F. PURDY.

ENGINE INDICATING APPARATUS.

APPLICATION FILED JAN. 19, 1909.

Patented Feb. 15, 1910.

3 SHEETS—SHEET 1.

949,129.

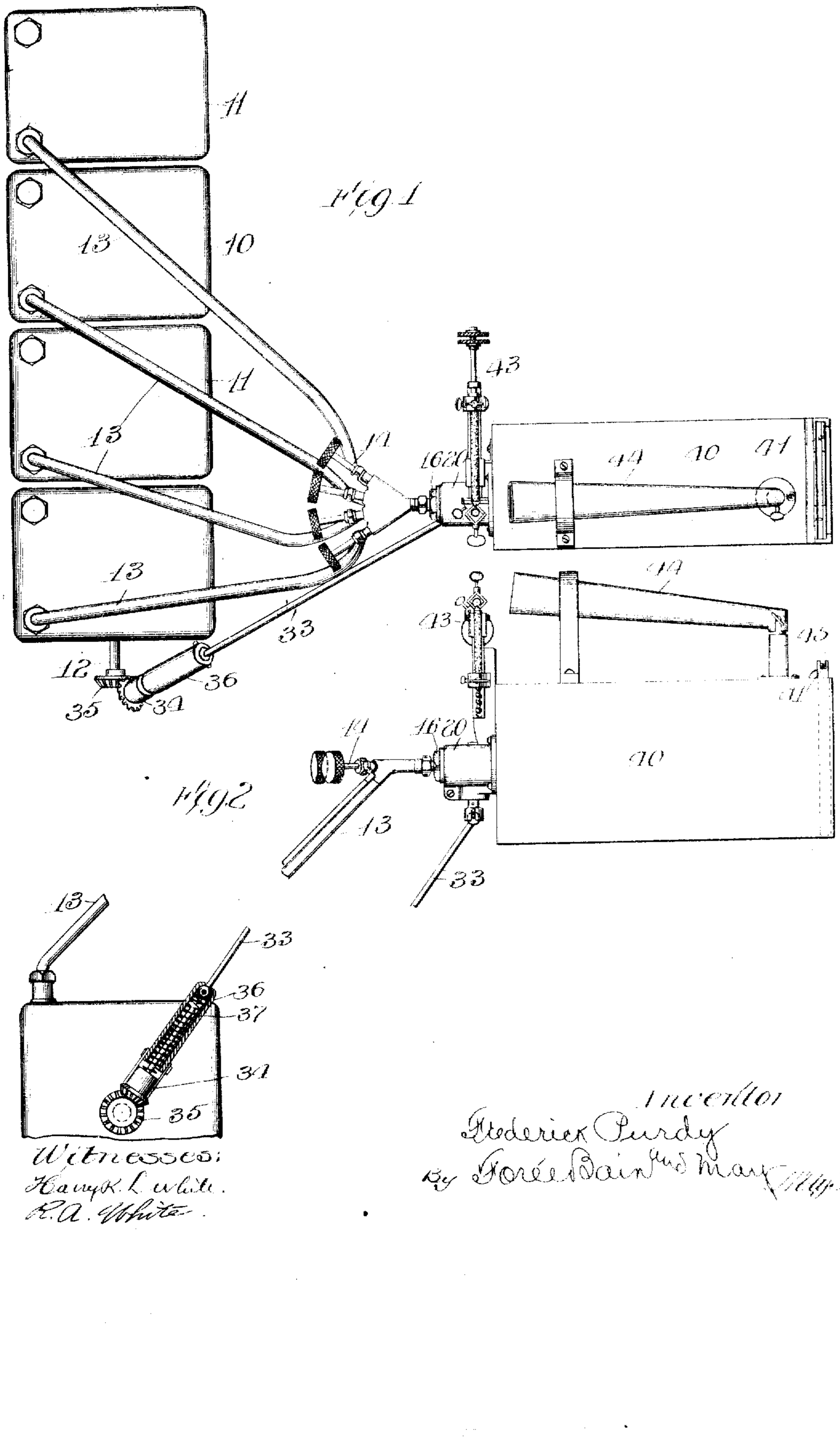

Fig. 1

Fig. 2

Witnesses:
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R. A. White.

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3 SHEETS—SHEET 2.

Fig. 3

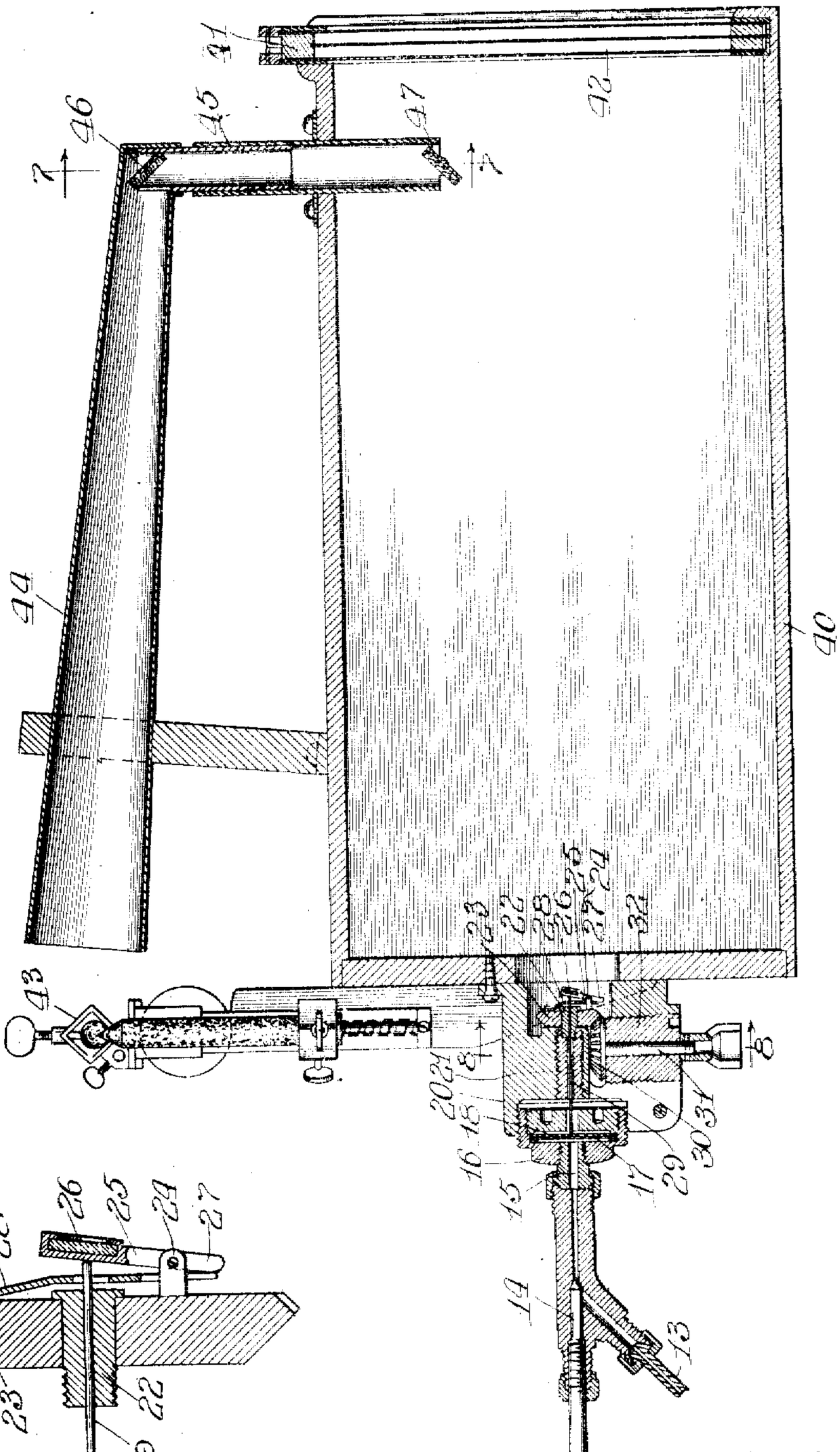

Fig. 4

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3 SHEETS—SHEET 3.

Fig 5

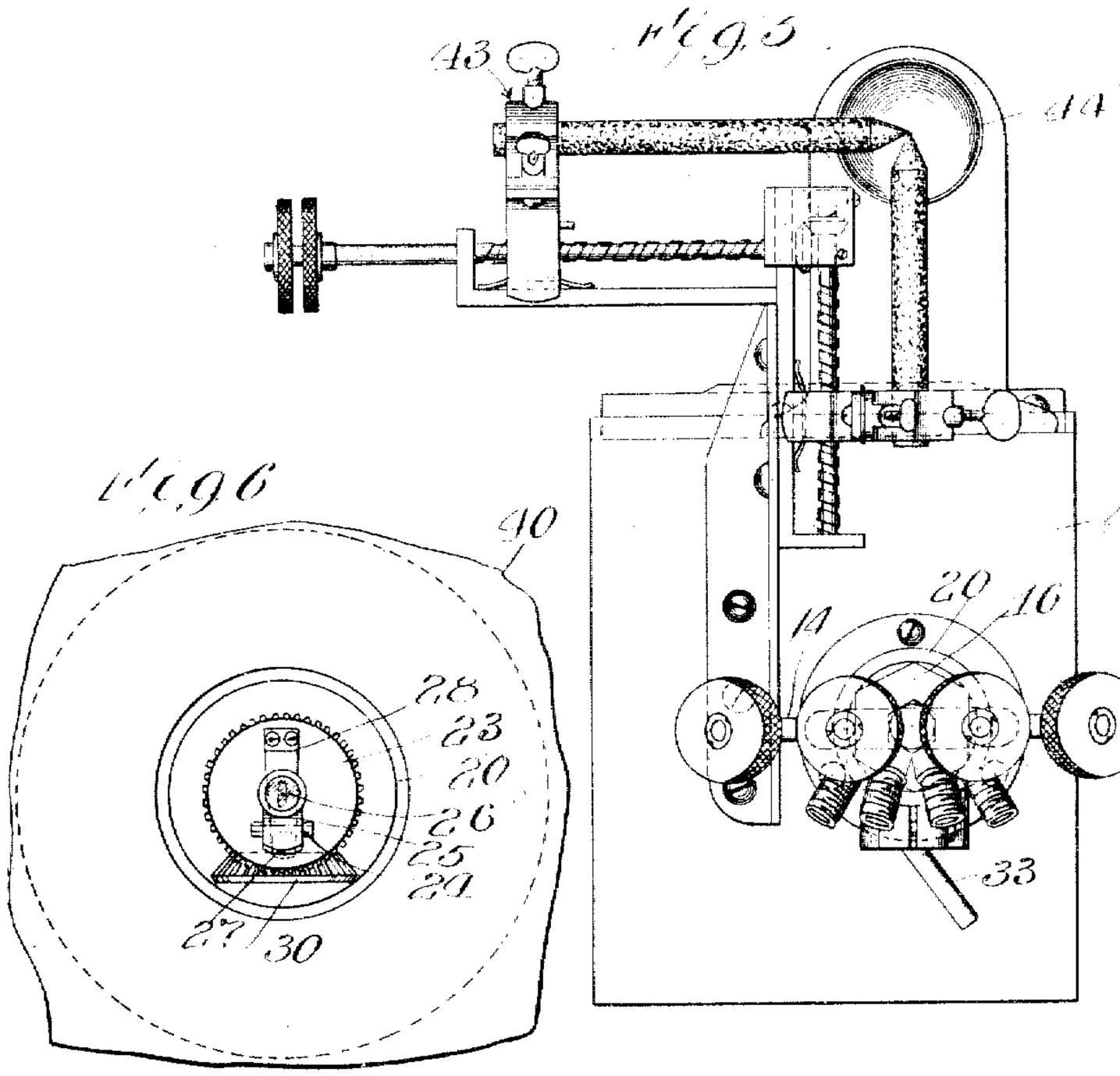


Fig 6

Fig 8

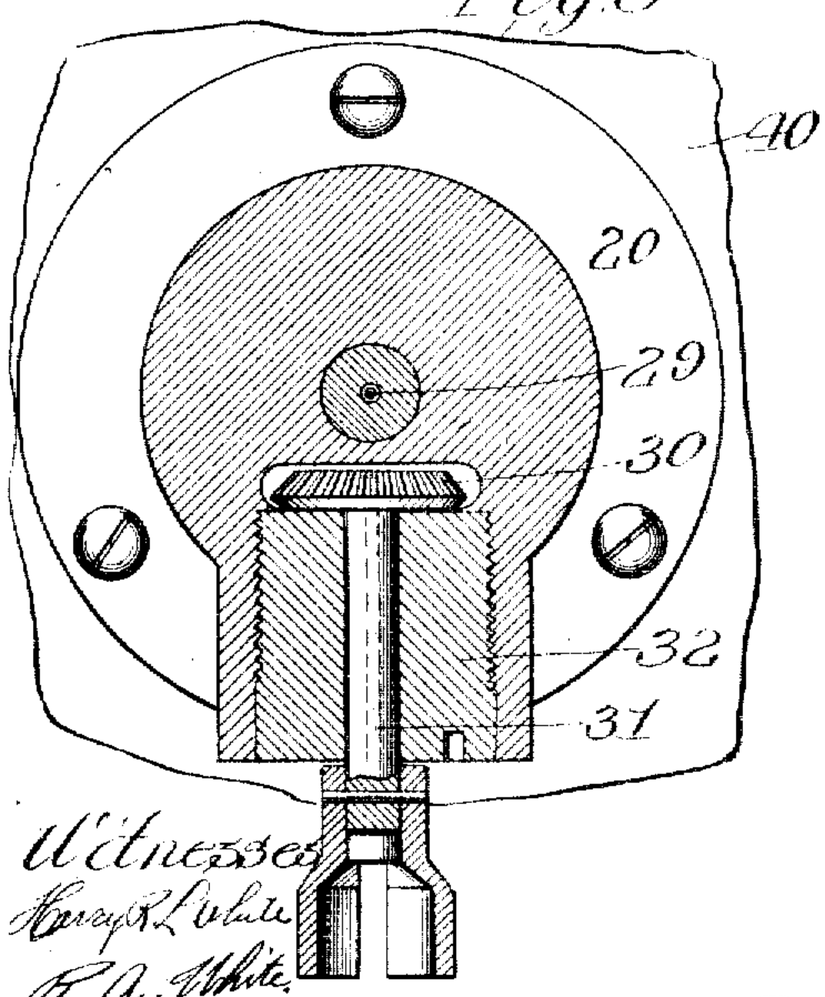


Fig 7

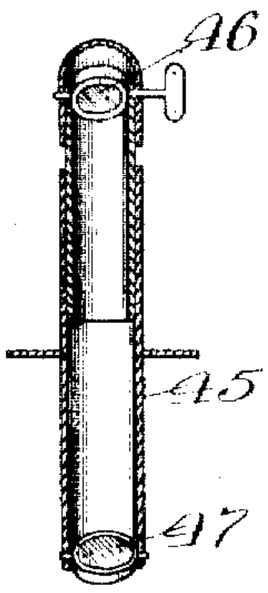
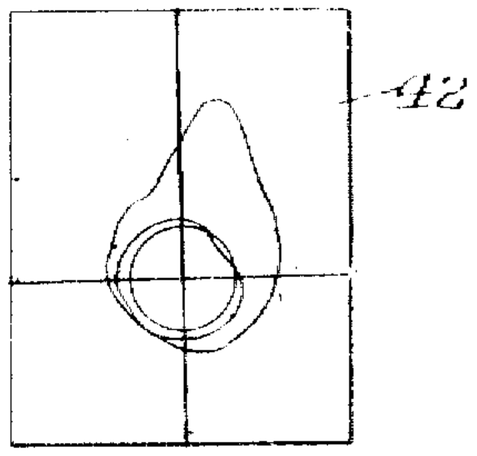


Fig 9



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UNITED STATES PATENT OFFICE.

FREDERICK PURDY, OF KENOSHA, WISCONSIN, ASSIGNOR OF ONE-HALF TO FOREE BAIN, OF LA GRANGE, ILLINOIS.

ENGINE INDICATING APPARATUS.

949,129. Specification of Letters Patent. Patented Feb. 15, 1910.

Application filed January 19, 1909. Serial No. 473,142.

To all whom it may concern:

Be it known that I, FREDERICK PURDY, a citizen of the United States, residing at Kenosha, in the county of Kenosha and State of Wisconsin, have invented certain new and useful Improvements in Engine Indicating Apparatus, of which the following is a specification.

My invention relates to improvements in engine indicating apparatus, and has for its primary object to provide a graphical indication by a curve, related to a single center, of the pressure conditions within an engine cylinder throughout one or more cycles of its operation, or portions thereof and to provide means for producing such indication.

Heretofore it has been the practice to indicate engine pressure by a curve related to rectilinear coördinates, but such system has disadvantages, particularly where sought to be applied to high speed engines or engines having short connecting rods, or to engine with off-set cylinders, conditions all of frequent occurrence in gas engine practice. Further, in "rectilinear" indication, the card movement coincides with the piston movements and very small card movement attends the passage of the crank through the 20° or 30° including the dead center points at the ends of the piston stroke, yet in a gas engine these are the critical portions of the stroke and require most careful observation in securing high efficiency. This last mentioned method of indication I may refer to as "rectilinear" indication, and as distinguished therefrom I may refer to the indication effected by the means hereinafter described as "circular" indication.

My invention broadly considered consists of the provision of an applicator and a receptive surface, one rotating with respect to the other in consonance with a cycle of operation of the pressure employing engine to effect a circular indication, or tracé, upon the receptive surface one of said coacting parts being movable in response to variations in pressure in the pressure-employing engine to vary the radial distance of the indicated trace upon the receptive surface from a center or pole alining with the axis of rotation of the rotatable element, so that the cyclic periods are indicated circularly and pressure conditions are indicated radially upon the receptive surface.

My invention further consists in a card bearing a trace indicating by rotative progression about a single center the cyclic progression of an engine part, and by radial displacement from said center the pressure conditions resulting in or from each progression of the engine part.

Other objects of my invention will become apparent from the following description, taken in conjunction with the accompanying drawings, illustrating a single convenient embodiment of the invention, and wherein;

Figure 1 is a plan view of an indicator connected by a common head with a four-cylinder engine; Fig. 2 is a side elevation thereof; Fig. 3 is an enlarged central vertical section; Fig. 4 is an enlarged detail of the reflecting applicator and its mounting; Fig. 5 is an end view from the left of Fig. 1; Fig. 6 is a front view of the applicator shown in Fig. 4, in its position in the apparatus; Fig. 7 is a sectional detail on line 7—7 of Fig. 3; and, Fig. 8 is a sectional detail on line 8—8 of Fig. 3. Fig. 9 is a card or record.

In the drawings 10 indicates a four cylinder gas engine, whereof 11—11 are the frames for the cylinders, such construction being typical of any pressure-utilizing or producing engine broadly, and 12 indicates the crank shaft of the engine, typifying any engine part operating in consonance with the cyclic operations of the engine. Pressure communicating connections are made from the cylinder or cylinders of the engine to suitable pressure responsive means which may be common to all of the cylinders or individual devices each associated with a separate cylinder, it being my preference in testing multiple cylinder gas engines to employ a common pressure responsive device and associated mechanism for all of the cylinders in order that there may be no comparative errors in the readings taken with respect to the several cylinders, due to peculiarities of individual responsive parts. To this end I employ, as typical of any suitable pressure responsive means a single diaphragm, having plural leads, each valved for individual control, to the several cylinders of the engine. In the particular construction shown 13—13 indicate tubes, connecting with the several engine cylinders, communicating through suitable needle valves 14, with a common rotatable union 15, secured to a head 16, and communicating with

a chamber 17 within said head, said chamber being closed at its far side as by a diaphragm 18. Provision is made of an applicator for directing a tracing medium, and a receptive surface whereon the indication is made, one of said elements being rotatable with respect to the other, about what I may term the axis or center of indication, and one radially movable with respect to the other to vary the position of the traced curve radially with reference to the axis of rotation of the rotatable part. In the preferred construction shown connection is made from a suitable part of the engine, such as the crank shaft, to an applicator, mounted for rotation in consonance with a cycle of operation of the engine, and also related to the pressure responsive device or diaphragm for control by such diaphragm in such a way that the radial location of the trace or indication registered by the operation of the applicator is controlled by such pressure responsive part or diaphragm. In the particular construction shown the trace or indication is registered or applied through the medium of a light ray, directed by an applicator in the form of a reflecting surface or mirror mounted for rotation, about an axis generally at right angles to the plane of the mirror in consonance with a cycle of operation of the engine and controlled as to radial deflection by the diaphragm as heretofore generally described. But while I prefer the use of a reflected light ray as a card-tracing medium, it will be understood that any other medium of registering the movements of the applicator might be employed.

In the construction shown, 20 indicates a bearing block into which is adjustably screwed the diaphragm-carrying head 16. Within the block 20 in advance of the head 16 is threaded a sleeve 21 carrying at its front end a tubular bearing 22 affording bearing support to a rotatable element 23, shown as a beveled pinion, said pinion bearing on its front face a bracket 24 in which is pivoted a radial lever 25 carrying, in alinement with the center of the wheel 23, a reflecting surface or mirror 26, said lever 25 having a tail piece 27 against which bears a leaf spring 28, mounted on pinion 23 and tending constantly to move the mirror rearwardly toward the surface of the rotatable carrier or pinion 23. To the diaphragm is connected a rod 29, extending from the diaphragm through the bore of the sleeve 21 and bearing 22, and through a suitable aperture in spring 28, to touch the lever 25 in alinement with the center of the carrier, so that the spring 28 and diaphragm 18 may operate in opposition to each other. Normally the diaphragm pushes the lever forward so that the reflector is slightly inclined from right angles to the axis of rotation. For driving the carrier 23 in rotation in consonance with the cyclic operations of the engine, a gear 30 is provided in mesh with the gear 23, carried by the shaft 31 extending through an adjustable bearing member 32, said shaft 31 having a tumble shaft connection 33 with a pinion 34 meshing with a similar gear 35 upon the engine shaft 12. For convenience of relative adjustment of the two gear pairs relative to each other, the tumble shaft connection is made capable of ready disconnection and replacement, and to this end the socket of the pinion 36 associated for rotation with pinion 34 is elongated and incloses a spring 37 against which the tumble shaft may yield when pressed downward, so that the upper end thereof may readily be disconnected from the socket carried by shaft 31.

For producing a light ray and directing it upon the reflector 26 and for receiving the trace of said light ray when reflected from the applicator 26, any suitable apparatus may be provided. Preferably I provide a casing 40, closed except as hereinafter stated, at one end carrying the bearing block 20, suitably disposed to prevent the applicator or reflector 26 to the interior of the casing, and at its other end providing a photographic plate holder 41 or other suitable apparatus carrying a receptive surface 42, which may be a photographic plate or film if permanent record is to be made, of ground glass or other image receiving surface for visual observation, as will be understood by those skilled in the art. At a suitable point exterior to the casing I provide a source of light such as the electric arc lamp 43 mounted in front of the light tube 44, bent at an angle, and having an adjustable extension 45 leading down into the casing 40, such tube being provided with a reflector 45 at its joint, and a second reflector 47 at its lower end whereby a ray of light from the arc lamp 43 passing through the tube 44 and extension 45 and deflected by the surfaces 46 and 47, may be directed upon the reflecting applicator 26 and by it thrown upon the receiving surface.

The operation of a device as described is as follows: When the diaphragm 18 is under atmospheric pressure the reflecting applicator 26 stands at an angle such that by revolution it will direct the projected ray of light in a circular path of comparatively small diameter upon the receiving surface 42. Now it will be apparent that any desired engine cylinder may have its valve connection 14 to the diaphragm chamber opened, all others being closed, so that the angular position of the diaphragm relative to the axis of rotation is dependent upon the pressure conditions existing within the cylinder and responds by movement to the engine operations involving changes in pressure in such cylinder. At the same time the appli-

cator is rotated in consonance with the cyclic operation of the engine, its axis of rotation including the center of indication and consequently the beam of light thrown upon the receiving surface describes a curve about a pole or center of indication on the axis of rotation of the applicator, indicating by its circular progression the cyclic progression of the engine operations, and by its radial distance from the axis showing the variations of pressure within the engine cylinder. The resultant card or record made upon a sensitized plate or film, from a four-cycle gas engine geared to rotate the applicator with each crank rotation will be somewhat in the form shown in Fig. 9, the true circle, arbitrarily inscribed upon the sensitized surface, representing the atmospheric line. The trace, or indication, it will be apparent, is a continuous curve related to a single center, or axis of indication, as a resultant of angular or rotary progression of a point about said center in harmony with cyclic progression of an engine part, and radial displacement of the point in harmony with pressure variations resulting in or from such cyclic progression of the engine part, the radial displacement being preferably from a circle indicative of a basic pressure, such as atmospheric pressure. For comparative tests, a card of a standard cylinder may be made and preliminarily impressed upon the sensitized surface or printed upon the photographic printing paper, so that the diagram of a cylinder under test may be mechanically superposed thereon, or for absolute pressure determinations the apparatus may be tested to determine deflection due to predetermined differences in pressure, and such lines preliminarily plotted and pressure areas subsequently figured from the traced record. Of course for ordinary practice the record made upon a plane surface is sufficiently accurate for acceptance, but for theoretically accurate work allowance may be made in the use of a plane receptive surface for the errors due to the varying radial distance of said plane from the focal points of the applicator, or a parti-spherical receiving surface having its center in such focal point of the reflector should be employed.

While I have herein shown and described the particular apparatus which I have used in practice and have found successful, it will be understood that I do not intend to limit my invention in its broader aspect to the particular construction shown and described, as I believe to be new and broadly claim the provision in an engine indicator of a receptive surface and an applicator controlling the application of a tracing medium to such surface, one of said elements being rotatable relative to the other in consonance with a cycle of operations of the engine, and one of said elements being movable to vary the radial distance of the trace or indicating curve from a single center in correspondence with the varying pressure conditions within the engine; and I also broadly claim the indicator card bearing a trace as produced by such circular indication. Furthermore it will be understood that I do not limit the operation of my invention to any particular kind of engine, but contemplate its use with any engine wherein the pressure is variable throughout a cycle of operations.

Having thus described my invention, what I claim is;

1. In an engine indicator, the combination of a receptive surface and an applicator for directing a tracing medium upon said surface, one mounted for rotation relative to the other to produce a circular indication by the tracing medium, and one mounted for movement to produce radial displacement of the indicating trace, and pressure responsive means for effecting such movements of the appropriate element to produce the radial displacement.

2. The combination with an engine, of an indicator comprising a receptive surface and an applicator for directing a tracing medium upon said receptive surface, one rotatable relative to the other about the center of indication, the rotative part having connection with the engine for rotation in consonance with the cycles of operation of the engine, and said applicator being movable to radially deflect the tracing medium upon the receptive surface to vary its distance from the center of indication, and means responsive to pressure within the engine for so moving the applicator.

3. The combination with an engine, of an indicator comprising a relatively stationary receptive surface, and a relatively movable applicator arranged to direct a tracing medium with respect to said receptive surface, means for imparting rotary movement about the axis of indication to said applicator in consonance with a cycle of operations of the engine, and means for imparting another movement to said applicator in accordance with varying pressure conditions within the engine to effect radial displacement of the trace.

4. The combination with an engine, of an indicator comprising a relatively stationary receptive surface, an applicator for directing a tracing medium, mounted for rotation to direct the tracing medium circularly upon the receptive surface, and for other movement to deflect the tracing medium radially upon said receptive surface, operative connections between the engine and applicator whereby the rotative movement of the applicator conforms with the cyclic operations of the engine, and means responsive to pres-

sure conditions within the engine for effecting the deflecting movements of the applicator.

5. In an engine indicator, a carrier rotatable about the axis of indication, an applicator pivoted upon said carrier, and adapted to direct a tracing medium at varying angles to the axis of indication, means for rotating said carrier in consonance with the cycles of operation of the engine, and means for pivotally moving said applicator upon the carrier in accordance with varying pressure conditions within the engine.

6. In an engine indicator, the combination of a relatively stationary receptive surface, a reflecting applicator mounted for rotation about its focal axis on the axis of indication, means for rotating the applicator, means for delivering a ray of light to the applicator, and pressure responsive means for moving said applicator to vary the radial deflection of the light from the axis of indication.

7. In an engine indicator, the combination of a rotatable carrier, a reflector pivotally mounted upon said carrier, with its focal center in the axis of rotation of the carrier, and arranged for pivotal movement toward and from right-angle position with respect to the axis of rotation, and a pressure responsive means having connection with said reflector to vary its angular position upon the carrier.

8. In an engine indicator, the combination of a receptive surface and an applicator for directing a tracing medium upon said surface, one mounted for rotation relative to the other to produce a circular indication by the tracing medium, and one mounted for movement to produce radial displacement of the indicating trace, and pressure responsive means for effecting such movement of the appropriate element to produce said radial deflection, arranged, when under atmospheric pressure, to position said appropriate element for tracing a circle upon the receptive surface, circumscribing as its center the center of rotation of the rotative element.

9. The combination with an engine of an indicator comprising a receptive surface and an applicator for directing a tracing medium upon said surface, one mounted for rotation relative to the other about the axis of indication to produce a circular indication by the tracing medium, and said applicator being mounted for movement to provide radial displacement of the indicating trace upon said receptive surface, an operative connection between an engine part and the rotative element whereby the rotative movements of said element conform with the cyclic operations of the engine, and means responsive to pressure conditions within the engine for effecting movements of the applicator to produce radial displacement of the trace.

10. An engine indicating card bearing a visible trace in the form of a continuing curve related to a single center of indication, said curve being a resultant of angular displacement of a point about said center in harmony with cyclic progression of an engine part and radial displacement of said point with respect to said center in harmony with those pressure variations in the engine resulting in or from such progression of the engine part.

11. An engine indicating card bearing a visible trace in the form of a continuing curve related to a single center of indication, said curve being a resultant of angular displacement of a point about said center in harmony with cyclic progression of an engine part and radial displacement of said point from a normal radial distance from said center indicative of a basic pressure within the engine, said radial displacement being constantly in harmony with the variations of pressure within the engine, above or below a basic pressure, resulting in or from such progression of the engine part.

In testimony whereof I hereunto set my hand in the presence of two witnesses.

FREDERICK PURDY.

In the presence of—

FOREÉ BAIN,

MARY F. ALLEN.