(No Model.) 5 Sheets—Sheet 1.

M. N. FORNEY.

MEANS FOR COUNTERBALANCING MOMENTUM OF RECIPROCATING ELEMENTS.

No. 528,294. Patented Oct. 30, 1894.

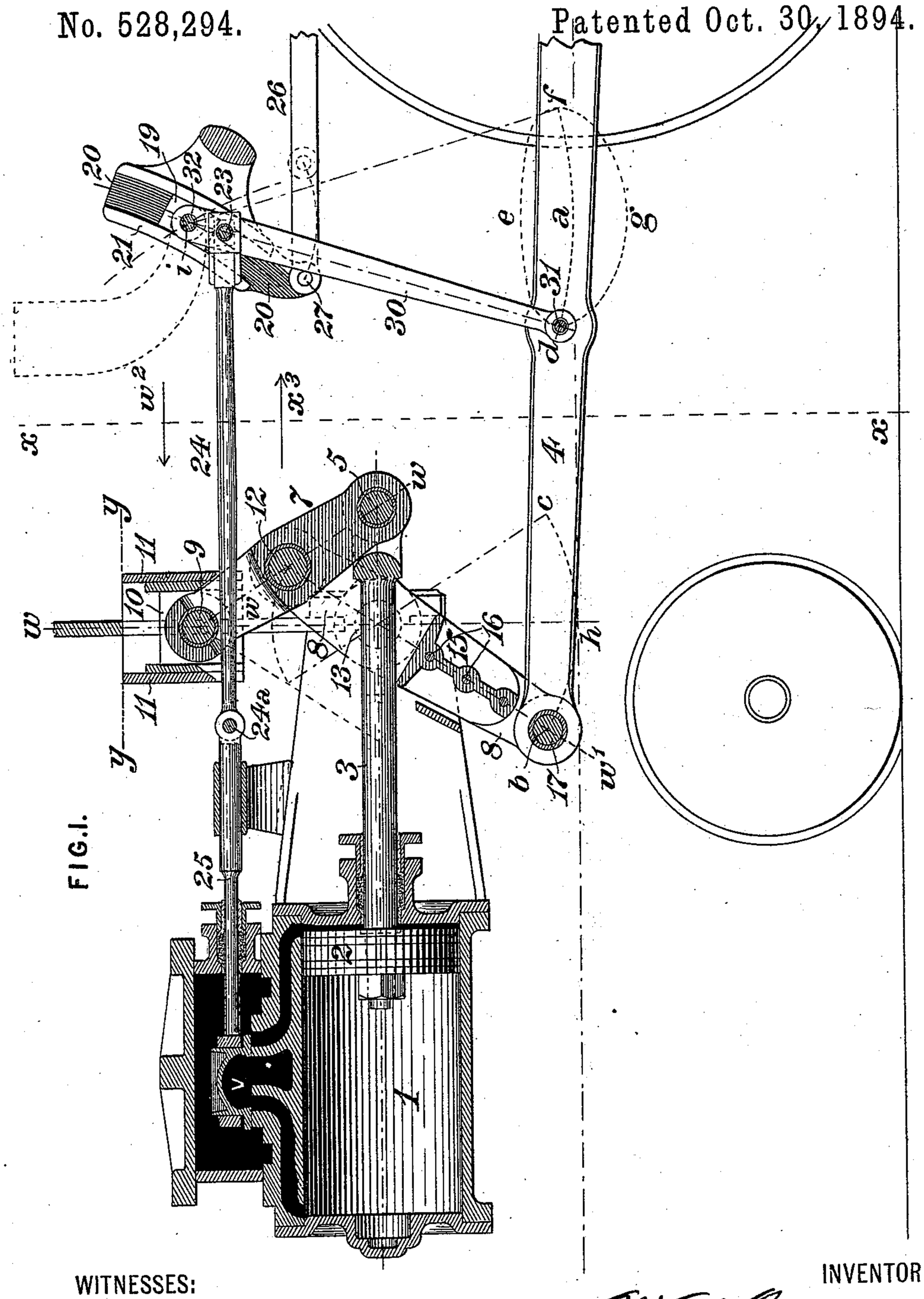

FIG. I.

WITNESSES:

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F. E. Gaither.

INVENTOR

M. N. Forney.

BY

Howson & Sons.

ATTORNEY

(No Model.) 5 Sheets—Sheet 2.

M. N. FORNEY.

MEANS FOR COUNTERBALANCING MOMENTUM OF RECIPROCATING ELEMENTS.

No. 528,294. Patented Oct. 30, 1894.

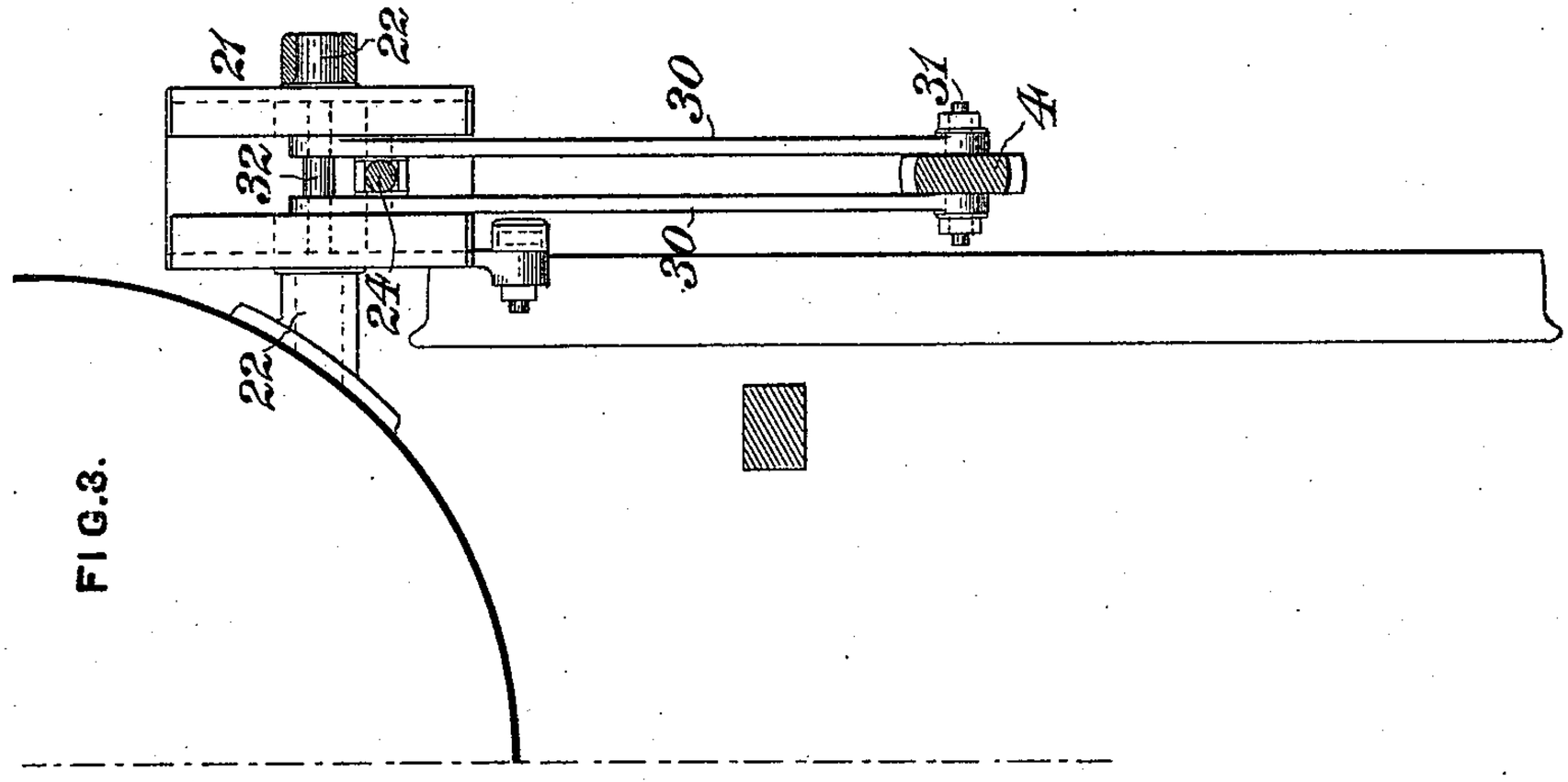

FIG.3.

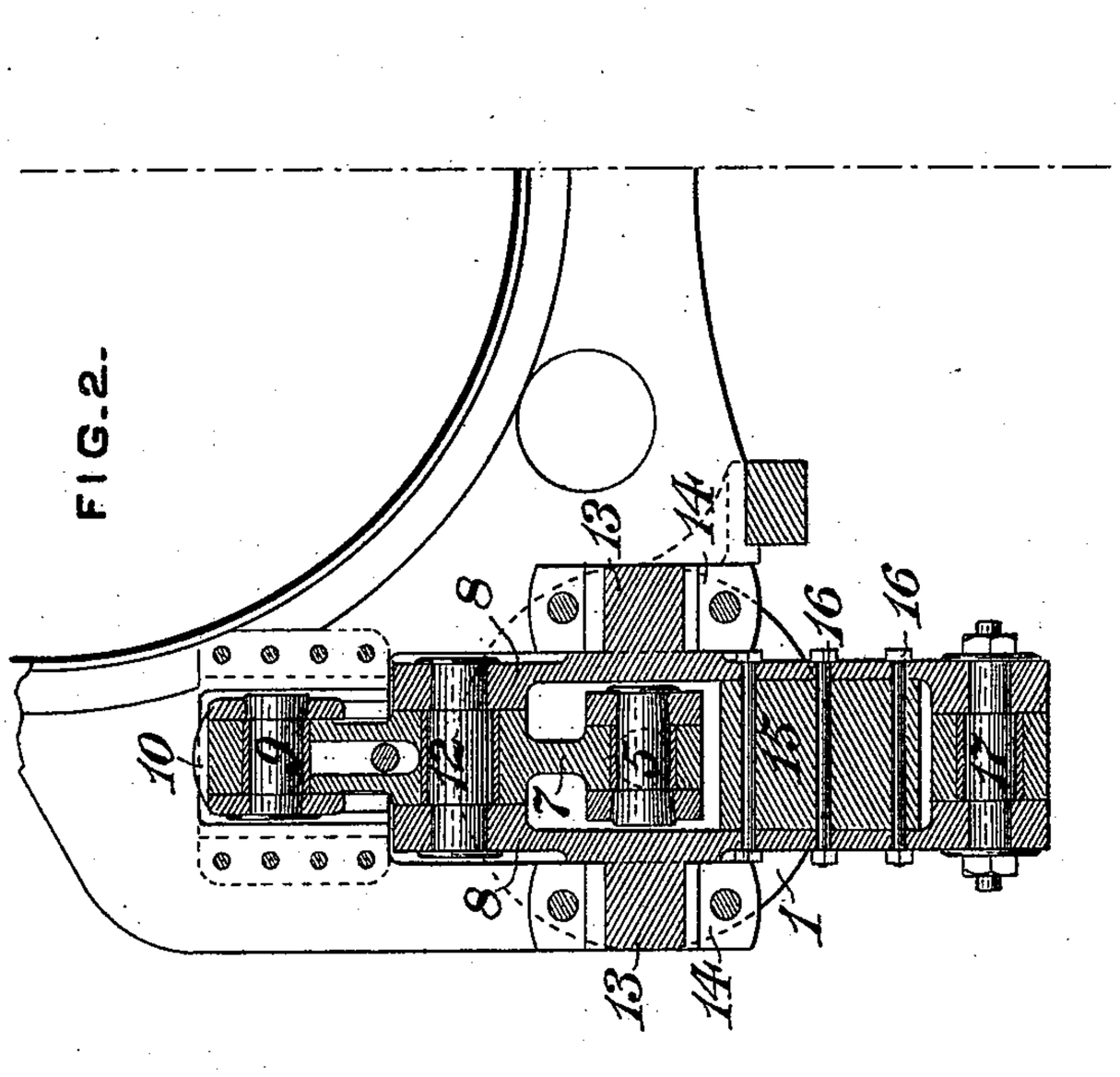

FIG.2.

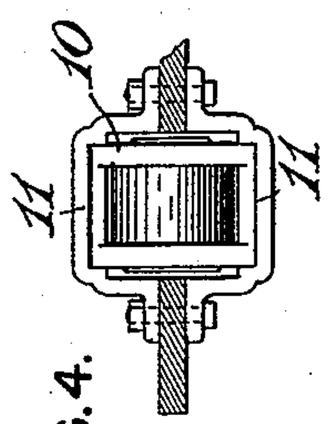

FIG.4.

WITNESSES:

T. J. Hogan.

F. E. Gaither.

INVENTOR

M. N. Forney

BY

J. Howard Bell.

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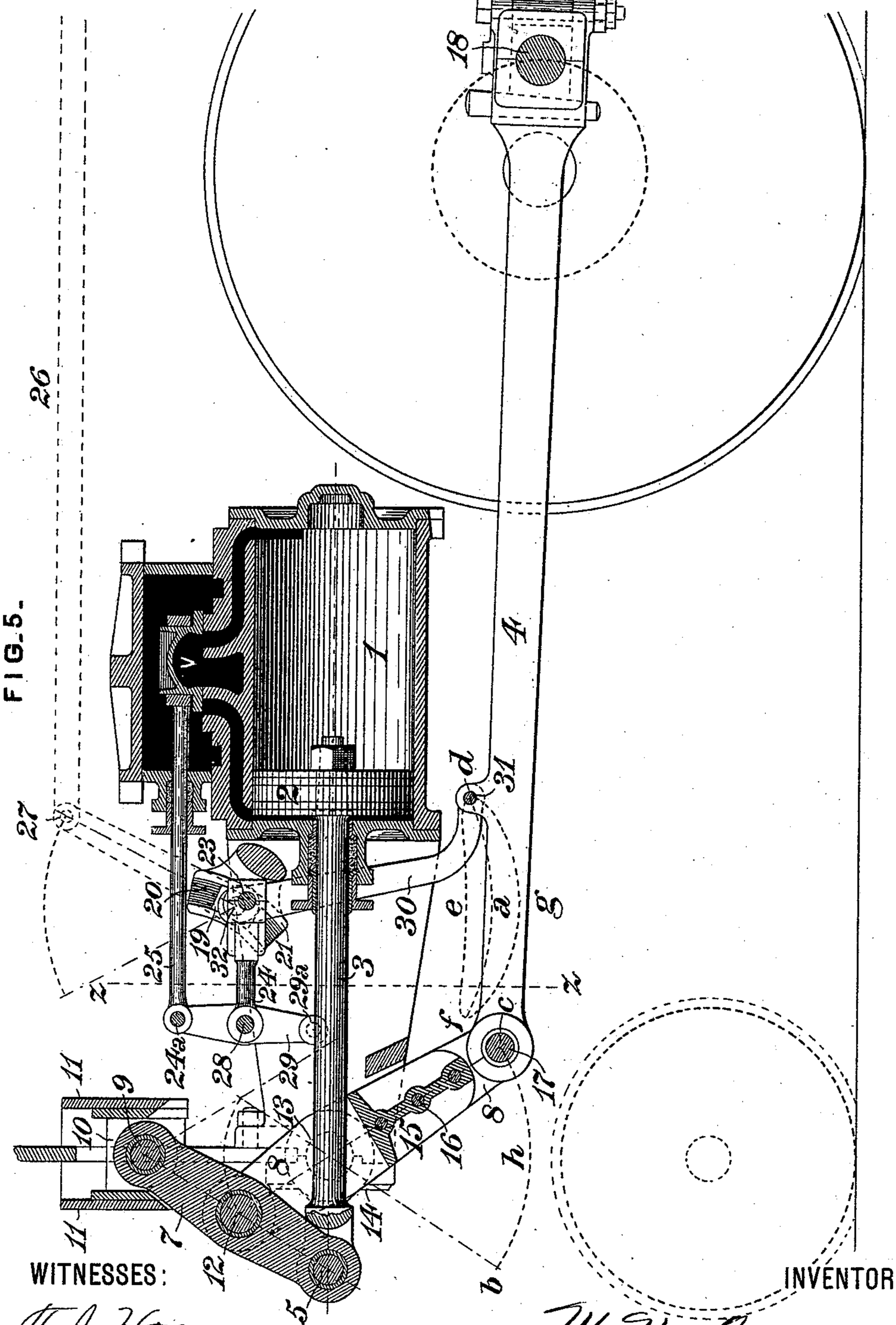
(No Model.) M. N. FORNEY. 5 Sheets—Sheet 3.

MEANS FOR COUNTERBALANCING MOMENTUM OF RECIPROCATING ELEMENTS.

No. 528,294. Patented Oct. 30, 1894.

FIG. 5.



WITNESSES:

T. J. Hogan.

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INVENTOR

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J. Snowden Bell.

ATTORNEY

(No Model.) 5 Sheets—Sheet 4.

M. N. FORNEY.

MEANS FOR COUNTERBALANCING MOMENTUM OF RECIPROCATING ELEMENTS.

No. 528,294. Patented Oct. 30, 1894.

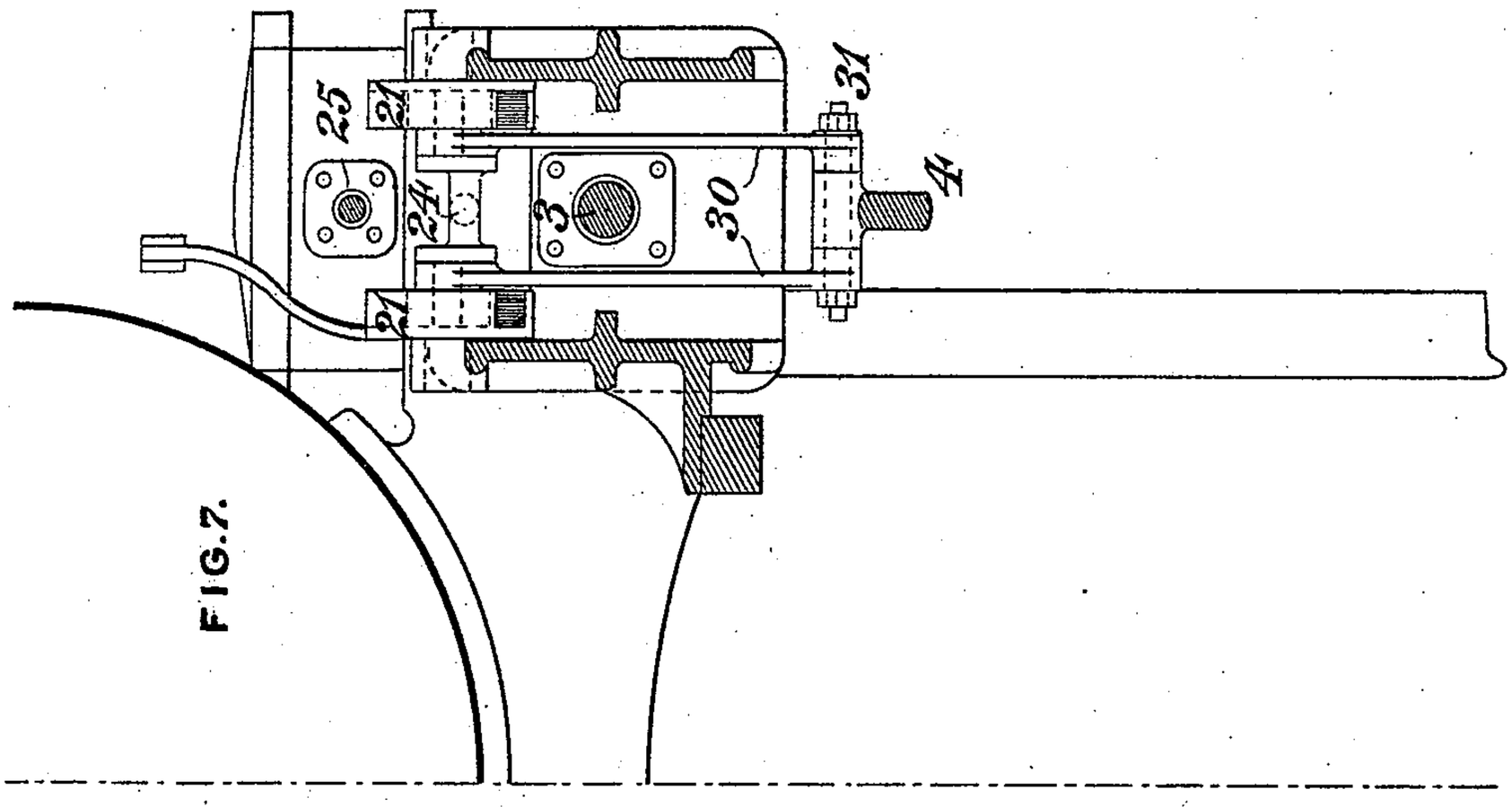


FIG. 7.

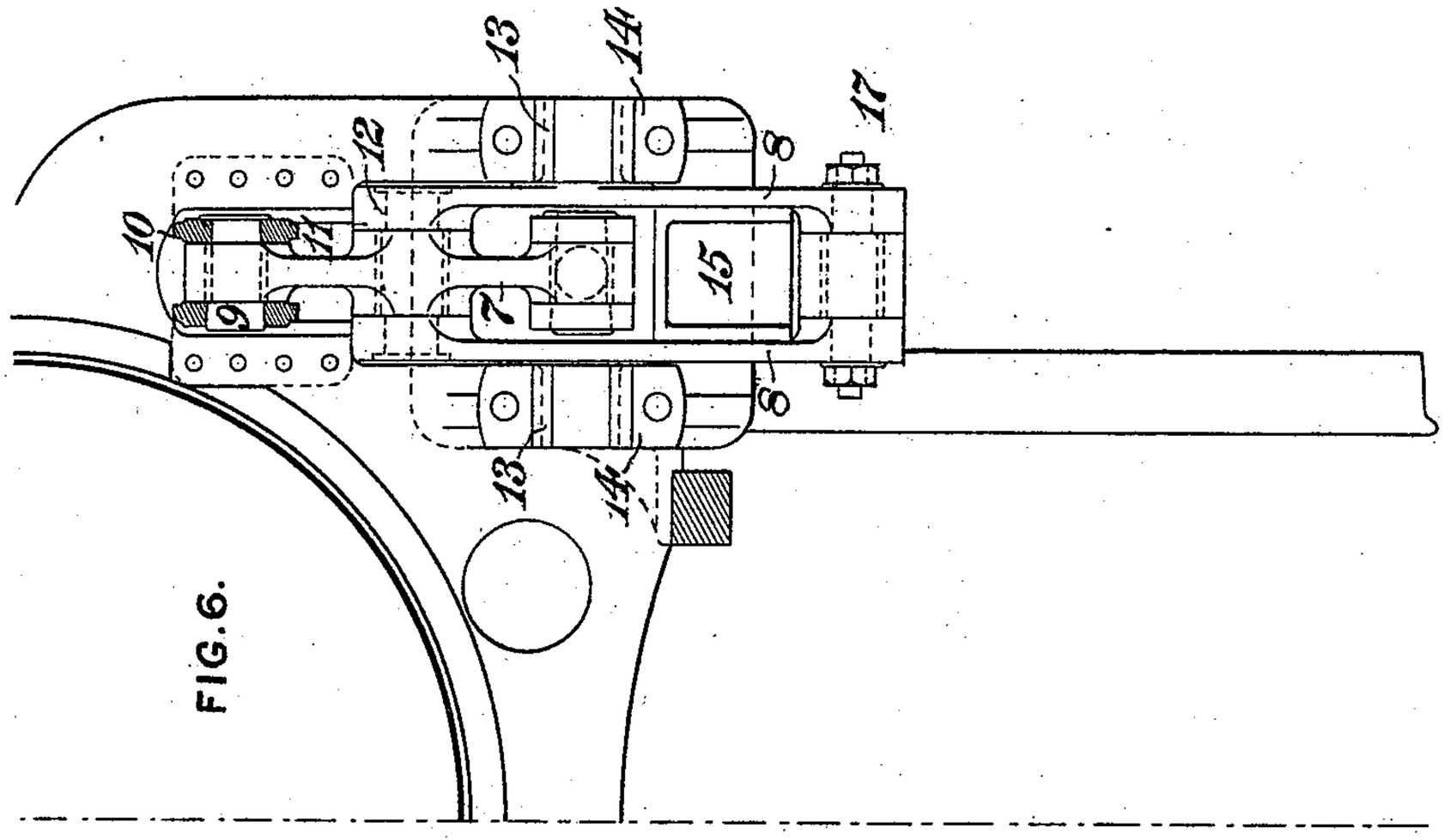


FIG. 6.

WITNESSES:

F. J. Hogan.

F. E. Gaither

INVENTOR

M. N. Forney.

BY

J. Howden Bell

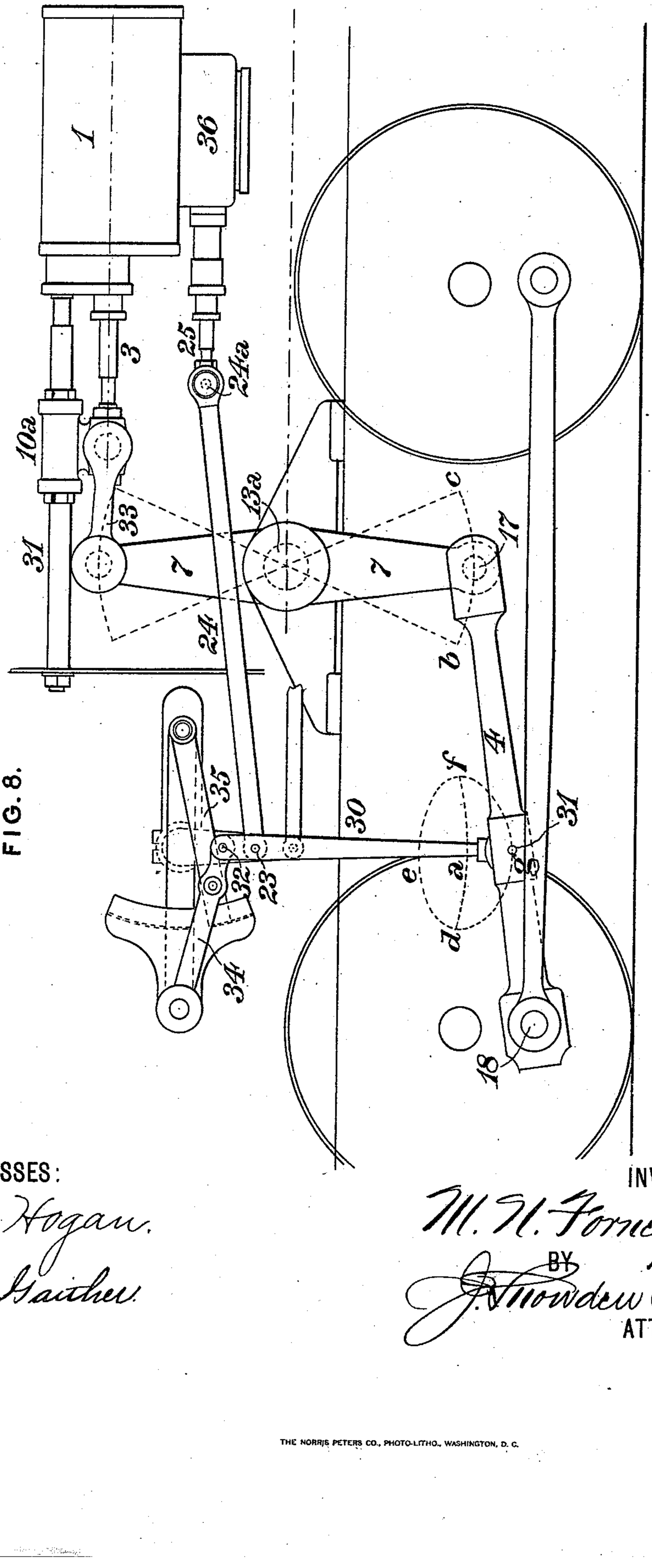
ATTORNEY.

(No Model.) 5 Sheets—Sheet 5.

M. N. FORNEY.

MEANS FOR COUNTERBALANCING MOMENTUM OF RECIPROCATING ELEMENTS.

No. 528,294. Patented Oct. 30, 1894.



Old construction.

FIG. 8.

WITNESSES:

T. J. Hogan.

F. E. Gaither.

INVENTOR

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BY

J. Snowden Bell.

ATTORNEY

UNITED STATES PATENT OFFICE.

MATTHIAS N. FORNEY, OF NEW YORK, N. Y.

MEANS FOR COUNTERBALANCING MOMENTUM OF RECIPROCATING ELEMENTS.

SPECIFICATION forming part of Letters Patent No. 528,294, dated October 30, 1894.

Application filed February 13, 1894. Serial No. 500,063. (No model.)

To all whom it may concern:

Be it known that I, MATTHIAS N. FORNEY, of the city, county, and State of New York, have invented a certain new and useful Improvement in Means for Counterbalancing the Momentum of Reciprocating Elements, of which improvement the following is a specification.

My present invention, which is, in part, an improvement on that for which Letters Patent of the United States No. 489,648 were granted and issued to me under date of January 10, 1893, while more particularly designed for application in simple or single expansion engines, is also applicable in compound engines, and its objects are to provide means for counterbalancing the momentum of reciprocating elements, one by another, without inducing disturbing action at right angles to the movement of such elements; also, to provide a simple and effective valve mechanism actuated by and combined with the counterbalancing system referred to.

The improvement claimed is hereinafter fully set forth.

In my Letters Patent No. 489,648, aforesaid, the weight of the piston, piston rod, and part of the weight of the connecting rod, is balanced by a swinging counterweight, suspended from a system of oscillating levers connected to the piston rod. Under my present invention, the piston rod is coupled to primary levers, as set forth in Patent No. 489,648, and the connecting rod is coupled to secondary levers, as in the compound engine exemplified in said patent. In the compound engine construction of said patent, however, the weight of the low pressure piston and rod, which is the larger and heavier, is balanced by that of the smaller high pressure piston, piston rod, cross-head, connecting links, and a part of the weight of the connecting rod. Under my present invention, the connecting rod may be made sufficiently heavy to enable the weight of its end which is coupled to the secondary levers, to balance the weight of the piston and piston rod coupled to the primary levers. If, for any reason, it should not be desirable to make the connecting rod so heavy that its weight alone, or the weight of that portion of it which is supported by the secondary levers, would be sufficient to balance the weight of the piston and piston rod, in such case a counterweight may be added and connected to the secondary levers, so that its weight, added to that of one end of the connecting rod, will be equal to the weight of the piston and piston rod.

My invention further consists in a valve gear, combined with and actuated by the counterbalancing system above referred to. The valve gear is composed of a lever or levers coupled to the main connecting rod, at some point between its ends, and coupled, at the opposite end or ends, to a block or blocks sliding in a groove or grooves, the position or inclination of which may be changed as desired. By this means, the direction or extent of the travel of the steam distribution valve, the stem of which is coupled to the lever, may be changed, and the engine may thus be reversed, or the point at which the valve cuts off steam may be altered. The combination of such valve gear with the counterbalancing system, enables the valve moving mechanism to be materially simplified, relatively to those heretofore employed.

In the accompanying drawings: Figure 1 is a side view, partly in elevation and partly in section, illustrating an application of my invention in a locomotive engine; Fig. 2, a transverse section, partly at the line w, w, w, and partly at the line w, w, w' of Fig. 1, and looking in the direction of the arrow, w^2; Fig. 3, a similar section, at the line x, x, and looking in the direction of the arrow, x^3; Fig. 4, a sectional plan view, at the line y, y, of Fig. 1; Fig. 5, a side view, partly in elevation and partly in section, illustrating an application in a locomotive engine, in which the engine is "back" connected, that is, having the connecting rod extending, from the oscillating lever system, toward and below the cylinder to the crank pin; Fig. 6, an end view, looking toward the right in Fig. 5; Fig. 7, a transverse section, at the line z, z, of Fig. 5, and looking toward the right, and Fig. 8, a side view, in elevation, illustrating for purposes of comparison, a prior construction.

While my invention is herein shown and will be described, as applied in a locomotive steam engine, it is equally applicable in stationary and marine engines, and in engines using motive fluid other than steam.

Referring to the drawings, the cylinder 1, which is of the ordinary construction, is fitted with a piston 2 attached to a piston-rod 3, the outer end of which is coupled to a lever 7, such as is termed, in Patent No. 489,648, a "primary lever" which is pivotally connected at its upper end, as by a pin 9, to a sliding block 10, which is fitted to work on or between a fixed guide or guides 11. The primary lever 7 is intermediately coupled, by a pin 12, to the upper ends of a pair of "secondary" levers 8, 8, which are located on the outside of the primary lever 7, in order to insure greater stability and to permit the primary lever to work freely between them. The secondary levers are provided with journals 13, which are mounted in fixed bearings 14, forming fulcra about which the secondary levers 8 are adapted to oscillate, as in Patent No. 489,648.

Under my present invention, in lieu of coupling the connecting-rod directly to the end of the piston-rod, as shown in the figures of Patent No. 489,648, which represent the parts of a single cylinder simple engine, it is coupled to what, in this case, are the lower ends of the secondary levers, and its opposite end is coupled to an ordinary crank-pin, which is not shown in Fig. 1. As the connecting-rod thus moves in an opposite direction to the piston and piston-rod, if the weight of that end of the connecting-rod which is coupled to the secondary levers is made equivalent to that of the piston and its rod, these latter members will be balanced by the connecting rod. If the levers are so proportioned that the piston and the lower end of the secondary levers move unequal distances, then the product of the weight of the end of the connecting-rod coupled to the levers, multiplied by the distance through which it moves, should be equal to that of the piston and its rod, multiplied by the distance through which they move. The end of the connecting-rod which is coupled to the crank-pin, is balanced by a revolving weight attached to the wheel or crank opposite to the crank-pin in the usual way.

In order to maintain the two secondary levers securely in their proper relative position, a distance piece or casting 15 is placed between them, and the levers are fixed securely to said distance piece by bolts 16, (see Figs. 1, 2 and 5,) which pass thrcugh the levers in the casting. The distance piece 15 also serves to some extent as a counterweight for the piston and its rod, and if the weight of the end of the connecting-rod is not sufficient to balance the piston and its rod, the weight of the distance piece may be increased so as to supplement that of the rod.

It will be seen, from Figs. 1 and 5, that the center of the pin 17, by which the connecting-rod 4 is coupled to the lower ends of the secondary levers, moves in a path *b*, *h*, *c*, which is an arc of a circle. If any point, as *d*, between the two ends of the connecting-rod, and its path, during one revolution of the crank-pin, be taken, it will be found that such point moves in curves represented by the dotted line *d*, *e*, *f*, *g*, in Figs. 1 and 5. It will also be found that an arc of a circle *d*, *a*, *f*, may be drawn, which will intersect the two points *d* and *f*, which are occupied by the center of the pin *d*, when the crank is at its two dead-points, and also the vertical center *a*, which is midway between the top *e*, and the bottom *g*, of the curves *d*, *e*, *f*, *g*. The centers *i*, of the arcs *d*, *a*, *f*, can be readily found in the two figures, and a lever or levers 30 can be proportioned so that, if pivoted at *i*, their lower ends *d* would oscillate in the paths *d*, *a*, *f*, of Figs. 1 and 5. Under my invention this peculiarity of the curves *d*, *e*, *f*, *g*, which are described by points in connecting-rods connected at one end to an oscillating lever system and at the other to a crank, is utilized by coupling two levers 30 to some suitable point, as *d*, on the connecting-rod by a pin or pivot 31. The upper ends of the levers 30 are coupled, by a pin 32, to blocks 19, which slide in segmental grooves 20, formed in a block 21, which will be called a "link," owing to the fact that it performs the same function as that of the member called by that name in an ordinary link-motion valve-gear. The link 21 is fitted to turn on pivots or journals 22, 22, (Figs. 3 and 7,) whose axial positions coincide with those in which the pins 32 are shown in Figs. 1 and 5. As shown in Fig. 1, the stem 25, of the steam distribution valve *v*, is coupled by a pin 24^a, to a rod 24, the opposite end of which is coupled by a pin 23, to the block 19.

It will be obvious that if the levers 30 are coupled to the connecting rod at the point *d*, a vertical motion will be imparted to the blocks 19, causing them to slide in the grooves 20, 20. If these grooves are inclined from a vertical position, as shown in Fig. 1, the blocks 19 will receive a certain degree of horizontal movement, which is due to the inclination of the grooves or slots, and this movement will be imparted to the valve stem 25, and by it to the valve *v*. The degree and direction of this movement or travel will be determined by the degree and direction of the inclination of the link, which is regulated by a rod 26, coupled by a pin 27 to an arm attached to the link. The rod 24 being coupled to the levers 30, by the pin 23, a short distance below the pin 32, the horizontal movement of the pin 31 imparts a similar motion to the pin 23, which is communicated to the valve, and gives it the required "lead," as it is called.

The modified form of application shown in Figs. 5, 6, and 7, accords, in all substantial particulars, with the instance above described, differing therefrom in such relative location of the members as is due to the fact that, in this case, the engine is "back" connected, the piston rod 3 passing through the front head of the cylinder 1, and the connect-

ing rod 4 being coupled to the front, instead of the back, end of the piston rod, and passing backward, below the cylinder, to the crank pin 18.

In all other particulars, the construction and relation of the members of the counterbalancing system are as first described.

The valve gear, while embodying the same essential elements as in the first instance, differs therefrom in the particular that the valve stem 25 is indirectly connected to the blocks 19, the rod 24 which is coupled to the levers 30, being, in this case, coupled, at its opposite end, by a pin 28, to the middle of a pair of intermediate rocking levers 29, which are journaled, at their lower ends, on fixed pivots 29^a, and are coupled, by a pin 24^a, at their upper ends, to the valve stem 25.

The operation of the counterbalancing system and valve gear is similar to that of the corresponding members in the instance first described.

It will be seen that under this construction, as the combined movement of the levers 30 and blocks 19 is imparted to the middle of the levers 29, that the movement is doubled at the upper ends of the levers to which the valve stem 25 is coupled. This multiplication of movement is made for the reason that in a back connected engine in which the levers 30 are coupled to the connecting rod at a point between the oscillating counterbalancing levers and the cylinder, the vertical movement of the point at which the levers 30 are coupled to the connecting rod is so slight, that, unless the connecting and piston rods are made unduly long, or the link is given an excessive degree of inclination, the movement of the sliding blocks in the links will not impart sufficient travel to the valve. If the link should be inclined sufficiently, then, in some positions of the connecting rod, the levers 30 would stand nearly at right angles to the center line of the link, so that the levers would be subjected to great strains at such points.

In lieu of the segmental slots or grooves, and sliding blocks, of the constructions above described, links similar to those shown in Fig. 8, coupled at one end to movable pivots and at the other to the levers 30, may be substituted as mechanical equivalents, if desired.

The operation of the valve gear above described is similar to that of the well known "Joy" gear, and others of the same general type. In valve gears of such type, the difficulty has been developed that, owing to the fact that one end of the ordinary connecting rod moves in a straight line, instead of in an arc of a circle, as in my improved construction, the center line *d*, *a*, *f*, of the curve in which any point of the connecting rod moves, is a straight line, and, consequently, no single lever could be connected so that its end would travel on this line. It was therefore necessary to provide several levers, in order to properly effect the travel of the valve.

Under my invention, only a single lever, or preferably a pair of levers, side by side, is employed, one end of which is coupled directly to the connecting rod, and the other to the sliding link blocks, the valve stem being connected to the pair of levers between their two ends. The link is located and operated substantially as in the Joy and analogous constructions.

As an exemplification of the prior art, and for the purpose of making clear the difference between my improved valve gear and prior constructions operating on the same general principle, and indicating such features of similarity existing between the two as are not claimed as of my invention, I have illustrated, in Fig. 8, the valve gear of Charles Brown, formerly of the "Société Suisse pour la Construction de Locomotives et de Machines, a Winterthur, Suisse," as shown in a catalogue issued by said company, and described in English engineering journals. In this construction, the cylinder 1 is fitted with the ordinary piston, the rod 3 of which is attached to a cross head 10^a, working on a guide 31 in the usual manner. The cross head 10^a is coupled, by a short connecting rod 33, to the upper end of an oscillating lever or beam 7, which works on a fixed journal or pivot 13^a, midway between its ends; and is coupled, at its lower end, by a pin 17, to the connecting rod 4, which is, in turn, coupled to the main crank pin 18. The lower end of the beam 7 consequently moves in an arc *b*, *c*, or in a similar path to that of the levers 8 in Figs. 1 and 5. The center of the crank pin 18, of course moves in a circle, and any point, as the center of the pin 31, between the two ends of the connecting rod, describes an oval path, *d*, *e*, *f*, *g*, the top of which is flatter than the lower portion, or, if the point be taken near to the pin 17, the top of the curve will be concave, while the bottom is convex, as shown in Fig. 5. A lever, 30, is coupled at its lower end, by a pin 31, to the connecting rod, and is coupled at its upper end, to an articulated system of links, 34, 35, which is the equivalent of the slotted link 21 before described, which link I deem preferable to a system of jointed links.

In order that the distribution valve may be thrown equally on each side of the ports, the lever 30, Fig. 8, must be so proportioned that when its upper end is in the central position of its vertical movement, the lower end will describe an arc *d*, *a*, *f*, which will intersect the two points, *d*, and *f*, occupied by the center of the pin 31 in the connecting rod, when the crank pin 18 is at its dead points, and through a point midway between the points *e* and *g* at the top and bottom of the curve. In order to do this, the lever 30 must be of a definite length, corresponding with the radius of an arc drawn through *d*, *a*, and *f*, which would bring the center of the coupling pin 32 at its upper end about in the position as shown.

To connect the pin 23 with the valve stem 25, by a direct connection, the steam chest 36 and the steam distribution valve must be located below the cylinder, owing to the height of the latter above the pivot 13ª of the beam 7. This position of the steam chest is found to be inconvenient in making repairs, and in that position it is difficult to keep the valve steam tight on its seat.

It will be seen that if a piston is connected to the beam or lever 7 shown in Fig. 8, the center line of the cylinder must be placed at a distance above the center, 13ª, of the beam, nearly or quite equal to the length of the upper arm thereof. The required length of the lever 30 is consequently not sufficient to admit of locating the steam chest and valve on top of the cylinder, which is the location in which steam chests are now almost universally placed, especially on locomotives in the United States, by reason of the convenience of access to the valve which is thus afforded, and the greater facility of repairing or refacing the valve seats.

By reference to Figs. 1 and 5, it will be seen that, with the system of oscillating levers therein employed, the center line of the cylinder, instead of being at some distance above the fixed journals 13, of the oscillating levers 8, is coincident therewith. In other words, this construction would permit the center line of the cylinder shown in Fig. 8, to be located so as to coincide with a horizontal line drawn through the center of the journal 13ª, as in Figs. 1 and 5. If the cylinder shown in Fig. 8 were thus lowered, the steam chest 34 could then be placed on its top, and a direct connection could be made by a rod, similar to the rod 24, from the valve stem 25 to the pin 23 on the lever 30. The advantages and conveniences thus attained by my improved construction are due to the combination of the valve gear and improved system of balanced oscillating levers previously described, and were not available, so far as my knowledge and information extend, prior to my invention.

My improved system of oscillating levers and the connection of the piston and connecting rod thereto, attains the advantage of rendering the engine more perfectly balanced than is practicable under the ordinary constructions, and by the combination of this counterbalancing mechanism with a valve gear such as is described, a location of valve and steam chest is practicable which could not otherwise be employed. The valve gear, which is extremely simple, is not claimed, in and of itself, as of my invention, but its combination with the counterbalancing system above described, attains the advantages of simpler, more compact, and more convenient construction, and is believed and claimed to be novel and of my invention.

I claim as my invention and desire to secure by Letters Patent—

1. The combination, with a reciprocating piston and piston rod, of a primary lever connected at one end to the piston rod and at the other to a sliding member, a fixed guide on which the sliding member moves rectilinearly, a secondary lever journaled in fixed bearings and having one of its arms pivotally connected to the primary lever at the middle thereof, and a connecting rod connected to the opposite arm of the secondary lever, and to a crank, substantially as set forth.

2. The combination, with a reciprocating piston and piston rod, of an articulated system of oscillating levers or links, coupled to the piston rod and forming a guide to insure rectilinear motion thereof, a guiding member for said system of levers, and a connecting rod which is coupled to said system of levers and to a crank, and moves in opposite directions to the piston rod, said connecting rod being of a weight sufficient to counterbalance the piston and rod, substantially as set forth.

3. The combination, with a reciprocating piston and piston rod, of a primary oscillating lever coupled at one end to the piston rod and having a movable fulcrum at its opposite end, a double armed secondary lever, oscillating in fixed bearings and having one of its arms pivotally connected to the primary lever at the middle thereof, and a connecting rod coupled to the opposite arm of the secondary lever, and to a crank pin and moving in an opposite direction to the piston and its rod whereby the momentum of the said connecting rod counterbalances that of the piston and its rod, substantially as set forth.

4. The combination of a reciprocating piston and piston rod, a primary oscillating lever coupled at one end to the piston rod and having a movable fulcrum at its opposite end, a double armed secondary lever, oscillating in fixed bearings and having one of its arms pivotally connected to the primary lever, a connecting rod coupled to the opposite arm of the secondary lever and to a crank pin, a link oscillating on fixed bearings, a block fitted to slide therein, and a lever coupled to said block, to the connecting rod, and to a distribution valve, substantially as set forth.

5. The combination of a reciprocating piston and piston rod, a primary oscillating lever coupled at one end to the piston rod and having a movable fulcrum at its opposite end, a double armed secondary lever, oscillating in fixed bearings and having one of its arms pivotally connected to the primary lever, a connecting rod coupled to the opposite arm of the secondary lever and to a crank pin, a link oscillating in fixed bearings, a block fitted to slide therein, a lever coupled to said block and to the connecting rod, and an intermediate lever coupled to said lever and to a distribution valve, substantially as set forth.

6. The combination of a cylinder, a piston secured to a piston rod and reciprocating in said cylinder, a distribution valve working on a valve face above the lower line of said cylin-

der, a counterbalancing lever system, substantially as set forth, coupled to the piston rod, a connecting rod coupled to said counterbalancing lever system and to a crank pin, a link oscillating in fixed bearings, a block fitted to slide therein, a lever coupled to said block and to the connecting rod, and connections coupling said link with a distribution valve, substantially as set forth.

MATTHIAS N. FORNEY.

Witnesses:
FRANK J. FRENCH,
LENA F. VANNED.