(No Model.)

4 Sheets—Sheet 1.

G. WESTINGHOUSE, Jr., & F. MOORE.

DYNAMOMETER.

No. 349,130. Patented Sept. 14, 1886.

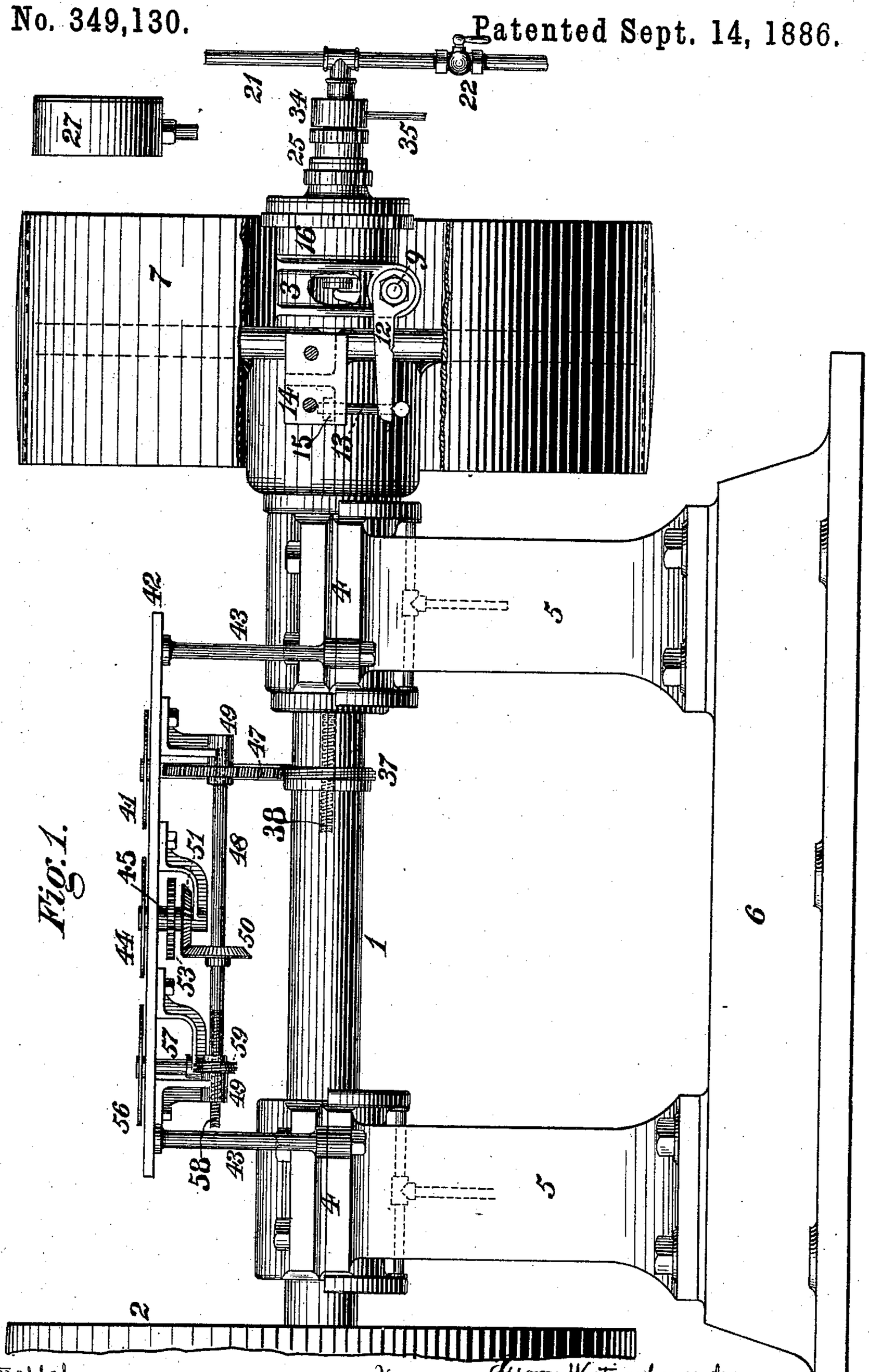

Fig. 1.

Witnesses
J. Thomas Bell. C. M. Clarke.

Inventors George Westinghouse, Jr.
Frank Moore,
By Attorney George H. Christy

(No Model.) 4 Sheets—Sheet 2.

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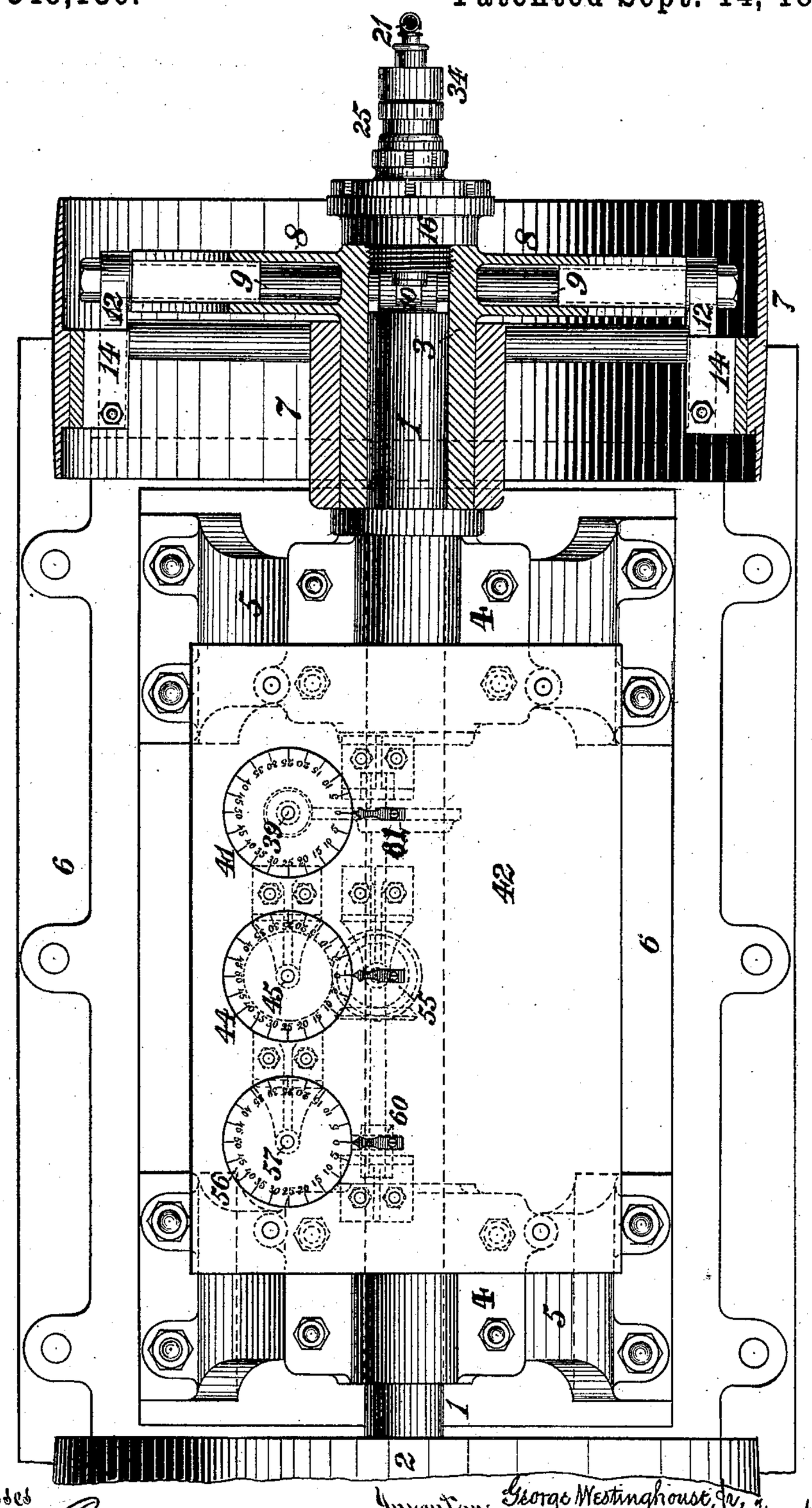

Fig. 2.

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G. WESTINGHOUSE, Jr., & F. MOORE.

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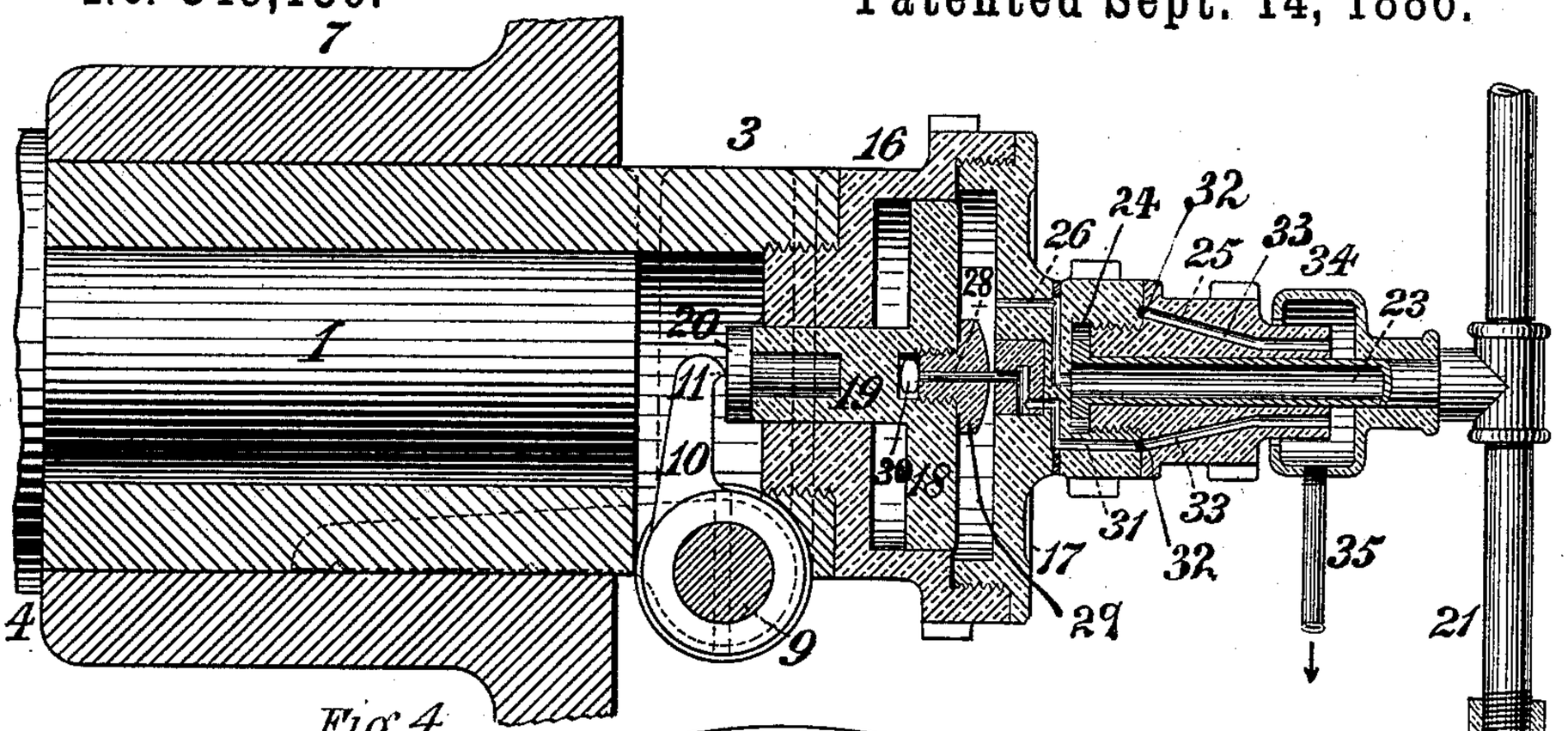

Fig: 4.

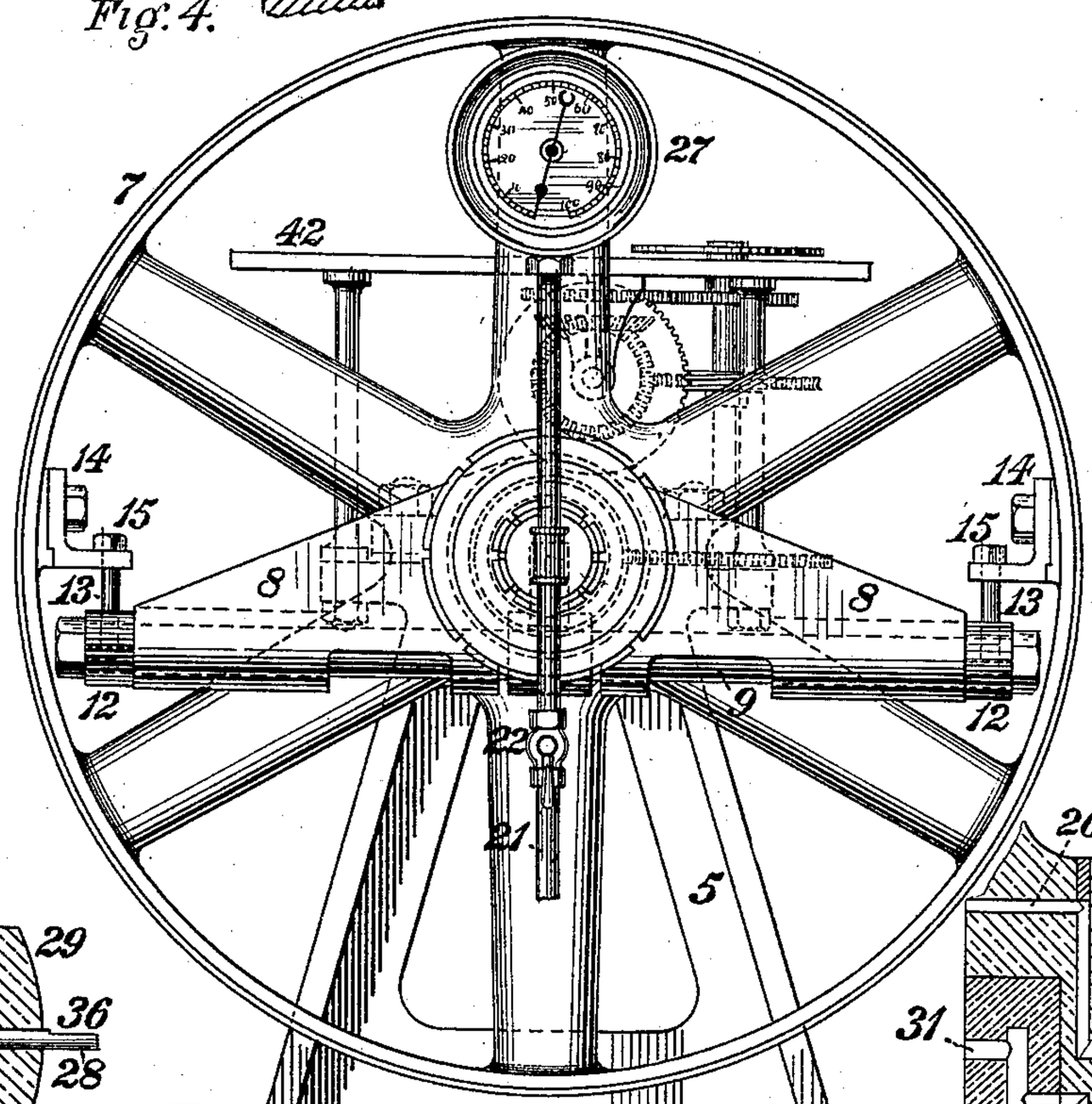

Fig: 3.

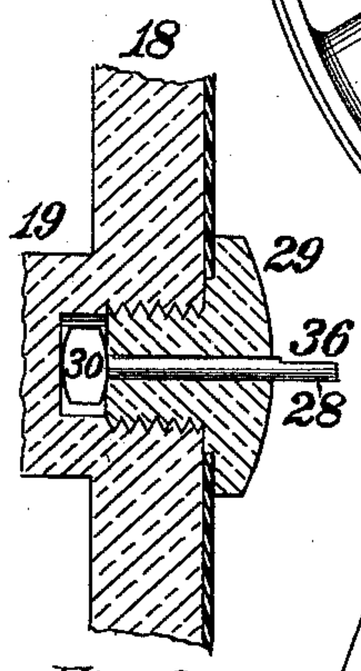

Fig 6.

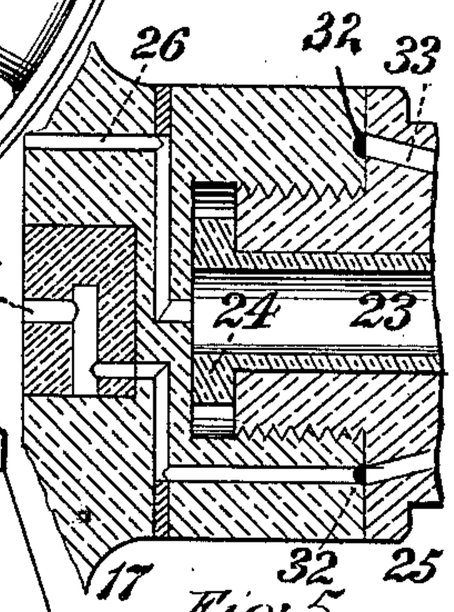

Fig: 5.

Witnesses
J. Howden Bell.
C. M. Clarke.

Inventors.
George Westinghouse, Jr.
Frank Moore.
By Attorney
George N. Christy

(No Model.) 4 Sheets—Sheet 4.

G. WESTINGHOUSE, Jr., & F. MOORE.

DYNAMOMETER.

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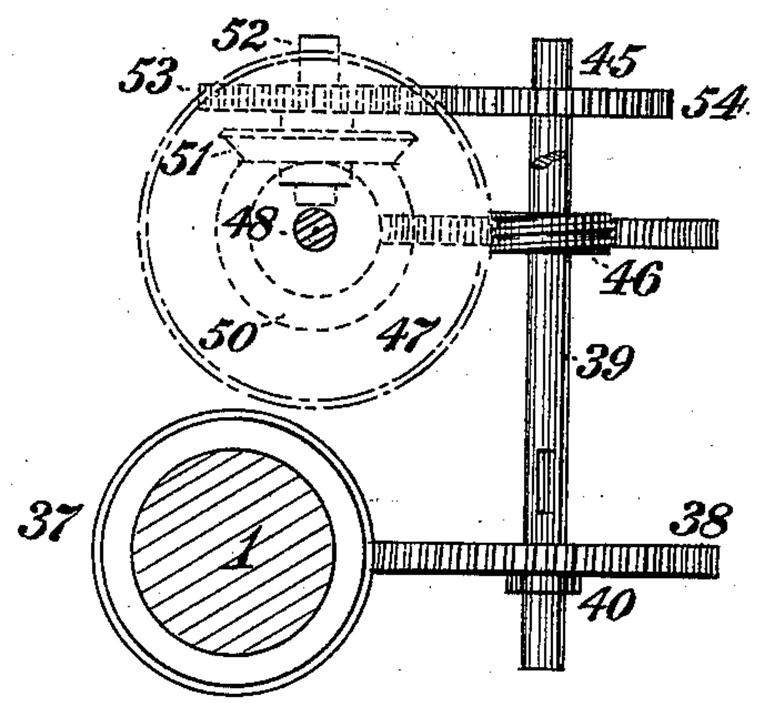

Fig: 7.

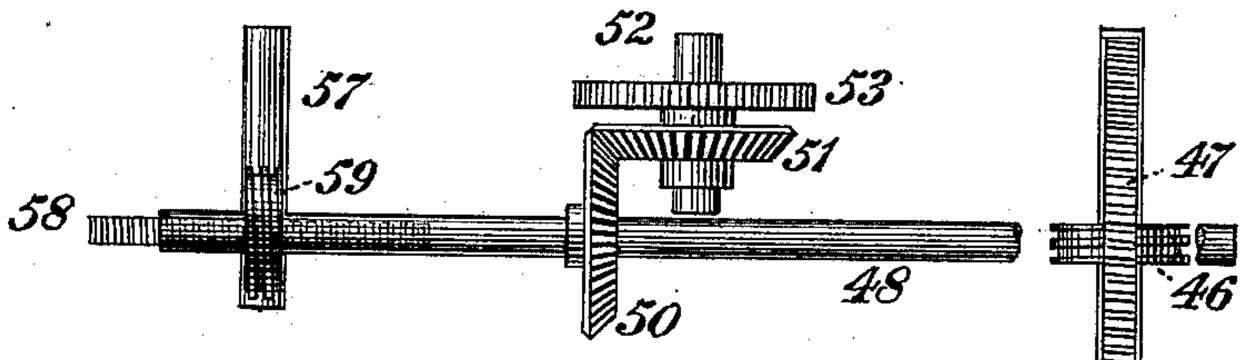

Fig: 8.

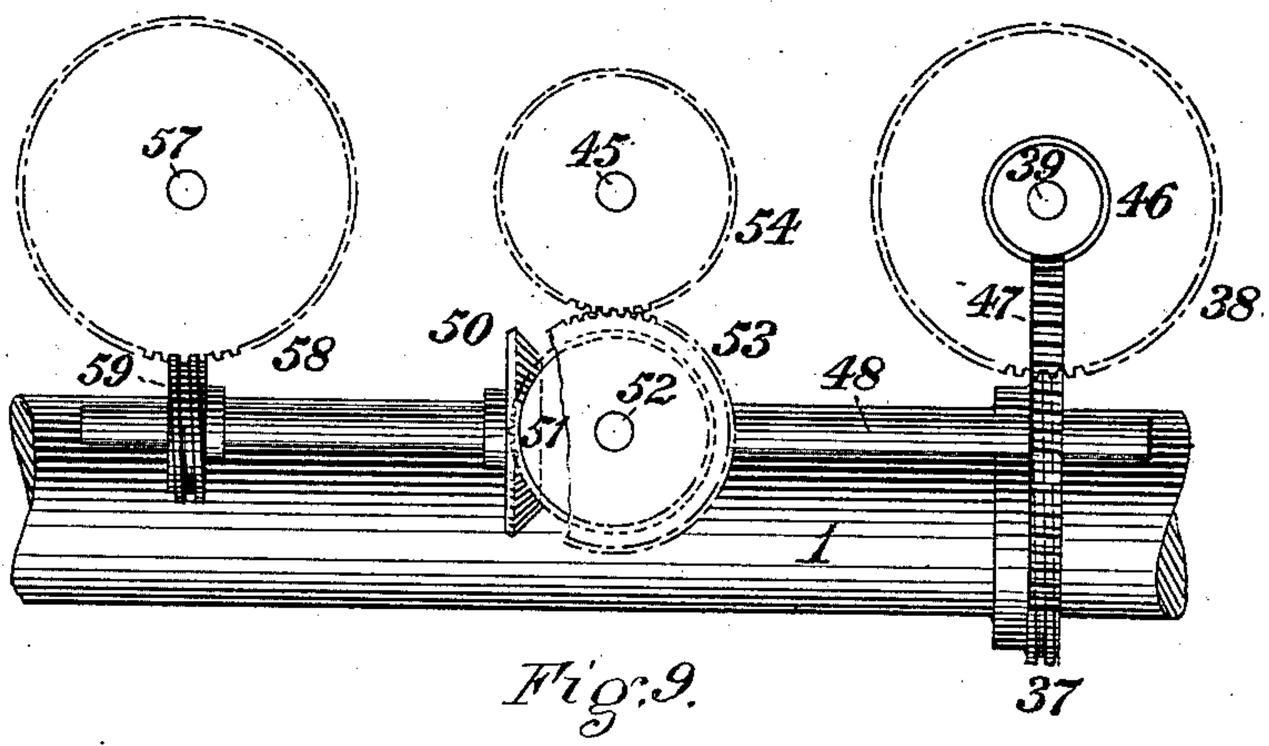

Fig: 9.

Witnesses
J. Snowden Bell
C. M. Clarke

Inventors. George Westinghouse, Jr
Frank Moore,
By Attorney George H. Christy

N. PETERS, Photo-Lithographer, Washington, D. C.

UNITED STATES PATENT OFFICE.

GEORGE WESTINGHOUSE, JR., AND FRANK MOORE, OF PITTSBURG, PA.

DYNAMOMETER.

SPECIFICATION forming part of Letters Patent No. 349,130, dated September 14, 1886.

Application filed May 3, 1886. Serial No. 200,911. (No model.)

To all whom it may concern:

Be it known that we, GEORGE WESTINGHOUSE, Jr., and FRANK MOORE, both residing at Pittsburg, in the county of Allegheny and State of Pennsylvania, and both citizens of the United States, have jointly invented or discovered certain new and useful Improvements in Dynamometers, of which improvements the following is a specification.

In the accompanying drawings, which make part of this specification, Figure 1 is a side view, in elevation, of a dynamometer embodying our invention, a portion of the rim of the measuring-pulley being broken away to show the construction more clearly; Fig. 2, a plan view, partly in section, of the same; Fig. 3, an end view in elevation, as seen from the right; Fig. 4, a longitudinal central section, on an enlarged scale, through the sleeve which carries the measuring-pulley and its accessories; Fig. 5, a similar section through the head of the piston-chamber and its supply and discharge passages; Fig. 6, a similar section through the piston; Fig. 7, an end view, in elevation, of the gearing of the speed-registering mechanism, as seen from the right; Fig. 8, a side view, and Fig. 9 a plan or top view, of the same.

The object of our invention is to provide an efficient and reliable dynamometer of the rotary and hydrostatic type which will afford a continuous indication and register the measure of power transmitted from a prime mover without involving the necessity of adjustment under varying conditions of load.

To this end our invention consists in certain novel devices and combinations whereby the degree of power applied in the rotation of a pulley from which such power is transmitted to a resistance to be overcome is measured by establishing a constant equilibrium between the applied power and a fluid-pressure resistance acting in reverse direction thereto.

The improvements claimed are hereinafter fully set forth.

The measurement of power under our invention is effected by applying it to the rotation of a pulley fixed upon one end of a shaft, on the opposite end of which a measuring-pulley is fitted freely on a sleeve secured upon the shaft. Power is transmitted from the main shaft to the measuring-pulley to effect the rotation of the latter through a bell-crank or lever shaft journaled in the measuring-pulley sleeve at right angles to the main shaft. An arm on the bell-crank shaft abuts against the stem of a piston working in a fluid-pressure cylinder located at the outer end of the sleeve in line with its axis, said piston actuating a valve governing the discharge of fluid under pressure, which is continuously admitted to the cylinder from a supply-pipe provided with a regulating-valve and leading to a pressure-gage. The bell-crank shaft carries a pulley-arm at right angles to its piston-arm, the pulley-arm abutting against a bearing connected to the inner surface of the rim of the measuring-pulley and effecting the rotation of the latter in unison with the main shaft and measuring-pulley sleeve. The pressure due to the applied power which is exerted through the pulley-arm upon the measuring-pulley is transmitted through the piston-arm to the piston, and, acting in opposition to the pressure on the opposite side thereof, maintains a constant balance between the pressure of the power and that of the fluid in the pressure-cylinder, the regulation of the latter in correspondence with variations of applied power being effected by the greater or less degree of opening imparted to the discharge-valve by the movements of the piston, and the variations of pressure being indicated upon the gage. Increase of power will be balanced by corresponding increase of fluid-pressure exerted in the cylinder and indicated on the gage, and, proportionately to decrease of power, fluid will be permitted to escape from the cylinder by the automatic adjustment of the discharge-valve until the equilibrium of forces is established, a correspondingly-reduced pressure being indicated upon the gage. A determined pressure in excess of the pressure exerted by the power is maintained in the fluid-supply pipe up to the regulating-valve which controls its admission to the pressure-cylinder, and between the pressure-cylinder and gage the pressure varies, as before stated, proportionately to variations in the power applied to the pulley-shaft and transmitted through the same to the measuring-pulley. The

area of discharge from the pressure-cylinder is so large relatively to the supply that no pressure can accumulate in the pressure-cylinder unless the discharge-valve is held to its seat.

In the computation of horse-power exerted the ascertainment of the distance traversed in a given period by the point of application of the power to the measuring-pulley becomes a necessary element, for which purpose we provide a speed-registering apparatus consisting of a series of dials actuated through gearing from the main shaft and moving relatively to fixed indexes, the apparatus enabling the speed of the main shaft to be ascertained at any time by taking the number of revolutions in a given period, and serving both as a revolution-counter and a revolution-register.

In the practice of our invention a main shaft, 1, on the opposite ends of which are secured, respectively, a driving-pulley, 2, which receives a belt through which power to be measured is transmitted to the shaft, and a sleeve or cylindrical extension, 3, is mounted to rotate freely in bearings 4 on the upper ends of standards 5, fixed upon a substantial base or bed plate, 6. A measuring-pulley, 7, having a rim adapted to receive a belt through which the applied power is transmitted to the resistance to overcome which its action is exerted, is mounted freely on the sleeve 3, so as, except as presently to be described, to be free to rotate thereon. The sleeve 3 is provided with a pair of long lateral bearings, 8, located below and at right angles to its axis, said bearings supporting a bell-crank or lever shaft, 9, having formed or fixed upon it at its center a piston-arm, 10, which projects upwardly, and is provided with a bearing, 11, which is preferably in the form of a knife-edge at its upper end, said bearing extending transversely to the axial line of the main shaft on the side of the arm 10 nearest the outer end of the sleeve 3. A pulley-arm, 12, is fixed upon either or upon both of the ends of the bell-crank shaft, (the latter case being illustrated,) according as it may be desired that the apparatus may have the capacity of operation in one or in both directions of rotation of the main shaft, said arms being located substantially at right angles to the piston-arm 10 and extending in the direction of the inner end of the sleeve 3. The pulley-arms 12 are notched or recessed on their lower sides adjacent to their free ends, as also at intermediate points if different leverages are desired to be provided for, to receive bearings on the lower ends of links 13, which are suspended with the capacity of end movement in lugs or brackets 14, secured to the inside of the rim of the measuring-pulley 7, the links 13 passing freely through the brackets 14, and having adjustable heads or stops 15, adapted to bear against the same. It will be seen that upon the rotation of the main shaft and sleeve in either direction one of the pulley-arms 12 will bear against the adjacent link 13, and through the same and its bearing-lug 14 effect the coincident rotation of the pulley, the resistance of the load of which will tend to move outwardly the upper end of the piston-arm 10. It will be obvious that, in lieu of carrying a fixed pulley for the reception of power, the shaft 1 may be connected to the end of the driving-shaft of a motor, or may form part thereof. A fluid-pressure cylinder, 16, is secured to the outer end of the sleeve 3, in line axially therewith, the outer end of the cylinder being closed by a removable head, 17. The cylinder 16 is fitted with a piston, 18, having a central stem or rod, 19, which projects through the inner end of the cylinder into the sleeve 3, and is provided with a hardened end face or bearing, 20, which abuts against the bearing 11 of the piston-arm 10. Fluid under pressure is admitted continuously to the cylinder 16, in the operation of the apparatus, through a supply-pipe, 21, leading from a steam-generator, air-compressor, or other source or reservoir of pressure, and governed by a suitable regulating valve or cock, 22. Communication between the fluid-supply pipe 21 and cylinder 16 is maintained and proper provision for the free rotation of the cylinder afforded by a trunnion-pipe, 23, leading out of the supply-pipe 21 in line axially with the cylinder and main shaft 1, and having an end collar, 24, which fits between a central face in the cylinder-head 17 and the adjacent end face of a socket, 25, fitting truly around the trunnion-pipe 23, and screwed into the cylinder-head concentrically therewith. A port or passage, 26, in the cylinder-head is continuously open to the trunnion-pipe, and leads therefrom to the space within the cylinder on the adjacent side of its piston 18. The fluid-supply pipe 21 is continued past the opening of the trunnion-pipe to a connection with a pressure-gage, 27, which may, if desired, be provided with an automatic registering mechanism of any preferred construction. The relief of fluid-pressure in the cylinder 16 is effected by a cylindrical discharge-valve, 28, which is secured centrally in the piston 18 by a screw-plug, 29, by which the head 30 of the valve is clamped within a recess in the piston and stem. The valve 28 fits and moves longitudinally in the inner end of a discharge port or passage, 31, leading from the inside of the cylinder-head 17 to a circular groove, 32, in the outer face of the central portion of the head, from which groove one or more passages, 33, extend into a chamber, 34, fixed upon the trunnion-pipe 23 and fitting freely around the socket 25. A waste-pipe, 35, leads from the chamber 34 to any convenient point of discharge. A lateral recess, 36, is formed on one side of the discharge-valve 28, between the face of which and the adjacent surface of the port 31 fluid finds exit from the cylinder 16 when the piston 18 has been moved sufficiently far in the direction of

the arm 10 to withdraw to a greater or less degree the recess 36 of the valve from the port 31.

In operation, power being applied to the driving-pulley 2, and through the main shaft 1 and its fixed sleeve 3 to the bell-crank shaft 9, one of the pulley-arms 12 of the latter, acting upon the adjacent link 13, will impart rotation to the measuring-pulley 7, through which the driving-power is transmitted to the resistance to be overcome or work performed. Such resistance tends to move the piston 18, through the bearing of the piston-arm 10 on the stem thereof, to the right, or in contrary direction to the fluid-pressure exerted upon it through the supply and trunnion pipes 21 23 and supply-port 26, such movement correspondingly closing the discharge-port 31 by the valve 28. Pressure will thereupon increase in the cylinder 16 to a degree sufficient to move the piston in the opposite direction and open the discharge-port sufficiently far to permit such and only such escape of fluid as will establish an equilibrium of pressure on the two sides of the piston, such pressure being indicated on the gage 27. The traverse of the point of application of the driving-power to the measuring-pulley being known, and the speed of the latter being ascertained, these factors, together with the pressure on the piston 18, as indicated, afford the necessary data for the calculation of the power applied to the driving-pulley.

To effect the ascertainment of the speed of the main shaft and measuring-pulley, we provide an indicating mechanism actuated by said shaft and adapted to serve both as a revolution-counter and a revolution-register, the construction of which is as follows: A worm, 37, fixed upon the main shaft 1, engages a worm-wheel, 38, which is fitted by means of a key and spline upon a vertical shaft, 39, so as to be moved out of engagement with the worm 37 when it is desired to discontinue the operation of the speed-indicating mechanism. The worm-wheel 38 abuts against a stop, 40, on the shaft 39 when engaged with the worm 37. A primary or hundreds dial, 41, is fixed upon the upper end of the shaft 39, and rotates therewith above a table, 42, supported by posts 43 on the frame-standards 5. The ratio of the worm 37 and worm-wheel 38 is such that the shaft 39 and dial 41 make one revolution to one hundred revolutions of the main shaft 1, and the indications are afforded by the position of the graduations on the dial 41 relatively to an index, 61, fixed upon the table 42. The second dial, 44, a single revolution of which indicates any desired and determined fraction of the number of revolutions made by the primary dial 41, as, say, one of the former to one hundred of the latter, is fixed upon a shaft, 45, which is rotated from the primary shaft 39 through a worm, 46, secured thereon and engaging a worm-wheel, 47, on a horizontal shaft, 48, journaled in bearings 49 below the table 42. A bevel-gear, 50, on the shaft 48 engages a similar gear, 51, of equal diameter on a vertical shaft, 52, which carries a spur-gear, 53, engaging a corresponding gear, 54, on the shaft 45 of the second dial, 44. The ratio of gearing is such as to effect the required reduction of speed of the shaft of the second dial, 44, relatively to that of the primary dial 41 as one to one hundred, being a proportion best adapted to facilitate calculation. The revolutions of the dial 44 are indicated by means of an index, 55, fixed to the table in proper relation to the dial. A third dial, 56, is secured upon a vertical shaft, 57, carrying a worm-wheel, 58, which engages a worm, 59, on the horizontal shaft 48. The ratio of gearing is such as to cause one revolution of the third dial to be made in one hundred revolutions of the second dial, 44, and the indications of the third dial are read by means of a fixed index, 60. The worm-wheel 38, through which the speed-indicating mechanism is primarily actuated by the main shaft, being, as before stated, movable into and out of gear with its driving-worm 37, the indicating mechanism may be held out of operation until the main shaft has attained its normal rate of speed, upon which, by engaging the worm-wheel with the worm, the mechanism may be put into action to indicate the entire number of revolutions of the main shaft during a power-test. The speed of the main shaft may be taken at any time by observing the number of revolutions in a given period.

We do not limit ourselves to the specific speed-indicating mechanism herein described and shown, as any other suitable apparatus actuated by the main shaft and having the capacity of indicating and registering the number of revolutions made by said shaft during any desired period of its rotation may be substituted therefor without departing from the structural or operative principle of our invention.

We claim herein as our invention—

1. The combination, in a dynamometer, of a shaft, a loose pulley mounted thereon, and a pressure-transmitting device journaled on and rotating with the shaft, and bearing in opposite directions, respectively, circumferentially on the loose pulley and in the direction of the axial line of the shaft thereof on a movable abutment subject to fluid-pressure, substantially as set forth.

2. The combination, in a dynamometer, of a main shaft, a driving-pulley fixed thereon for the reception of power to be measured, a measuring-pulley mounted freely thereon, a fluid-pressure cylinder located in line axially with the shaft, a fluid-supply pipe communicating with said cylinder and with a pressure-gage, a piston fitting said cylinder and provided with a valve controlling the discharge of fluid therefrom, and a bell-crank shaft journaled transversely to the main shaft in bearings fixed thereto, and having an arm adapted to abut

against the piston and an arm adapted to transmit pressure to a bearing on the rim of the measuring-pulley, substantially as set forth.

3. The combination, in a dynamometer, of a fluid-pressure cylinder, a supply-pipe controlled by a regulating-valve and communicating with said cylinder, a pressure-gage communicating with the supply-pipe and cylinder, a piston fitting the cylinder and carrying a valve controlling a discharge-passage leading therefrom, and an arm journaled on a shaft and transmitting the pressure exerted by power applied in the rotation thereof to the piston in opposite direction to the fluid-pressure in the cylinder, substantially as set forth.

4. The combination, in a dynamometer, of a main shaft, a fast and a loose pulley mounted thereon, a pressure-transmitting device journaled on and rotating with the main shaft, and bearing in opposite directions on the loose pulley and on a movable abutment subject to fluid-pressure, and a speed-indicating mechanism actuated by gearing driven from the main shaft, substantially as set forth.

5. The combination of a main shaft mounted in bearings on a supporting base or bed plate, a driving-pulley fixed thereon for the reception of power to be measured, a sleeve or cylindrical extension fixed upon one end of the main shaft and provided with lateral bearings exterior to the axial line thereof and at right angles thereto, a measuring-pulley fitting freely on said sleeve, a bell-crank shaft journaled in the bearings of the sleeve, and having an arm on one or both of its ends in position to transmit pressure to a bearing connected to the rim of the measuring-pulley, and a central arm provided with a bearing in or about in line axially with the main shaft, a fluid-pressure cylinder concentric with and adjoining the outer end of the sleeve fixed on the main shaft, a supply-pipe communicating with said cylinder and with a pressure-gage, a piston fitting said cylinder and having a stem projecting into the sleeve in position to abut against the central arm of the bell-crank shaft, and a valve connected to the piston and controlling a discharge port or passage leading out of the cylinder, substantially as set forth.

6. The combination, with the main shaft, of a sleeve fitting thereon and having lateral bearings exterior and at right angles to its axis, and a fluid-pressure cylinder secured to the outer end of the sleeve concentrically therewith, substantially as set forth.

7. The combination of a main shaft, a fluid-pressure cylinder connected concentrically to a sleeve on one end thereof, a piston fitting in said cylinder and having its stem abutting against a transmitting device, through which the pressure of power applied in rotating the shaft is exerted against the piston, a head closing the outer end of the cylinder and provided with supply and discharge passages, a trunnion-pipe communicating with a fluid-supply pipe and pressure-gage and with the supply-passage of the cylinder-head, a socket fixed to the head and fitting freely around the trunnion-pipe and against an end collar thereon between the socket and head, and a discharge-valve connected to the piston and controlling the discharge-passage in the cylinder-head, substantially as set forth.

In testimony whereof we have hereunto set our hands.

GEO. WESTINGHOUSE, JR.
FRANK MOORE.

Witnesses:
J. SNOWDEN BELL,
R. H. WHITTLESEY.