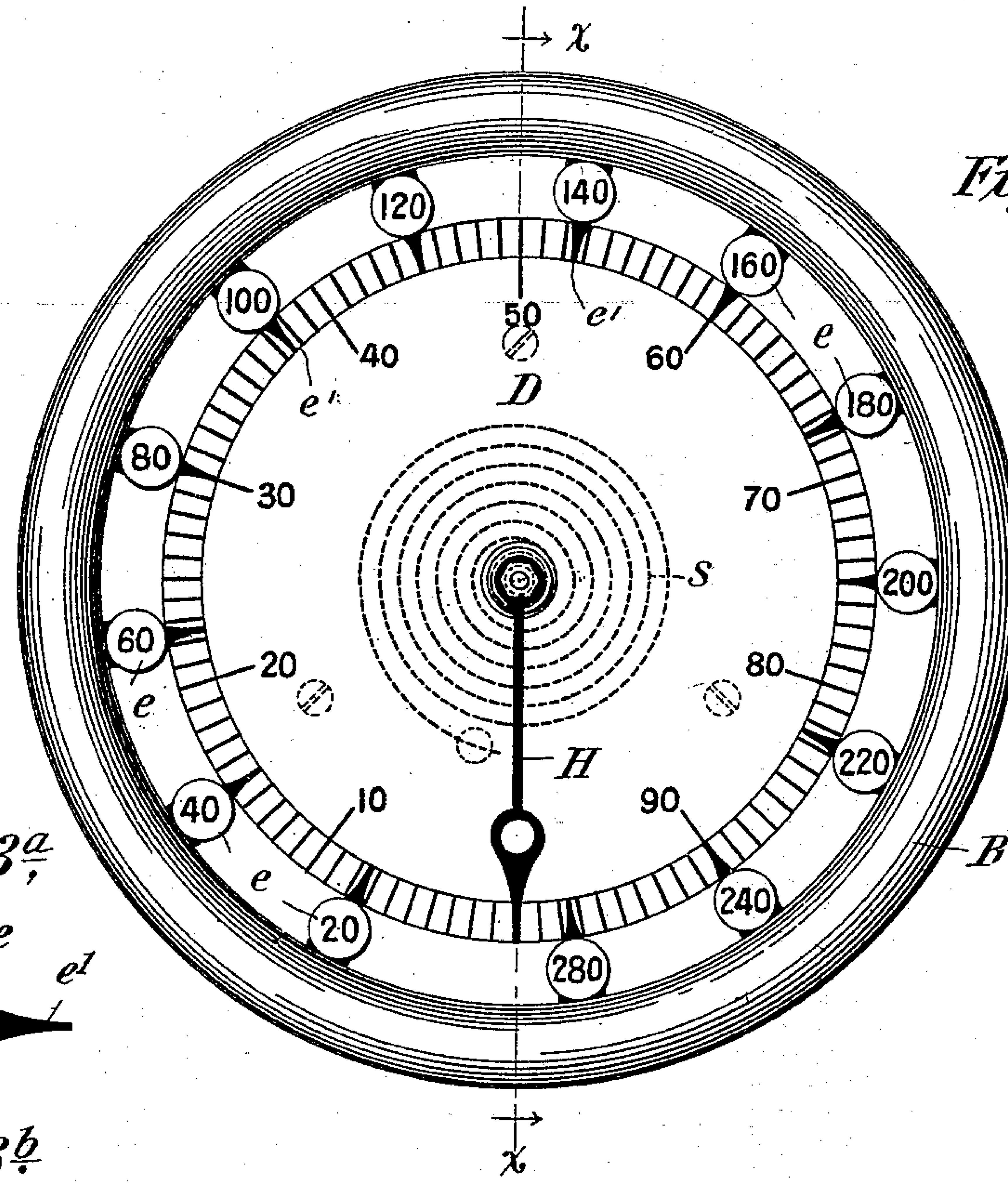


Fig. 3a,

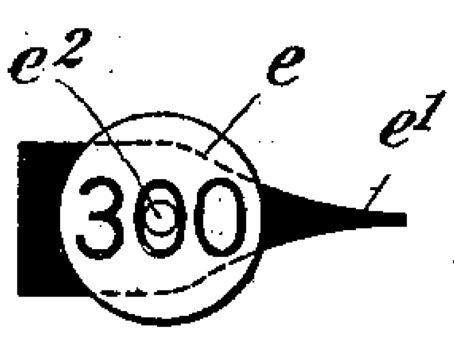


Fig. 3b,

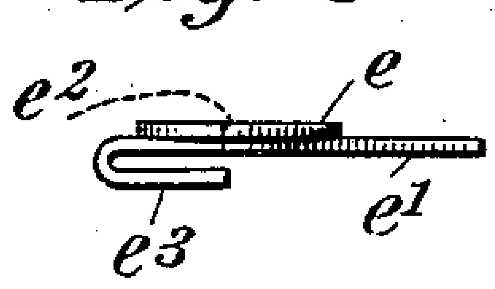
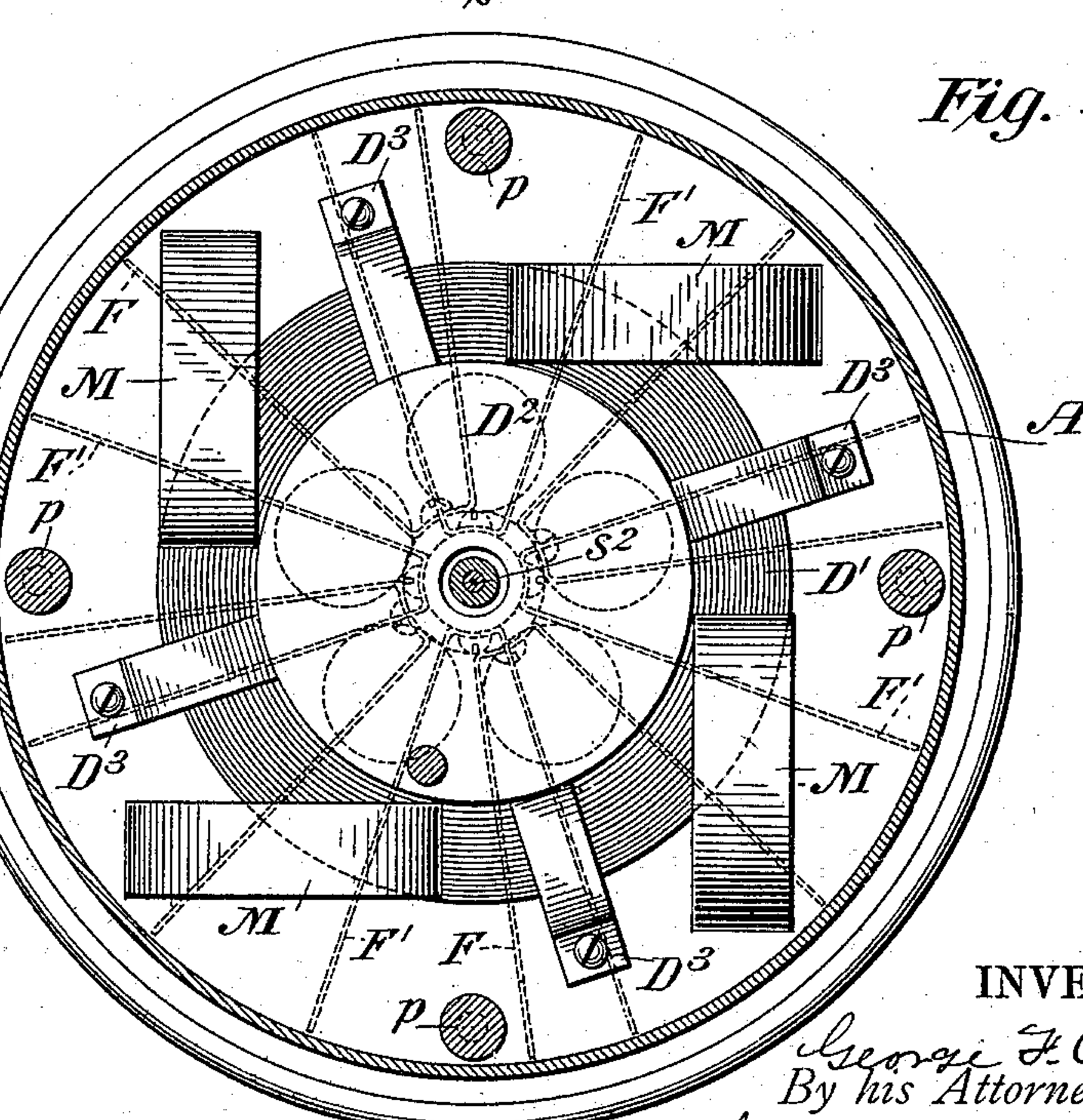


Fig. 4,



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(No Model.) 4 Sheets—Sheet 3.

Fig. 5,

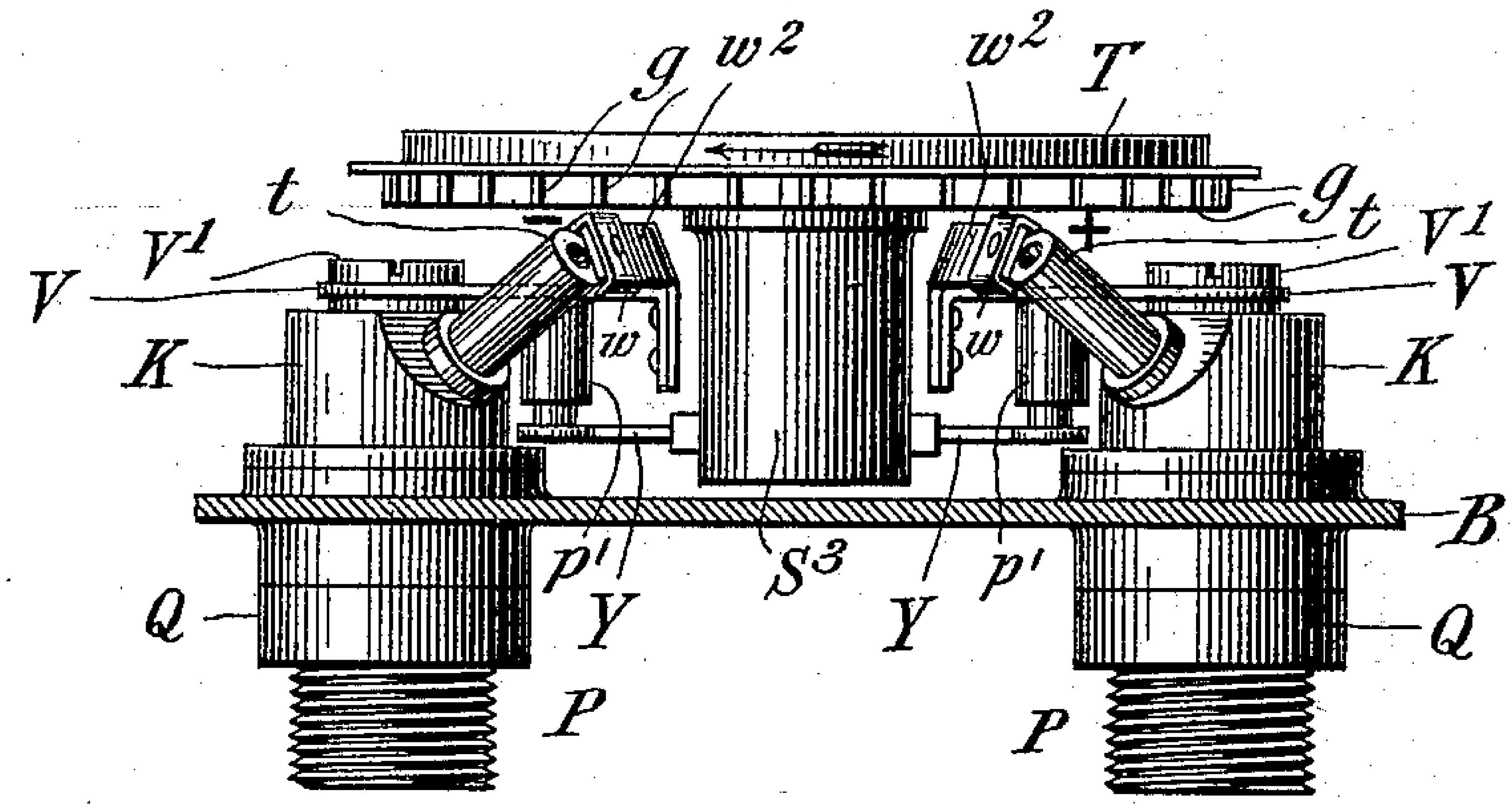


Fig. 5a.

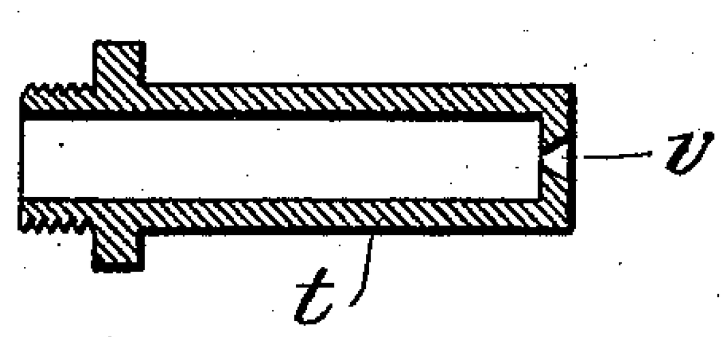
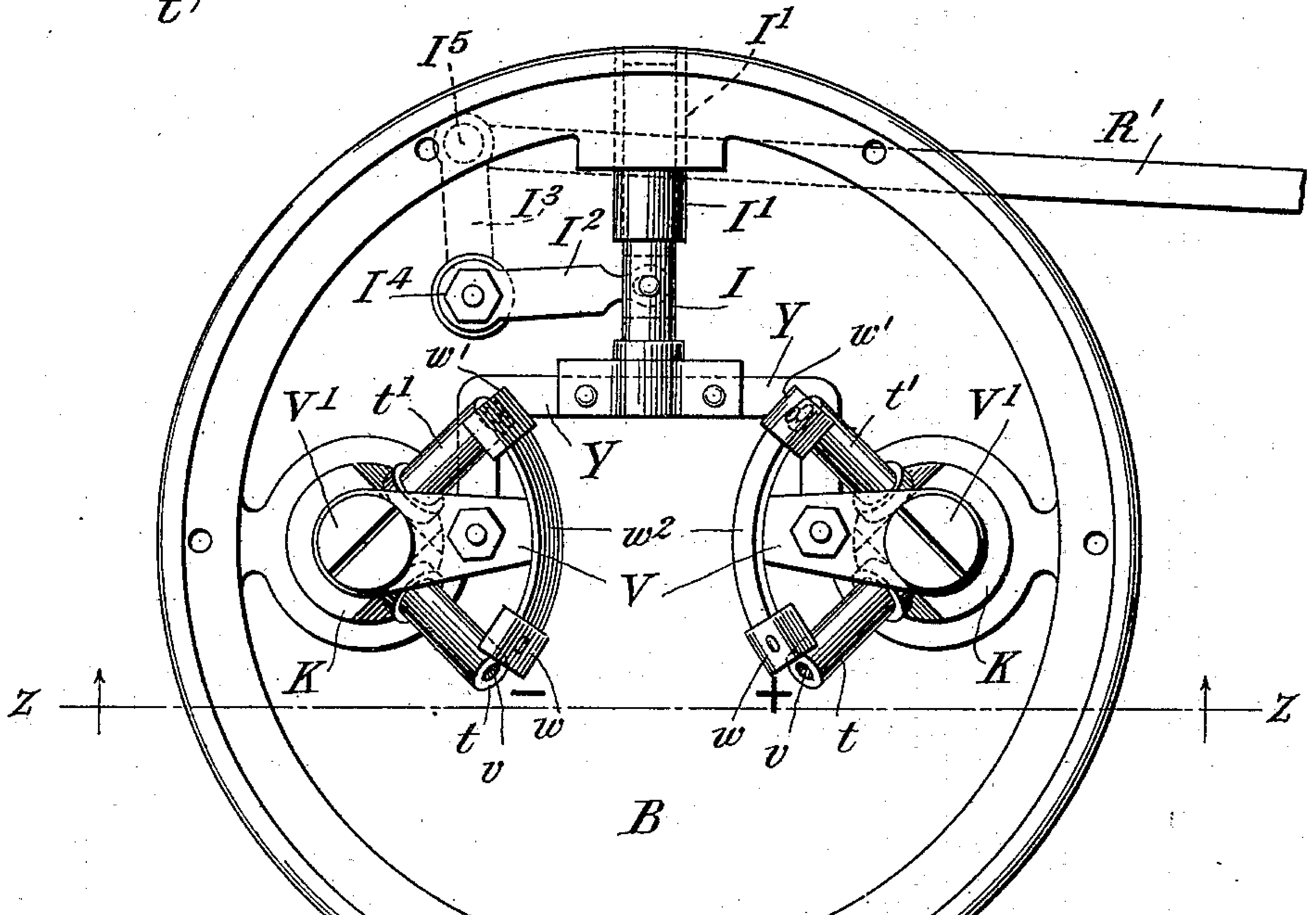


Fig. 6,



WITNESSES:

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MEAN EFFECTIVE PRESSURE INDICATOR.

(Application filed July 2, 1898.)

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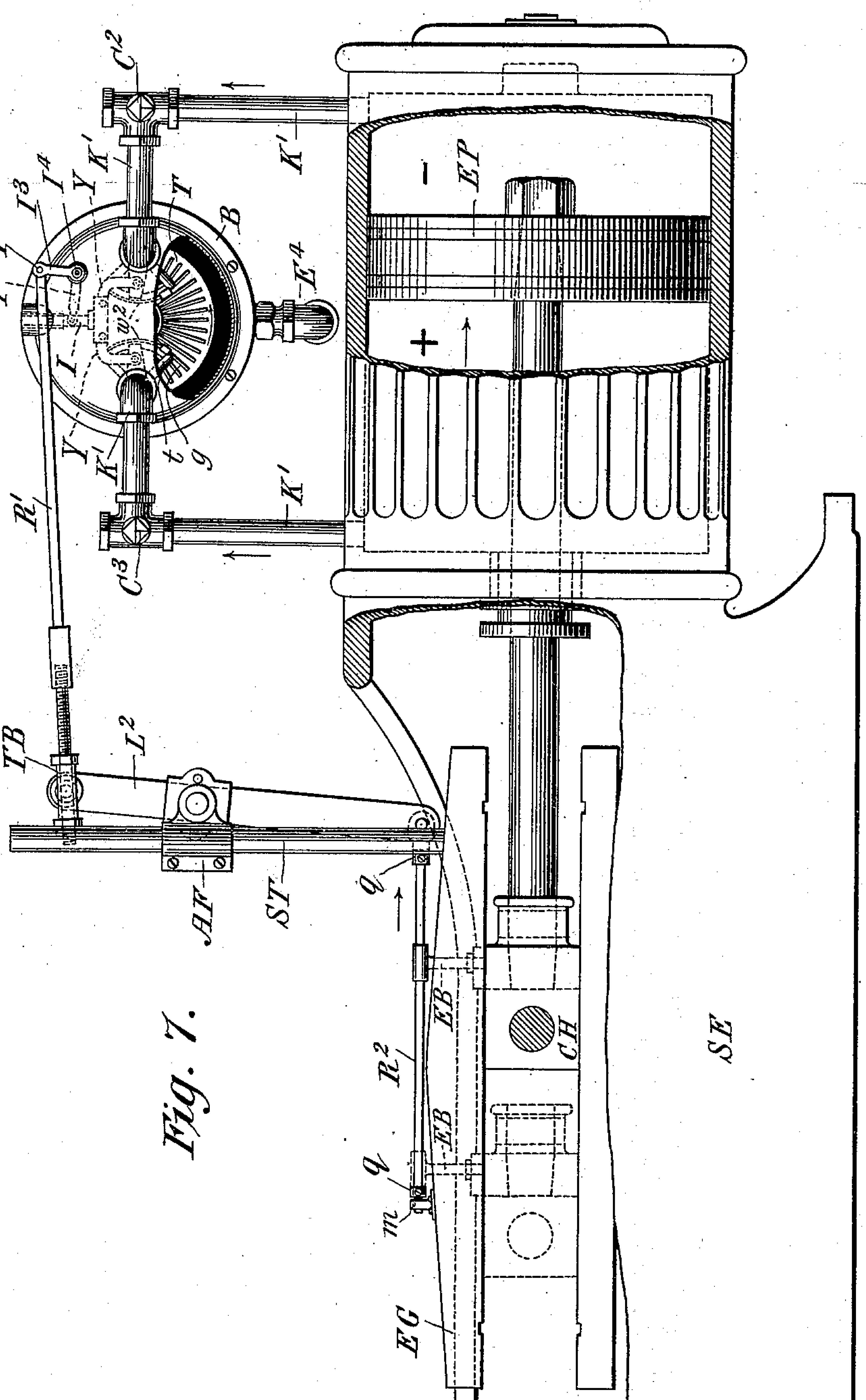

Fig. 7.

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UNITED STATES PATENT OFFICE.

GEORGE F. ATWOOD, OF ORANGE, NEW JERSEY, ASSIGNOR TO THE ATWOOD POWER AND SPEED GAGE COMPANY, OF NEW JERSEY.

MEAN-EFFECTIVE-PRESSURE INDICATOR.

SPECIFICATION forming part of Letters Patent No. 624,151, dated May 2, 1899.

Application filed July 2, 1898. Serial No. 685,072. (No model.)

To all whom it may concern:

Be it known that I, GEORGE F. ATWOOD, a citizen of the United States, residing at Orange, in the county of Essex and State of New Jersey, have made a new and useful Invention in Mean-Effective-Pressure Indicators, of which the following is a specification.

The present invention is directed to improvements upon an instrument disclosed in a prior application, filed by me in the United States Patent Office on the 9th day of March, 1897, bearing Serial No. 626,595; and its objects are, first, to provide an indicator of the character referred to which will more accurately indicate the mean effective pressure of the motive agent when in operation in prime movers—such, for instance, as steam, gas, air, or water motors—than was possible with the instrument disclosed in the prior application; second, to make it possible to calibrate an instrument of the character indicated in the factory where it is constructed instead of empirically in connection with the particular engine to which it is to be applied, as was the case with the instrument disclosed in the prior application; third, to provide a nozzle or nozzles for directing the flow of the motive agent to the motor which shall not become clogged or choked up with the decomposed or volatilized lubricants; fourth, to provide opposing sets of nozzles and movable screens for deflecting or shutting off the steam or other motive agent emitted therefrom upon the motor or turbine which drives the indicator in such manner that the effective pressure upon the piston of the prime mover or engine shall be practically duplicated in its action upon the rotary motor or turbine which drives the indicator. These several objects are accomplished by the invention hereinafter described and illustrated in the accompanying drawings, to which reference is had for a full understanding thereof and to the following specification, the essential points of novelty being particularly pointed out in the claims at the end thereof.

Referring now to the drawings, Figure 1 is a vertical sectional view of the entire instrument, taken on the line $y' y'$, Fig. 2. Fig. 2 is a rear elevational view of the instrument as seen looking at Fig. 1 from the left toward the right hand side of the drawings, part of the casing being broken away to better illustrate the interior structure of the instrument. Fig. 3 is a front elevational view as seen looking at Fig. 1 from the right toward the left hand side of the drawings. Fig. 3ª is a detail plan view, and Fig. 3ᵇ is a side elevational view, of an adjustable supplemental index to be used in connection with the stationary scale of the instrument. Fig. 4 is a transverse sectional view of the instrument, taken on the line y y (see Fig. 1) and as seen looking at that figure of the drawings from the right toward the left hand side thereof. Fig. 5 is a sectional view taken through Fig. 6 on the line z z, parts of the instrument being shown in elevational view as seen looking at said figure from the bottom toward the top of the drawings in the direction of the arrows. Fig. 5ª is a detail view of one of the nozzles which direct the propelling medium, such as steam, upon the buckets or vanes of the motor. Fig. 6 is a front elevational view of the nozzles and the pivoted screens for opening and closing the outlets of the nozzles and the interconnected mechanism for effecting such result. Fig. 7 is a side elevational view of an ordinary steam-engine, illustrating the application of my invention thereto, parts of the engine and instrument being broken away to better illustrate the working of the same.

In the use of the instrument disclosed in my prior application above referred to it was necessary to calibrate the scale thereof empirically in connection with the prime mover or engine to which it was to be applied and for given or fixed conditions as to valve adjustment, speed, and exhaust thereof.

To illustrate, suppose an instrument to be calibrated in connection with an engine running at a given speed and exhausting into the atmosphere. If it be desired to change the speed of the engine or to connect the exhaust to a heating system or a receiver for a low-pressure cylinder or in any way to vary the conditions under which it was previously calibrated, recalibration was necessitated, and it was with a view of overcoming this defect that the present improvement was devised. In that instrument the nozzles which directed the steam or motive agent to the motor were connected to pipes leading to the opposite ends of the cylinder and were so located in relation to the motor as to cause the steam or motive agent to alternately impinge upon the buckets or vanes thereof and rotate it continuously in the same direction.

It is a well-established fact in the operation of steam-engines that there is a wide variation of pressure in the cylinder upon the piston between the beginning and ending of each complete stroke and that the mean effective pressure upon the same, which is the quantity to be measured, is the resultant of the mean or average pressure on one side minus the mean or average pressure on the opposite side, the latter being due to the resistance of the "exhaust" and to "compression" after the exhaust-valves are closed, as will be more fully explained in connection with the description of the mode of operation of the present improvement.

In my prior invention the negative or back pressure acted to increase the velocity of the turbine or motor, because the buckets or vanes were so shaped and the nozzles so located as to cause the motive agent to drive the motor always in the same direction instead of retarding it as the piston of the engine was retarded, so that the motor did not under all conditions of usage give an accurate indication of the energy which was imparted to the piston.

Referring now to the drawings in detail, in all of which like letters of reference represent like parts wherever used, A represents a cylindrical metallic inclosing casing secured directly to a cylindrical motor-chamber B′, having a detachable head B, secured thereto by screws *n n n n*, said parts when united together constituting a steam-chamber for a rotary turbine or motor T of disk form, having one surface provided with radially-disposed buckets or vanes *g g*, said motor being secured to a shaft S by a hub S^3 and provided with ball-bearings *b b b b*, secured in the well-known manner in a stationary hub S^2 by cones and cups, as clearly illustrated in the drawings. (See Fig. 1.)

t t t′ t′ are pairs of nozzles secured to the upper ends of steam-tight collars K K, (see Figs. 5 and 6,) said nozzles being arranged at suitable angles for directing the flow of the steam or other motive agent against the buckets or vanes *g g* of the motor T. These nozzles are preferably constructed as shown in Fig. 5^a, in which the steam or other motive agent is emitted or ejected through an orifice *v*, having substantially the conformation shown. I have found in practice that the ordinary tapering nozzles as usually constructed and as shown in my prior application will become coated interiorly with a deposit of partially-carbonized oil, thus effectually choking or clogging them up, and the form of construction shown in Fig. 5^a of the drawings will effectually overcome this defect.

w w w′ w′ are movable screens carried at the outer ends of segments w^2 w^2, supported in turn by arms V V, pivoted to the collars K K by shoulder-screws V′ V′, the arrangement being such that when the screens *w w* are out of the path of their corresponding nozzles *t t* the other pair *w′ w′* will be directly in the paths of their corresponding nozzles *t′ t′*, and vice versa. Y is a yoke having its opposite ends pivotally connected with the free ends of the arms V V, the middle of said yoke being in turn connected to a reciprocating rod I, having vertical movement in a guide or sleeve I′, secured in the detachable head B. (See Fig. 1.) These movable screens *w w w′ w′* are made of as light a material as possible, and their arrangement before the nozzles *t t t′ t′* and out of actual frictional contact therewith is such as to offer the least frictional resistance to their movement and yet allow them when in front of said nozzles to deflect the steam or motive agent away from the turbine or rotary motor T. This is important for the reason that, as I have ascertained, valve movements cannot accomplish with the same efficiency the results attributable to said screens, because of the short duration of time during which the steam must be deflected or shut off from the turbine—to wit, that period of time at which the piston is substantially at rest at the termini of the stroke.

I^2 I^3 is a bell-crank lever secured to the detachable head B at I^4, the free end of the arm I^2 of said bell-crank lever extending into a slot in the reciprocating rod I, to which it is pivotally connected by a pin, as shown. (See Figs. 1 and 6.) The arm I^3 is pivotally attached at I^5 to a rod R′, provided with an adjustable turnbuckle T B, connected in turn to the upper end of a lever L^2, pivotally supported by an adjustable fulcrum A F to a stanchion or standard S T, rigidly secured to the bed-plate of the engine S E. (See Fig. 7.) To the lower end of the lever L^2 is secured a rod R^2, adapted to move in longitudinal directions through a bearing or support *m*, secured to one of the engine-guides E G, *q q* being collars or tappets adjustably secured to the rod R^2, E B being a lug or projection secured directly to the cross-head C H of the engine and adapted to engage said tappets at the termini of the strokes.

K′ K′ are pipes running from the opposite ends of the cylinder of the engine to the inlet-collars K K, said pipes being connected to the inlet-collars by nuts P P. (See Figs. 5 and 7.)

C^2 C^3, Fig. 7, are three-way cocks in the pipes K′ K′ for enabling one to apply the ordinary steam-engine indicators in the usual manner.

E^4 is the exhaust-pipe of the instrument, which may lead into the open air or into the exhaust of the engine, as is desired.

C is a cup or receptacle secured to the upper part of the instrument and connected to a tube *c*, running to the interior chamber of the ball-bearings *b* of the motor, its function being to supply a solvent material to said bearings for the purpose of preventing a coating or deposit thereon of the decomposed or partially-carbonized lubricant, which is carried into the ball-bearing chamber by steam from the engine.

C is an oil-cup secured in the top part of the casing A and connected by an oil-tube c to the ball-bearing chamber, and C′ is an adjusting-screw for regulating the outflow of a lubricant thereto, as desired.

F is a rotary fan having two or more blades or vanes secured by screws to a hub f, as shown, which in turn is secured to one end of the shaft S, (see Figs. 1 and 4,) said fan being adapted to rotate within the cylindrical casing A.

F′ is a second fan adjacent to and similar in all respects to the fan F and secured by a hub f' to a second shaft s^2, which in turn is provided with ball-bearings b' b', secured in the usual manner in cones and cups carried by metallic disks D^4 D^5, fitting snugly within the inner surface of the casing A and separated from each other by pillars p p.

H is a dial-hand secured to the shaft s^2 by a nut s', and s is a retractile spring having one end secured to the shaft s^2 by a hub h and the other to a pillar or post carried by a magnetic disk D^2, supported in turn beneath the spring s by a series of radially-disposed arms D^3, attached to the disk D^4 by screws, as shown, the function of the disk D^2 being to prevent the spring s from becoming permanently magnetized.

D′ is a Foucault disk of copper or other metal, secured to the shaft s^2 by the hub h and adapted to rotate between the poles of one or more permanent magnets M M M M, secured to the disk D^4, its function being to steady the dial-hand from undue fluctuations.

D is the dial, secured to the outer surface of the disk D^5 by screws, as shown in Figs. 1 and 3 of the drawings, said dial being calibrated to the desired units—such, for instance, as pounds pressure per square inch.

e e e, Fig. 3, are adjustable indices adapted to be moved independently around the periphery of the dial, said indices being provided with individual numbers, illustrated in the drawings as running from "20" to "280." In Figs. 3^a and 3^b I have illustrated these indices in detail, e^3 being a metallic clip integral with a pointer e', to which is pivotally secured the disk e for the numerals by a rivet e^2, the arrangement being such that when said indices are shifted or adjusted to different positions said disks may be individually rotated in order that the numerals thereof may always stand in a legible position. These indices are attached to the dial D by slipping clips e^3 over the outer edge of the dial, there being sufficient friction between the dial and the clips to maintain them in any position in which they may be set. The function of the outer scale of indices e is to provide an approximate indication of horse-power units when the instrument is attached to an engine.

G is a glass cover inclosing the dial D and attached parts, said cover being secured to the inclosing casing A by a ring or rim R and screws o o.

I will now describe the operation of my improvement, reference being had to Fig. 7 of the drawings, in which the steam is presumed to be driving the piston from left to right in the direction of the arrow, the effect thereof on said piston being indicated by the character "+." At the same time there is back pressure caused by the steam in the other end of the cylinder against the opposite side of the piston, which pressure is indicated by the character "—" and is due to the resistance of the exhaust and compression after the exhaust-valve is closed. These pressures, indicated by "+" and "—" characters, are varying within wide limits. For instance, supposing that steam be admitted to the cylinder at, say, eighty pounds pressure to the square inch and that at two-tenths of the stroke the valve closes, the steam now expands, driving the piston forward to the end of the stroke, its pressure falling by well-known law to, say, five pounds. A definite proportion of the steam now passes upward in the direction of the vertical arrow through the pipe K′, three-way cock C^3, and the lower nozzle t, impinging upon the buckets or vanes g of the rotary motor T, tending to impart motion thereto in the direction of the arrow. At the same time the back pressure, indicated by the character "—" in the right-hand end of the cylinder, causes a definite proportion of the steam to pass upward therefrom through the pipe K′ in the direction of the vertical arrow, through the three-way cock C^2, lower right-hand nozzle t, impinging against the buckets or vanes g of the rotary motor T, tending to retard the forward motion thereof, with the result that the rotary motor, due to its inertia and the arrangement of the nozzles, rotates in a direction and at a velocity which is the resultant and a measure of the mean effective pressure of the two forces. It will be apparent, therefore, that whatever may be the action of the steam upon the opposite sides of the piston during its stroke there will be a corresponding proportionate action upon the opposite faces of the buckets or vanes of the rotary motor T, as will be obvious on inspection of Fig. 5 of the drawings. As the piston approaches the end of its stroke the lug or projection E B, carried by the cross-head C H, comes into mechanical contact with the right-hand tappet q, carried by the rod R^2, so that the further advancement of the piston imparts to the lower end of the lever L^2 movement to the right and to its upper end a movement to the left, thereby causing the rod R′ to give to the arms I^3 I^2 of the bell-crank lever a corresponding movement and to the arms V V a rotary movement sufficient to cause the segmental screens w w to close the nozzles t t and at the same time remove the screens w' w' from before the nozzles t' t'. (See Fig 6.) Consequently as steam enters the right-hand end of the cylinder the pressures indicated by the "+" and "−" characters in Fig. 7 of the drawings are reversed, and in like manner a corresponding proportion of the steam now impinges upon the buckets or vanes g of the motor through the upper nozzles t' t', tending to impart motion to the rotary motor T in the same direction as before and with a like resultant effect due to the action of the steam from both of said nozzles. In like manner when the piston approaches the extreme left-hand stroke the lug or projection E B comes into mechanical contact with the left-hand tappet q and reverses the action of the parts, thus completing one cycle. These operations continue successively so long as the engine is running.

Referring now to Figs. 1, 2, 3, and 4 for a detail description of the operation of the indicating instrument, it will be apparent that when the rotary motor T is set in motion the fan F, mechanically connected thereto, imparts motion to the air within the fan-chamber, thereby tending to rotate the second or independent fan F' in the same direction against the retractile force of the spring s and causing the dial-hand H to assume a definite angular deflection over the scale of the dial D proportionate to the velocity of the fan F, the magnets M acting as a damper in a well-understood manner upon the Foucault disk D'.

In the event of any variation of load being put upon the engine there results a corresponding variation of pressure in the cylinder thereof, and consequently a proportionate variation in effect will be given to the motion of the motor. Inasmuch as the deflection of the dial-hand H is a measure or indication of the velocity of the rotary motor T, which in turn is a measure of the mean effective pressure on the piston, said dial-hand will give a deflection corresponding to these variations.

In calibrating the instrument for the fixed or M. E. P. (mean effective pressure) scale (indicated by the numerals "10," "20," "30," to "90," inclusive, Fig. 3 of the drawings) it is attached to a steam-boiler or compressed-air reservoir provided with a standard pressure-gage and steam or compressed air allowed to flow through one nozzle t only at definite pressures in such manner as to drive the motor T in the proper direction, the deflections of the dial-hand being noted and marked on the dial at the corresponding pressures "10," "20," "30," to "90," inclusive, as indicated by the standard pressure-gage, after which they are subdivided, as shown, into smaller units. If now the instrument be attached to a steam-engine and operated in the manner shown in Fig. 7 of the drawings, as hereinbefore described, it will be found that the variable pressures due to the action of the steam, as indicated by the "+" and "−" characters in Fig. 7, will give to the indicating-hand a deflection which corresponds to the mean effective pressure upon the piston. In other words, if the dial-hand H gives a definite deflection—say "30"—it will be found that the mean effective pressure on the piston at that time is thirty pounds.

Referring now to the outer scale, bearing numbers from "20" to "280" and as designed to indicate approximately the horse-power for different pressures, I will describe the function and manner of use thereof. In all self-governing steam-engines the speed is practically constant, and an instrument that will measure and indicate the mean effective pressure thereof can be calibrated so as to read in units of horse-power, inasmuch as the other quantities are constant, with the exception of the mean effective pressure which is to be measured, and this will vary in proportion to the total energy of horse-power. Bearing this in mind, it is an easy matter to provide an adjustable scale which may be set to indicate definite horse-powers for definite pressures when the engine is run at a constant speed.

Suppose, for instance, that the instrument be attached to an engine having a piston area of one hundred and seventy-six square inches traveling at a velocity of five hundred feet per minute and that the mean effective pressure thereon for a given load equals thirty pounds. By the well-known formula for calculating the horse-power of an engine and hereinbefore referred to the calculated horse-power would equal eighty. Therefore a movable index having the numeral "80" and adjusted opposite the figure "30" on the scale would indicate that a mean effective pressure of thirty pounds on the piston running at that speed would equal eighty horse-power. The same process is gone through for the remaining individual indices, with the result that an outer horse-power scale may be adjusted for the conditions as to speed under which the engine is working.

I do not limit the present improvements to the details of structure hereinbefore described, as I believe it is broadly new with me to devise an instrument for giving visual indications of the mean effective pressure of a steam-engine or analogous prime mover by causing a motor to be driven by a part of the motive agent which drives the engine and to direct the same upon the motor in such manner that the direction of rotation thereof and its velocity are the resultant of the differential action of two driving forces, said motor being adapted to control the movements of visual indicating apparatus which shall give visual indications of the mean effective pressure of the motive agent upon the piston, and my claims are directed generically to an instrument of the character indicated.

Having thus described my invention, what I claim, and desire to secure by Letters Patent of the United States, is—

1. A motor having a rotary member adapted to be driven by the impact of a fluid, in combination with a plurality of nozzles so arranged that a part thereof will direct the fluid to the rotary member in such a manner as to oppose the action of another part thereof, and means for connecting the nozzles to the cylinder of a fluid-engine.

2. In a mean-effective-pressure indicator a motor having a rotary member operatively connected to the cylinder of a prime mover, as a steam-engine, and adapted to be driven by a part of the steam therein through a plurality of nozzles directing the motive agent against the rotary member, in such manner that its direction of rotation and its velocity are the resultant of the differential action of two opposing driving forces.

3. In a mean-effective-pressure indicator, the combination of a rotary member adapted to be driven by the impact of a fluid and having sufficient moment of inertia to render its velocity substantially constant under varying driving forces so as to act as a measure of the mean pressure applied to the piston of the prime mover or engine with which it is to be used with a plurality of nozzles adapted to direct a part of the motive agent from the cylinder of the prime mover or engine to the motor, said nozzles being so arranged that the velocity of the motor is the resultant of two driving forces acting in opposing directions.

4. In a mean-effective-pressure indicator a rotary member having sufficient moment of inertia to render its velocity a measure of the mean pressure applied to the piston of the prime mover or engine with which it is to be used, and a plurality of nozzles adapted to direct a part of the motive agent from the cylinder of the prime mover or engine to the motor, said nozzles being so arranged that the velocity of the rotary member is the resultant of two driving forces acting in opposing directions, in combination with means for alternately opening and closing the nozzles at the termini of each stroke of the engine.

5. In a mean-effective-pressure indicator a rotary member having sufficient moment of inertia to render its velocity a measure of the mean pressure applied to the piston of the prime mover or engine with which it is to be used; in combination with a plurality of nozzles adapted to direct a part of the motive agent from the cylinder of the prime mover or engine to the rotary member of the motor, said nozzles having each a discharge-orifice of minimum longitudinal surface and being so arranged that the direction of rotation of said rotary member and its velocity are the resultant of two driving forces acting in opposing directions.

6. A mean-effective-pressure indicator consisting of a motor having a rotary member and an indicator driven thereby, in combination with a plurality of nozzles operatively connected to the opposite ends of the cylinder of a steam-engine or other prime mover with which it is to be used, in such manner that the resultant action of the steam or motive agent upon the rotary member causes the indicator driven thereby to give a correct indication of the effective pressure of the motive agent upon the piston of the engine or other prime mover, together with means for alternately opening and closing the nozzles at the termini of each stroke of the engine.

In testimony whereof I have hereunto subscribed my name this 30th day of June, 1898.

GEORGE F. ATWOOD.

Witnesses:
C. J. KINTNER,
M. F. KEATING.