L. M. FULLER.

RECOIL CHECK FOR ORDNANCE.

APPLICATION FILED FEB. 6, 1908.

913,488. Patented Feb. 23, 1909.

6 SHEETS—SHEET 1.

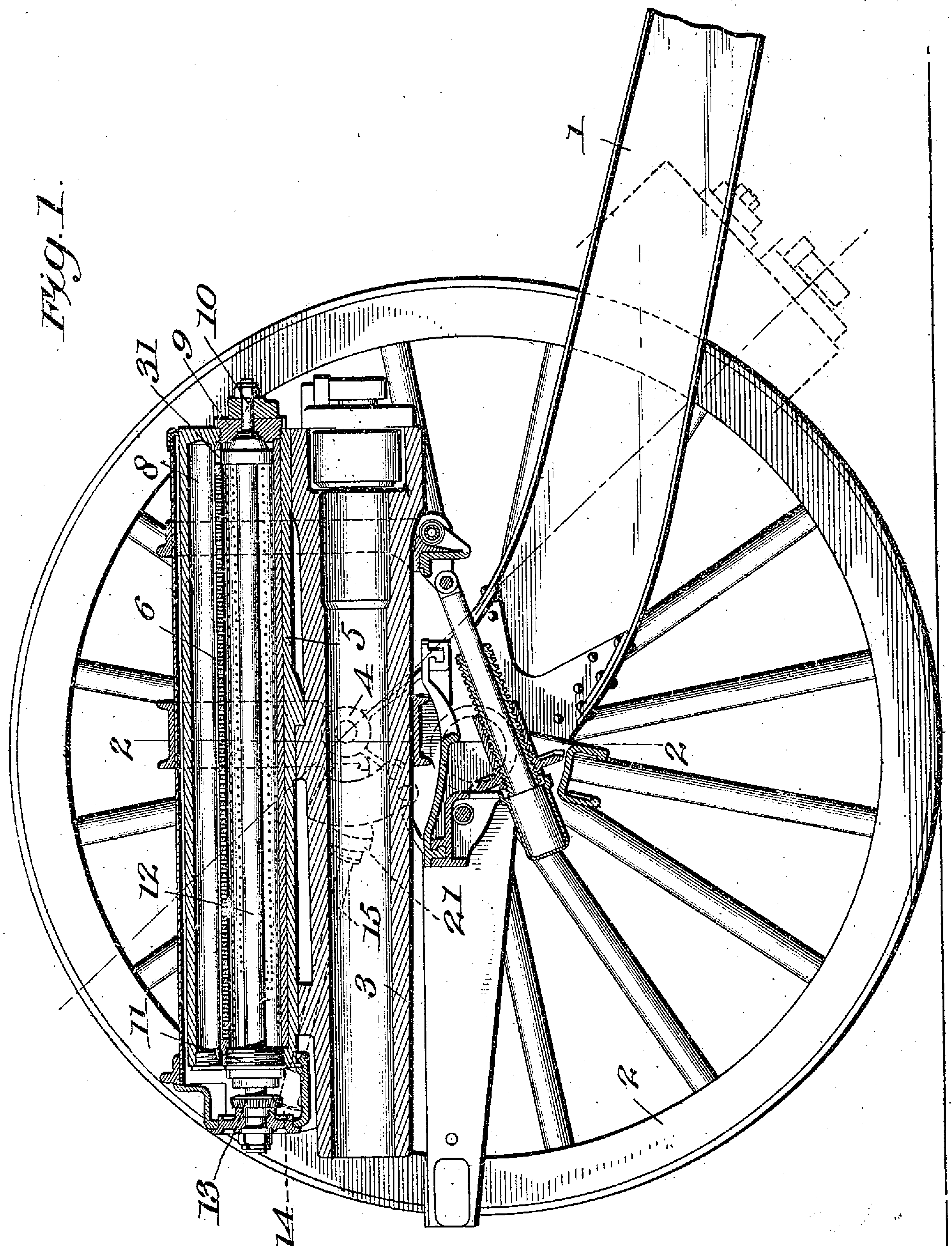

Fig. 1.

Witnesses

Geo. A. Byrne.

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6 SHEETS—SHEET 2.

Fig. 2.

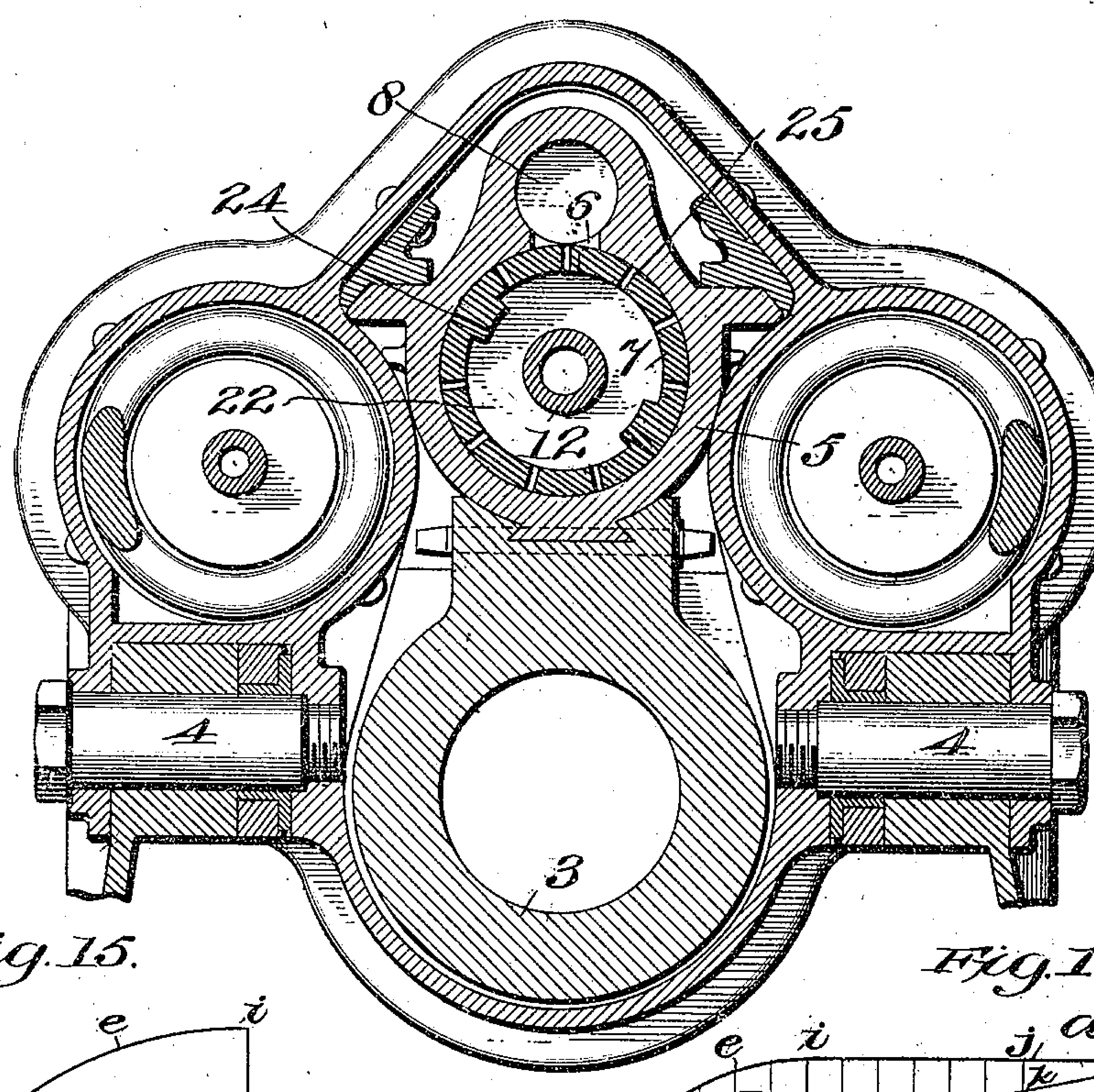


Fig. 15.

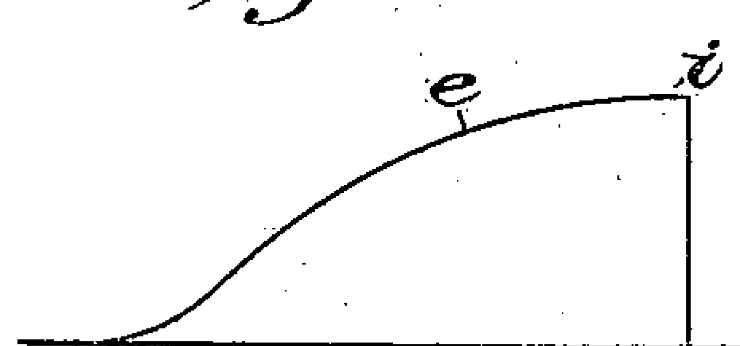


Fig. 16.

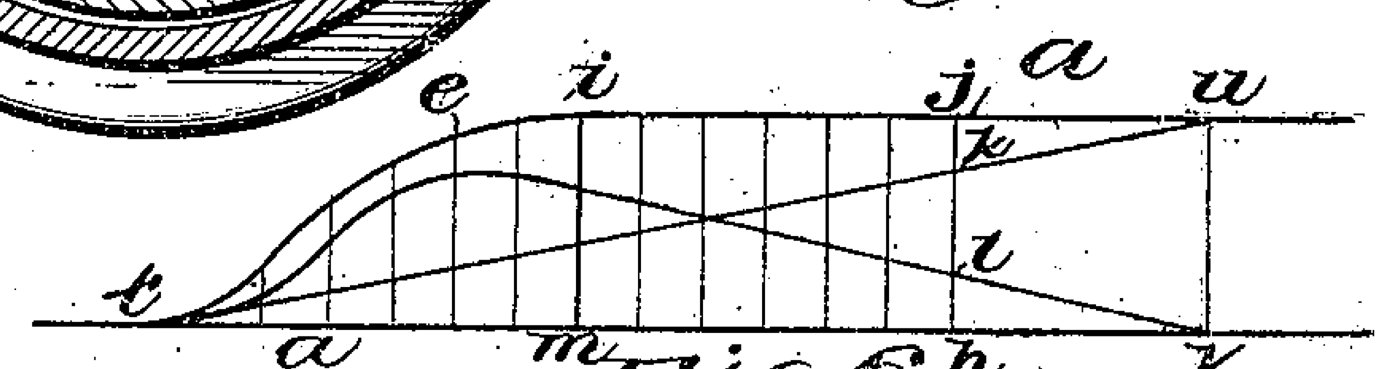
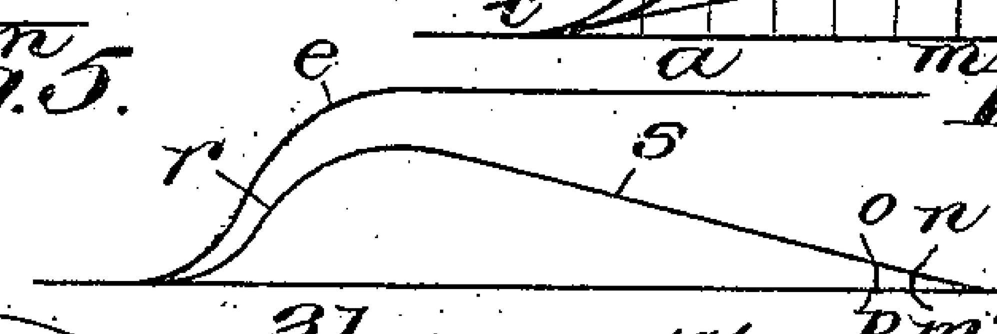


Fig. 5. Fig. 6.



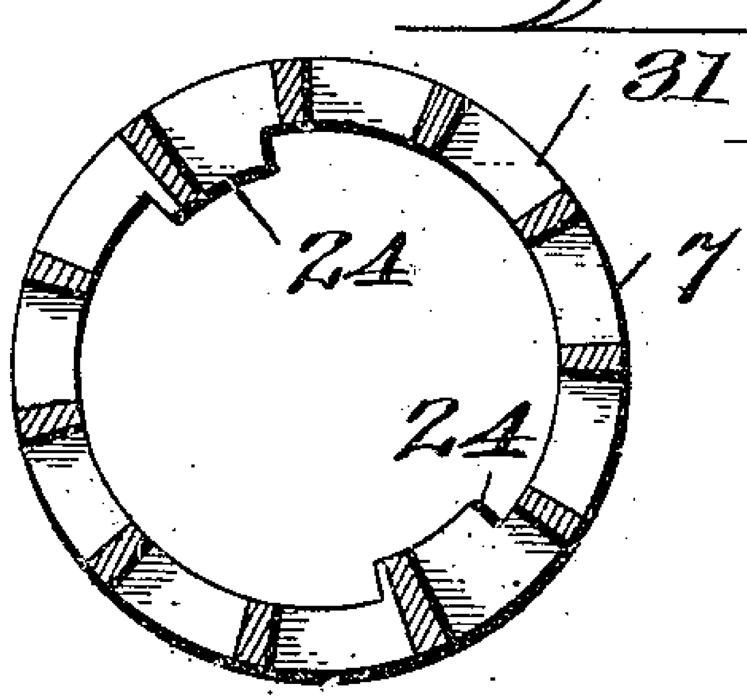


Fig. 17.

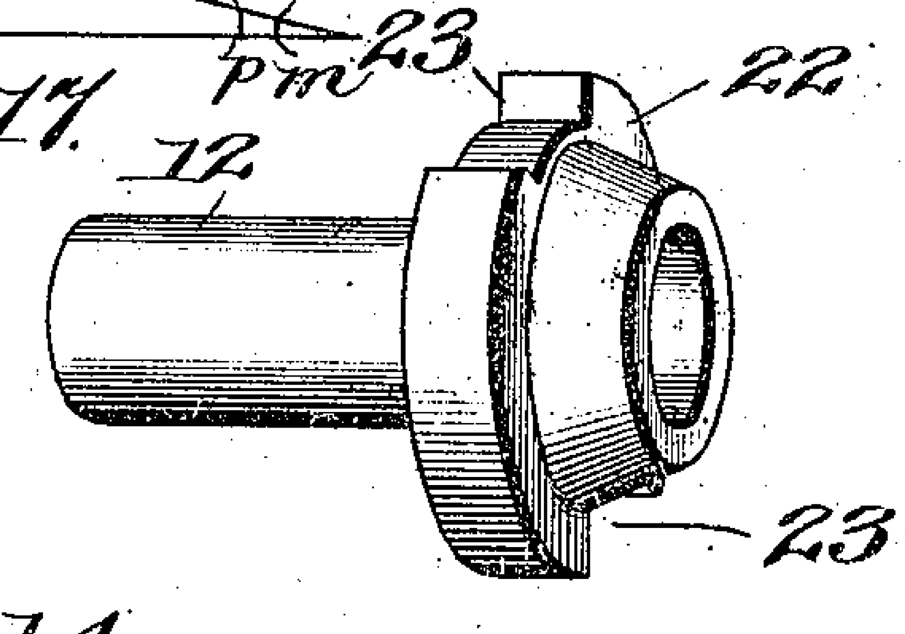
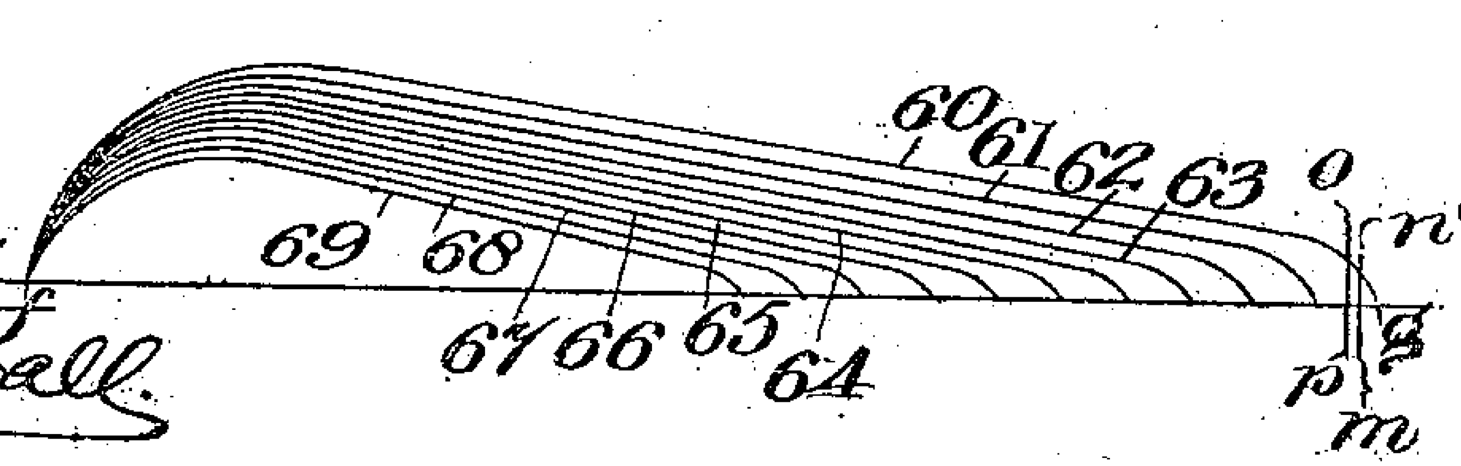


Fig. 14.



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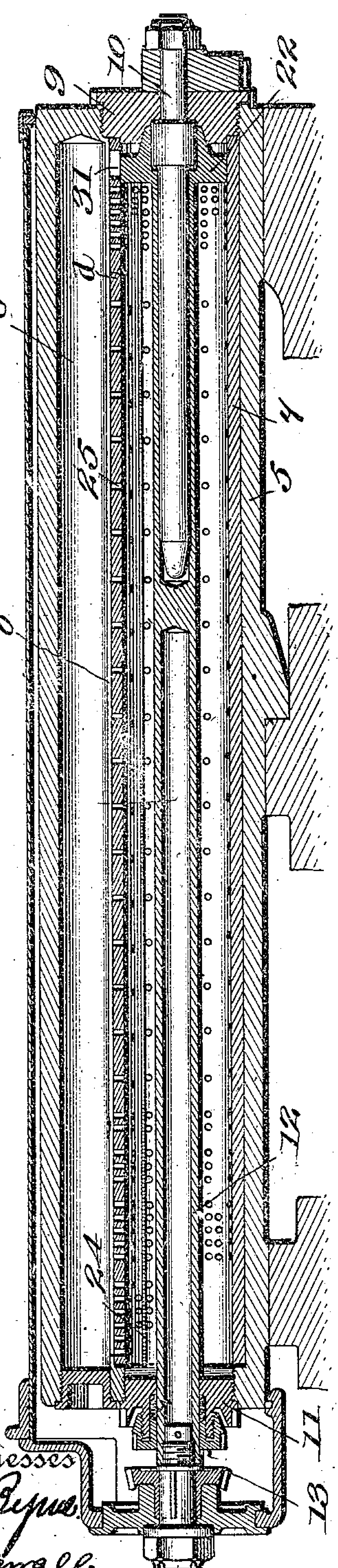

Fig. 3.

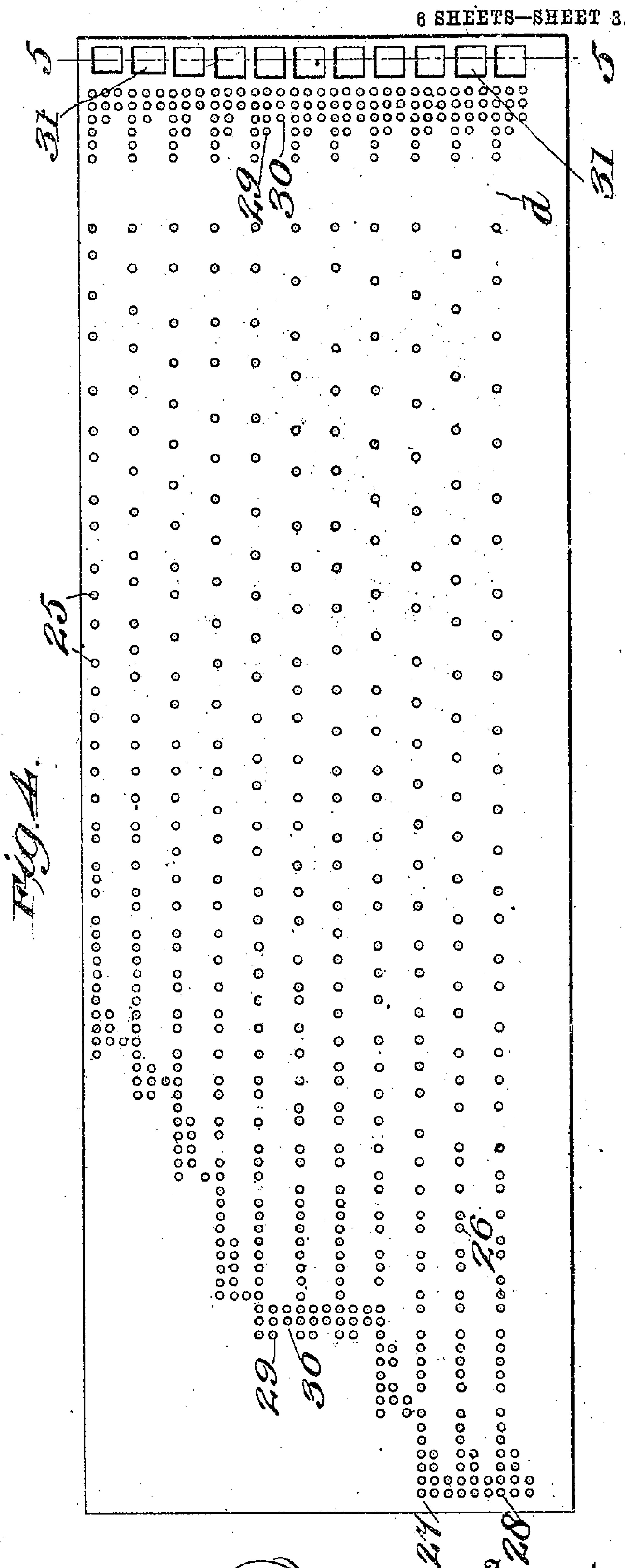

Fig. 4.

Witnesses

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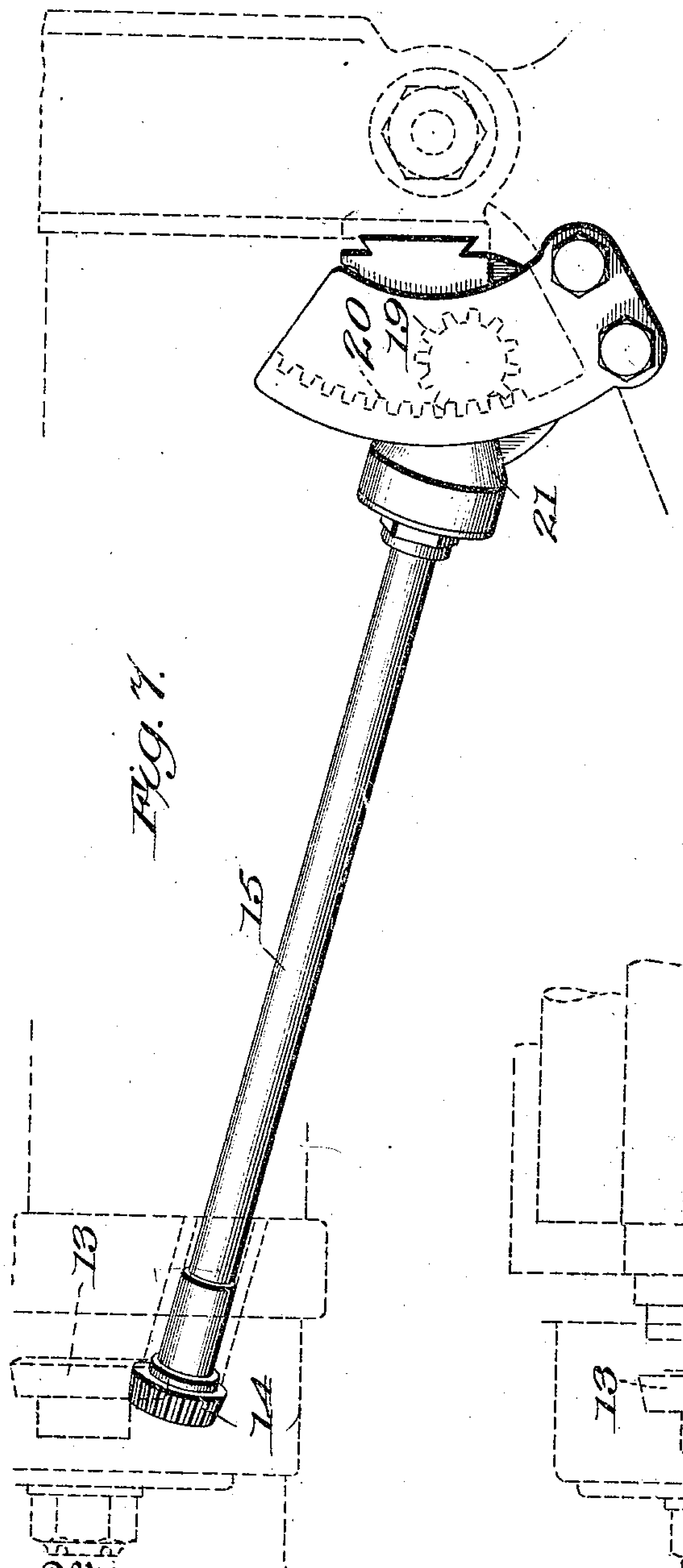

Fig. 7.

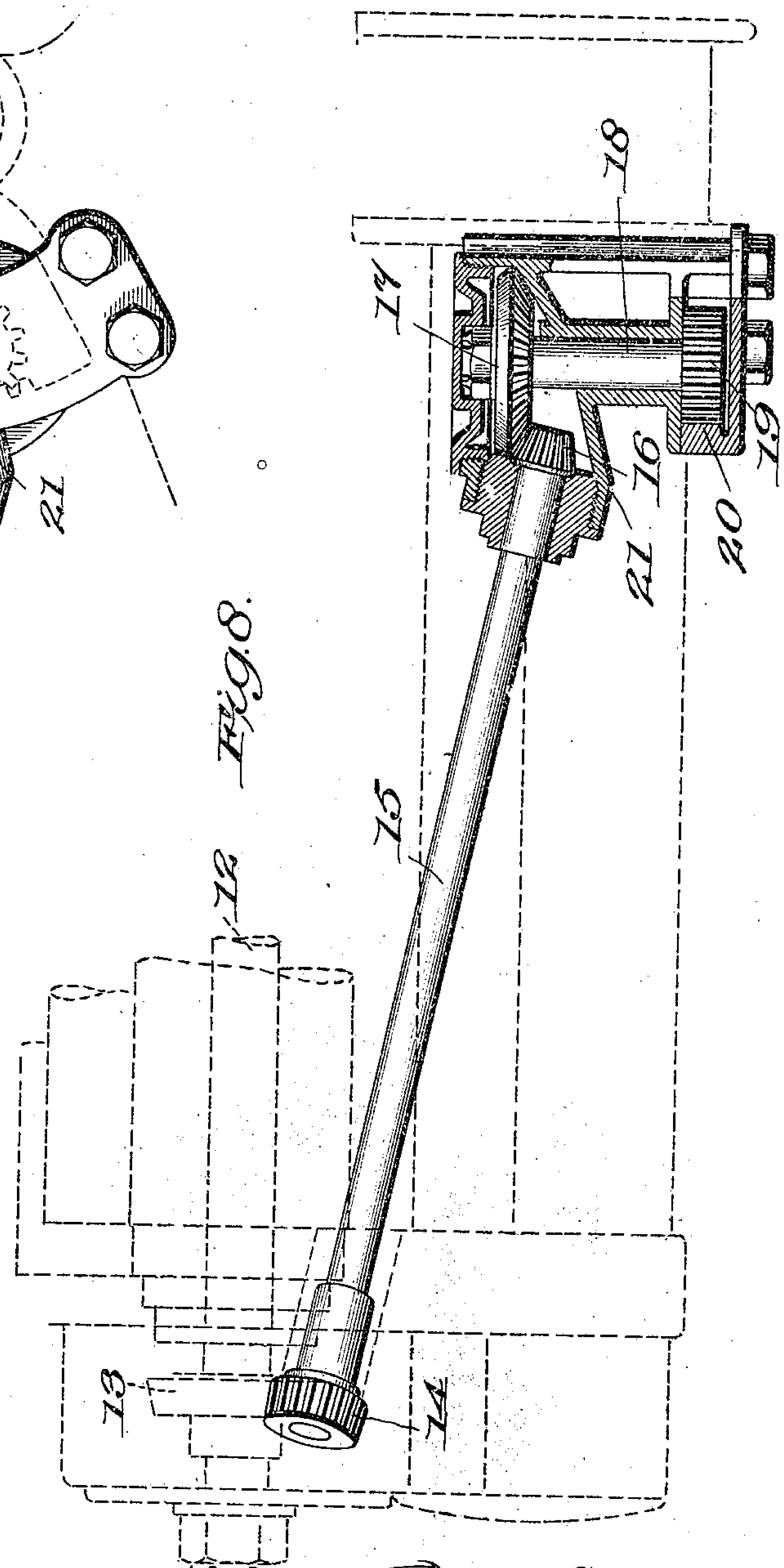

Fig. 8.

Witnesses

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6 SHEETS—SHEET 5.

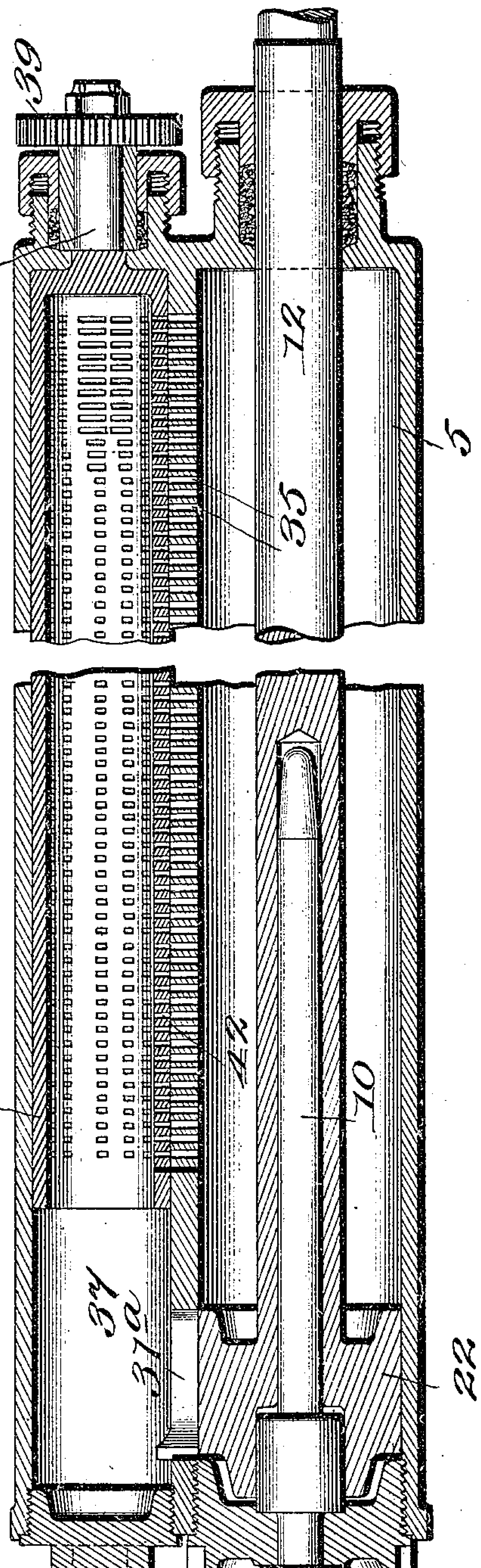

Fig. 9.

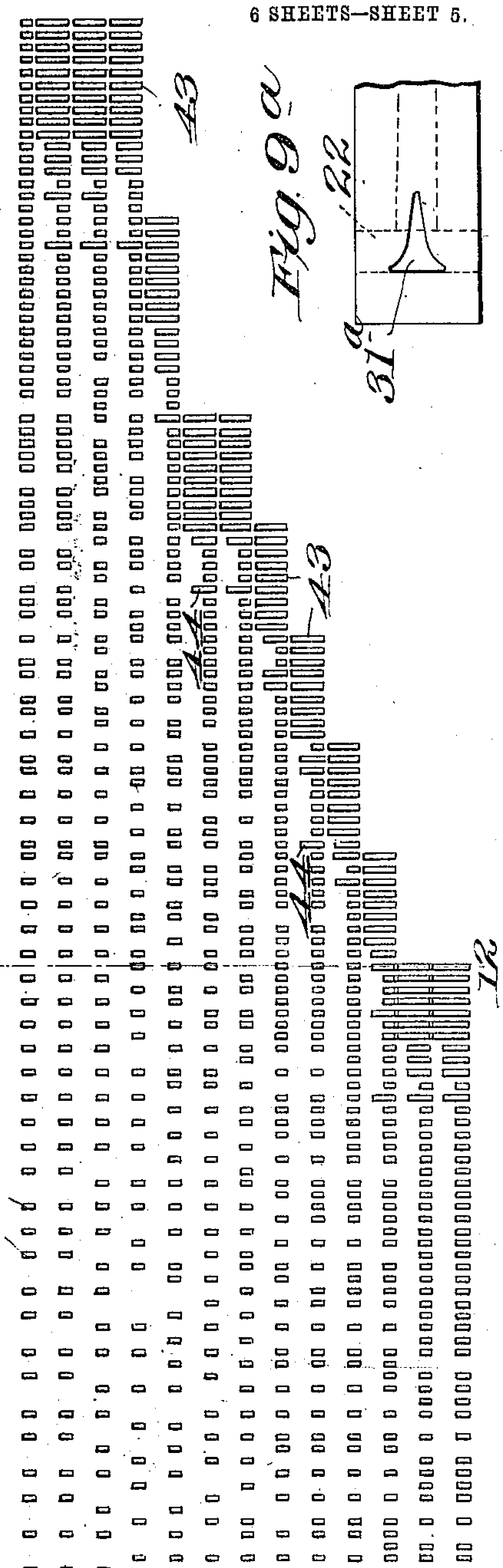

Fig. 11.

Fig. 9a

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6 SHEETS—SHEET 6.

Fig. 10.

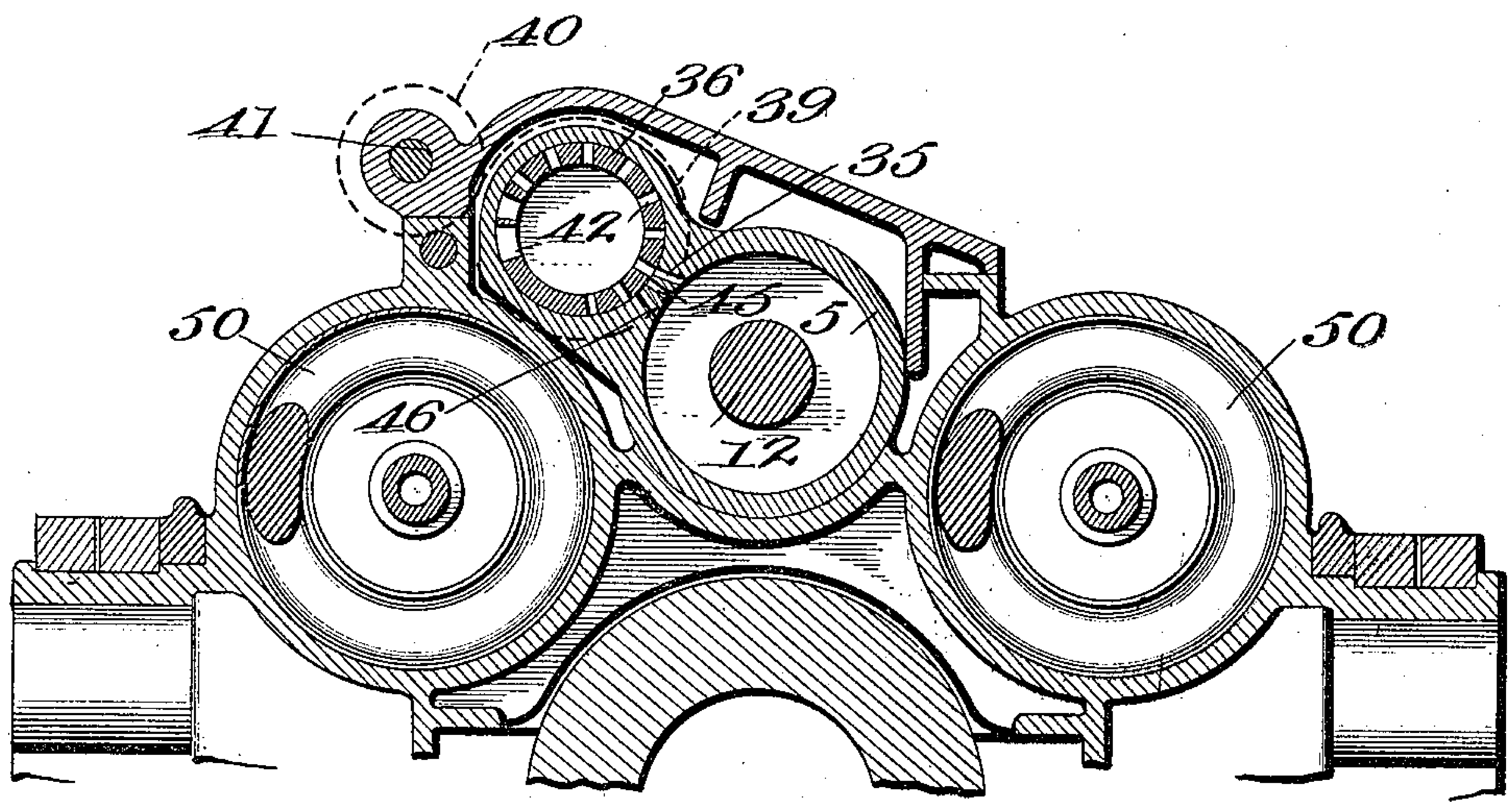


Fig. 13.

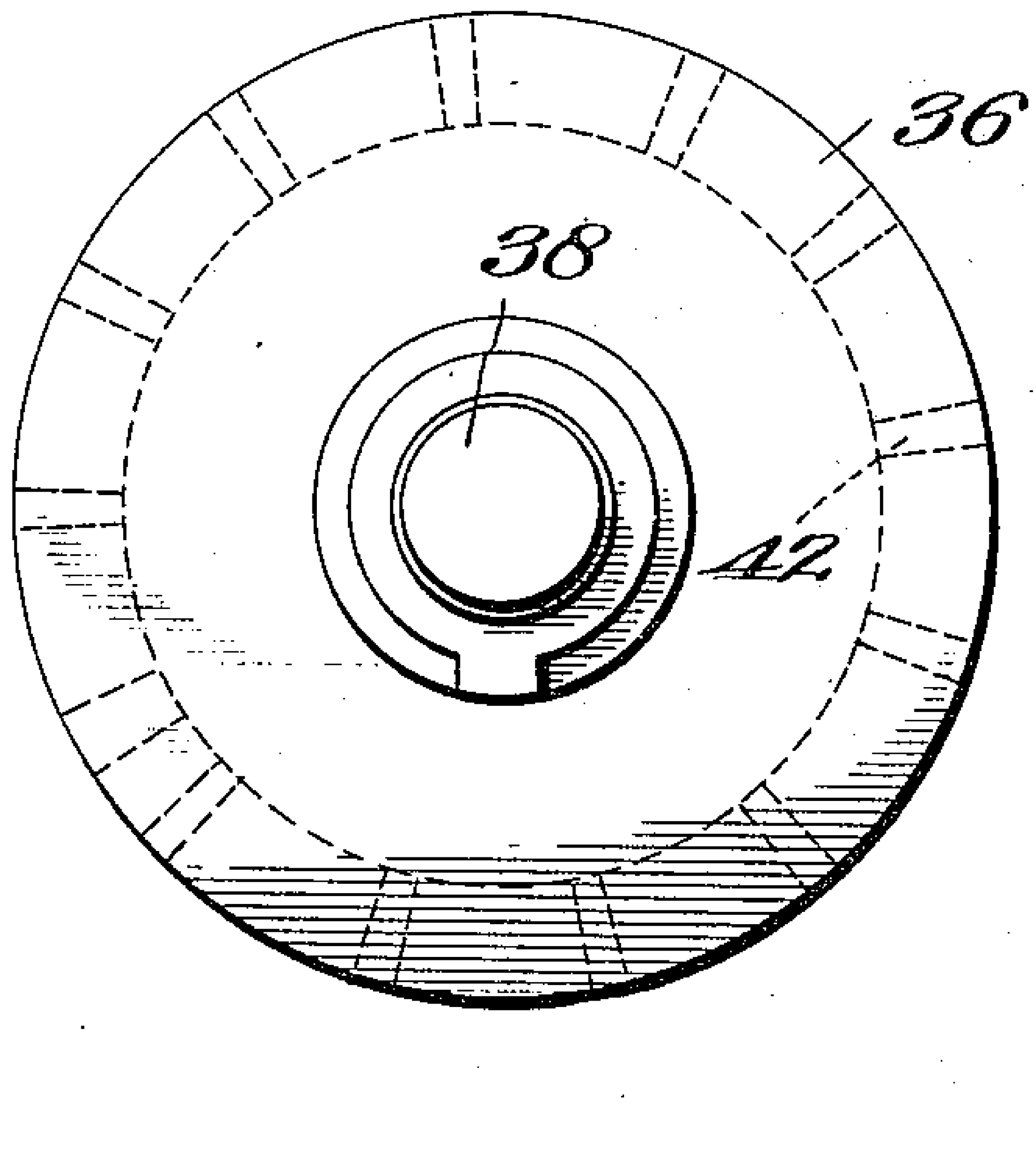
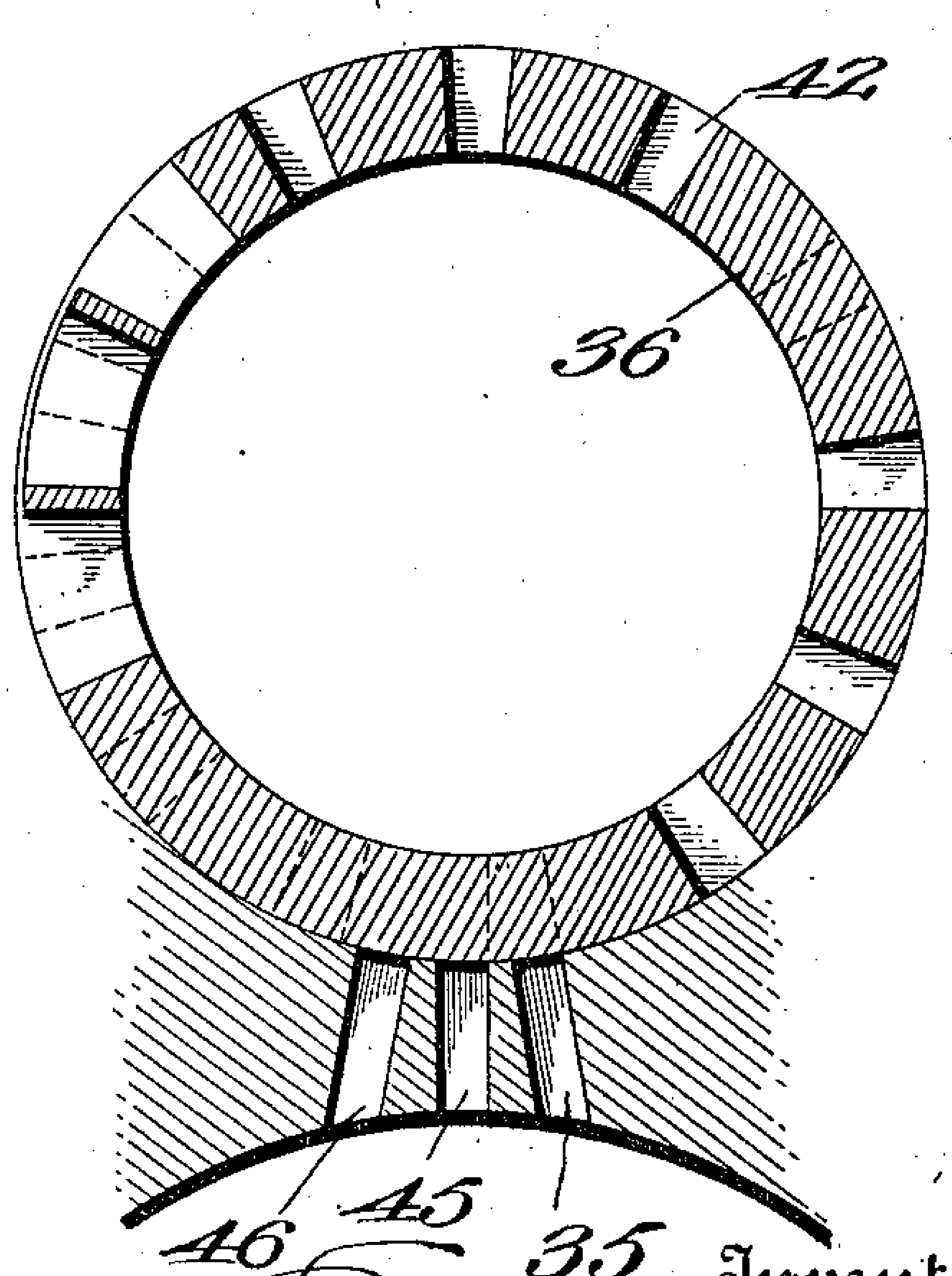


Fig. 12.



Witnesses

Inventor

UNITED STATES PATENT OFFICE.

LAWSON M. FULLER, OF THE UNITED STATES ARMY, ASSIGNOR OF ONE-FIFTH TO WILLARD L. VELIE, OF MOLINE, ILLINOIS.

RECOIL-CHECK FOR ORDNANCE.

No. 913,488. Specification of Letters Patent. Patented Feb. 23, 1909.

Application filed February 6, 1908. Serial No. 414,618.

To all whom it may concern:

Be it known that I, LAWSON M. FULLER, major U. S. Army, and a citizen of the United States, residing at Washington, in the District of Columbia, have invented certain new and useful Improvements in Recoil-Checks for Ordnance, and do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

My invention relates to recoil checks for ordnance, and the object of my invention is to produce a check, which shall be certain in action, simple to construct and which shall produce a substantially uniformly decreasing pressure in the recoil cylinder throughout maximum recoils corresponding to low angles of elevation or depression, and, also, a constant pressure throughout shortened recoils corresponding to higher angles of elevation.

To these ends my invention consists of a piston in a recoil cylinder having a by pass controlled by a valve, with means by which the total throttling area of the ports of the valve, at each instant of recoil, produces a uniformly decreasing or a uniform pressure as desired, in said cylinder at each instant of recoil, although the lengths of the various recoils may vary.

My invention further consists in such a cylinder, by pass and valve, combined with means for adjusting the latter automatically as the elevation of the gun is changed, and in such a manner as to permit a recoil exerting a constant decreasing or a constant pressure in the cylinder of a length suitable for any desired elevation.

My invention further consists in the novel method of obtaining the desired changing area of the throttling ports, and in the combination of parts and details of construction more fully hereinafter disclosed and particularly pointed out in the claims.

My invention is applicable to any form of gun in which it is desired to limit or control the recoil, but for convenience in description I will disclose it in connection with two field howitzer mounts of the type now used in the U. S. Army.

Referring to the accompanying drawings forming a part of this specification, in which like numerals refer to like parts in all the views:—Figure 1, is a longitudinal sectional view through the recoil cylinder and gun. Fig. 2, a transverse sectional view on the line 2—2 of Fig. 1. Fig. 3, is an enlarged longitudinal sectional view of the recoil cylinder and valve showing certain details of construction. Fig. 4, represents a development of the cylindrical valve. Fig. 5, is a sectional view taken on the line 5—5 of Fig. 4, through the extreme rear end of the valve. Fig. 6, represents a detail in perspective of a portion of the piston. Fig. 7, is a side elevational view of the valve operating mechanism. Fig. 8, is a plan view of the same. Fig. 9, is a longitudinal sectional view similar to Fig. 1, showing a modified form of valve. Fig. 9ᵃ, a detail of the triangular port used in connection with this modified form of valve. Fig. 10, is a transverse sectional view similar to Fig. 2, of a gun equipped with my modified valve. Fig. 11, is a development of the cylindrical modified valve. Fig. 12, is a sectional view of the modified cylindrical valve taken along the lines 12—12 shown in Fig. 11. Fig. 13, is an end elevational view of the modified valve. Fig. 14, is a diagram of curves corresponding to different recoils, which represent by their ordinates the velocities of retarded recoils of recoiling parts as a function of space, and whose ordinates are therefore directly proportional to the effective throttling area of the valve ports at each instant of recoil. Figs. 15 and 16, show curves whose abscissæ represent the times and whose ordinates represent the velocities of the recoiling parts when unconstrained, and Fig. 17, represents the curve when the parts recoil against a uniform resistance.

1, represents the trail; 2, the wheels; 3, the barrel; 4, the trunnions and 5, the recoil cylinder of an ordinary U. S. Army field howitzer and carriage. The recoil cylinder 5, is provided with a by pass 6, controlled by a rotating cylindrical valve 7, sliding over the piston 12, and, also with a cylindrical or other return passage 8. The rear end of the cylinder is closed by the screw threaded plug 9, through which passes the rod 10, rigid with the cylinder, as shown; and the front end of said cylinder is closed by the plug 11, provided with a suitable stuffing box, through which passes the piston rod 12, as shown. The front end of the piston rod 12, is suitably provided with the gear wheel 13, which meshes with the gear 14, carried by the rod 15, at its front end. To the rear end of the rod 15, is fixed the bevel pinion 16, which meshes with the bevel gear 17, on the short shaft 18, carrying the pinion 19, engaging the curved rack 20. The curved rack 20, is rigid with the mount, and is struck from the axis of the trunnions as a center, while the gears 16, 17 and 19, are carried by the housing 21, attached to the cradle, and move up and down with the same. It therefore results from this construction, that as the gun is elevated or depressed, the pinion 19, will be rotated by the rack 20, and cause the piston rod 12, to revolve by means of the power transmitted through the gears above enumerated. The rear end of the piston rod 12, is hollowed out to receive the rod 10, as shown, when the gun returns to battery; and it, also, carries the piston 22, provided with one or more cut away places 23, into which fit one or more longitudinal ribs 24, on the valve 7. These ribs 24, extend the entire length of the valve, and serve as guide ribs for the same.

The valve 7, is provided with a series of rows of perforations 25 consisting of a main or continuous row, and a plurality of auxiliary rows and each row of different length corresponds to a different recoil and each extends longitudinally along the cylinder. The number of these rows is one in excess of the number of theoretically correct recoils for which the valve is designed. That is to say, eleven rows are shown in the drawings, and they correspond to ten different and theoretically correct recoils, seven of which are of different lengths. The perforations 25, in any one row, including those in the associated auxiliary rows are so chosen and so arranged, that at any instant of recoil their total effective, or throttling area, is the calculated area for a uniform, or a uniformly decreasing pressure on the piston, as may be desired, all as will more fully appear herein below. That is to say, it is well known that the hydraulic pressure in a recoil cylinder depends upon the velocity of the cylinder relative to the piston and the total area of the orifices through which the contained liquid is forced. And in order to minimize and equalize the strains on the carriage, or mount, it is necessary to make the pull on the piston rod and consequently the pressure within the cylinder, a constant or a constantly diminishing pressure at each instant of recoil.

In certain types of carriages on which rapid fire guns are mounted, the center of gravity of the system shifts during recoil, and in such cases in order that stability may be insured, it is necessary at low angles of elevation, to provide for a constantly decreasing pressure and consequently a constantly decreasing pull on the piston rod. To accomplish these most desirable results, the total effective or throttling area of the orifices through which the fluid confined in the cylinder is forced, must constantly increase up to the time when the powder gases cease to act upon the projectile; and the total throttling area of these orifices must suitably decrease after that time, until it becomes zero at the end of the recoil. The dimensions of these total throttling or effective areas at each instant of recoil may be readily computed from well known laws, but I prefer to obtain them from a curve of retarded velocities which is of the general form of the curves 60—69, shown in Fig. 14. These curves are obtained as follows:—It is well known that in the case of a gun recoiling freely and therefore unconstrained, that the velocity of the recoiling parts increases until the powder gases cease to act on the projectile, or until a brief interval after the projectile leaves the bore, and that a curve *e*, whose ordinates represent the velocities and whose abscissa the corresponding times, would be of the general form shown in Fig. 15. In other words, a curve *e*, whose ordinates represent the velocities of recoil at each instant, and whose abscissæ represent time, would become a straight line such as *a*, Fig. 16, parallel to the axis of the abscissæ after the maximum velocity has been attained were it not for friction and other opposing agencies, which cause the same to gradually slope off as a straight line, until it reaches zero. But referring again to Fig. 15, since a velocity multiplied by a time represents a distance, the total area under the curve represents the distance the parts would recoil while being accelerated by the powder gases were there no opposing forces. But if opposing forces exist such as friction springs, hydraulic brakes etc., they may be so chosen as to uniformly retard the velocity of the recoiling parts; and in such case the curve *e*, *a*, in Fig. 16, will assume the form of curve *r*, *s*, in Fig. 17. In like manner the total area under the curve *r*, *s*, in Fig. 17, may be made to represent the distance the parts would recoil during the time they are accelerated by the powder gases and retarded by the particular opposing forces which brought them to rest, provided we choose said area of particular dimensions. In other words, the curve *e*, *a*, may be made to furnish a series of curves *r*, *s*, whose areas will correspond to a series of recoils of different lengths as will now be explained.

Going back to Fig. 15, in order to fix the idea, suppose the total area under the curve *e*, *i*, in a given experiment is found to be 11 square inches, and that the recoil corresponding to this area is found to be four inches in length, while we desire in practice a recoil of 44 inches. We would know at once that this area corresponded to a recoil eleven times too small, and that we must therefore get a curve *r*, *s*, having an area of 121 square inches if it is to correspond to a recoil of 44 inches.

In order to get the desired curve r, s, we would lay off in Fig. 16 the curve e, i, shown in Fig. 15, and draw the ordinate i, m, so that the area t, i, m, represents 11 square inches, and the abscissa t, m, represents 4 inches of recoil. We know the parts would recoil forever, expending no energy if they were not restrained by opposing forces, and that this curve t, e, i, Fig. 16, would become the straight line i, a, under such circumstances, all as above stated. Now let us suppose the parts do so recoil without expending energy, such an unknown distance as will make the area under curve r, s, 121 square inches corresponding to a recoil of 44 inches, and let this distance be i, u. The total area under the curve t, e, i, u, will now be the original 11 square inches plus the area of the rectangle i, u, v, m. Draw the line t, u. Then the area of the triangle t, u, v, will be $\frac{1}{2}\, u, v, \times (tm + mv)$ or $\frac{1}{2}\, i, m \times (mv + 4)$. If we now subtract this area from the total area under the curve t, i, u, above, we find the area under said curve and above said line t, u, to be $11 + im \times i, u - \frac{1}{2}\, im(mv + 4)$. If we substitute for i, u, its value m, v, and put the resulting area equal to the desired recoil 44 inches we get:—

$$11 + im \times mv - \tfrac{1}{2}\, im(mv + 4) = 44.$$

In this equation im is known since it, like t, m, may be determined from experiments, and the equation therefore contains only the one unknown quantity m, v, which can be immediately found, and which with t, m, gives the length of the abscissa of the particular curve r, s, we are seeking.

We have now obtained an area above the line t, u, bounded by the curve t, i, u, to represent a recoil of 44 inches, and it only remains to lay it off on the axis of X. To do this, suitable ordinates as illustrated at i, m, j, h, etc., Fig. 16, are drawn, and the distances on each ordinate, such as j, k, between the curve t, i, u, and the line t, u, are measured from the axis of X on each of said ordinates in Fig. 16. One of these measurements is represented at $h, l = j, k$, and the resulting curve t, l, v, corresponding to the points thus determined, reproduces the curve t, i, u, with the axis of X as the abscissa. This curve t, l, v, is identical with the curve r, s, in Fig. 17, and has the area required.

Having obtained a curve of the required area, and of the form of curve r, s, for a recoil of 44 inches, it is next necessary to obtain a curve whose ordinates represent velocities as before and whose abscissa represent distances instead of time. To do this, a distance f, g, Fig. 14, corresponding to 44 inches is laid off as an abscissa, and then the ordinates representing the velocity in feet per second for each inch of recoil are laid off. This is readily done by beginning at one end of the curve such as r, s, having the required area, and after laying off a unit of area then measuring the ordinate m, n, on said curve that bounds this unit of area. Then erect this ordinate at the end of the first inch laid off along the abscissa of the new curve to be obtained. Next segregate another unit of area in the curve such as r, s, having the 121 square inches of area, likewise measure its bounding ordinate o, p, and erect it at the end of the second inch of the abscissa and so on until the whole 121 units of area have been so treated. Then by drawing a curve through the upper extremities of all the ordinates m, n, o, p, etc., so obtained, the curve 60, in Fig. 14, results. The ordinates of this curve 60, will represent the velocities for each unit of length of recoil, and will therefore be proportional to the throttling areas for the corresponding units.

Since the pressures on the piston, and therefore the recoil velocities in a recoil cylinder having a by pass, depend upon the throttling area of the exit orifice, it is clear that if the total throttling area can be made to increase, and to diminish as fast as the recoil velocities increase and diminish, then the pressure in the cylinder would be constant. In other words, if after having obtained curve 60, in the manner above disclosed, or by calculation, we now construct a valve such as 7, and provide it with perforations 25 and orifices 31, of such a size, and so spaced apart that the total area of all the perforations orifices that are effective in throttling the fluid, or retarding the recoil increases and diminishes at each instant of recoil as fast as the ordinates of said curve increase and diminish, then the pressure in the cylinder will be constant throughout the recoil.

The drawings show eleven rows of perforations 25 each having two short or auxiliary rows and eleven openings 31, the total areas of which are disposed in such a manner that if we assign a particular set of perforations and a particular opening to a particular recoil, the row 28 together with its auxiliary rows and its corresponding opening 31, for example, and if we start at the right hand end of this row, the total area of all the throttling perforations in front of the piston as we go to the left at first increases up to the point d, which corresponds to the time the powder gases cease to act, and then it continually decreases, as is apparent from the distribution of the perforations. This is because the piston in its extreme position, as shown for example in Fig. 3, blocks, or cuts off, nearly all the throttling area of opening 31; and when the recoil begins, although this opening 31 is rapidly uncovered, some of the perforations 26 in the long row 28, and in its two associated short rows, are at the same time blocked. The result of this action is to practically prevent all fluid, except an exceedingly small quantity from flowing in behind the piston at the first instant of recoil, but to permit a rapidly increasing quantity to flow through the opening 31, and through the perforations 26 of row 28, and the perforations of the associated short rows, as the recoil proceeds. During this early period of recoil, before the piston reaches the point *d*, it will be observed that the throttling areas behind the piston wholly determine the pressure, and maintain it constant in the cylinder; while after the piston leaves the point *d*, and the opening 31, and some of the perforations 26 have been uncovered, the throttling areas behind the piston are ineffective, while those in front are the only ones effective in causing the pressure in the cylinder to be maintained constant. The proper distribution of throttling areas to cause the pressure in the cylinder to be maintained constant may be obtained from curve 60, by providing an orifice at each point along the valve which will be proportional in area to the decrease in the value of the ordinate of the curve corresponding to that point, so the orifice will bear such a relation to this decrease as will produce the pressure desired. In other words, these holes are so arranged that on recoil the piston passes the same, and thereby cuts them out as effective throttling areas, while the recoil velocities diminish; and puts them, as well as the ports 31 or 31^a, into action as effective throttling areas, as fast as the recoil velocities increase. A suitable formula may also be employed to ascertain the spatial relation and size of the perforations. It will be observed that this throttling area changes very abruptly at the beginning of this row, as it should, owing to the individual perforations being so closely grouped together at that point. In fact, each row of perforations 25, has associated with it two shorter or broken rows, such as 29 and 30 as above stated, thereby constituting a triple row; and thereby causing the piston to uncover first a large area which quickly converges like the port 31^a, in Fig. 9^a, and consequently causes the pressure to be constant at the beginning of the recoil. The effect of this combination is such that whether the elevation is just right for a long and two short rows to be in exact register at the beginning with the by pass or not, almost perfect results are nevertheless obtained as has been shown in practive. The reason for this is, the pressure, when a triple row is not in exact register, is never greater than that for the shorter triple row, nor is the recoil longer than for the longer row, as will more fully appear hereinafter. By suitable calculations and experiments, I have succeeded in so arranging these perforations as shown that their total throttling areas at each instant correspond so closely to the theoretical calculated areas for corresponding instants, that an indicator diagram, taken from a carriage in actual use, shows a perfect rectangle for the high angles of elevation, and a trapezoid of the desired form for the lower angles, and therefore that the said cylinder pressures are constant or constantly decreasing as desired at each instant of recoil.

Returning now to the value 7, controlling the by pass 6, and containing a plurality of rows of perforations 25, one triple row for each theoretically correct recoil, it is evident that so long as a particular row is in register with the by pass, as shown in Fig. 2, that the pressure in the cylinder will be constant or constantly decreasing as desired. It is however very desirable and often necessary to shorten the recoil as the gun is elevated, for reasons well known to those skilled in this art. To accomplish this purpose, I provide a distinct row of perforations for each shortened recoil, as above stated, and so group and distribute the perforations in each row that their throttling areas will at each instant correspond to the ordinates of the curve of velocities corresponding to the recoil in question. In Fig. 4, I have shown eleven triple rows for seven recoils of different lengths. Three of these triple rows 26, 27 and 28, are for recoils of one length, while the remaining triple rows are for shortened recoils corresponding to higher angles of elevation. These first three rows intended for point blank firing, and for a slight elevation and a slight depression of the gun, show their perforations so sized and spaced as to cause a slightly uniformly decreasing pressure in the cylinder before and after the projectile leaves the gun.

In order to bring that row of perforations in the valve, in register with the by pass, which corresponds to a particular elevation and a particular length of recoil, it is merely necessary to operate the elevating mechanism of the gun when the piston will be revolved by means of the piston rod and the gears connected therewith, above described, and the valve will be revolved through its guide ribs until the proper row comes into register. The construction is such that the gears 16, 17 and 19 serve to so multiply the movements in elevation that the valve 7, may revolve through about 350 degrees of arc, and therefore the wear, or lost motion, commonly met with in elevating gears has no appreciable effect on the length of recoil. Moreover, the recoil control is operated when the system is at rest, and not subjected to the pressures or strains due to firing, which is a distinct advantage. In addition to this, the contiguous rows are so spaced apart, that as one set of perforations begins to be moved out of register with the by pass 6, the other set of perforations begins to come into register, so that the by pass is always covered by a full continuous row of perforations and its auxiliary rows; thus making it theoretically correct, or it is covered by a part of a full row and a part of the next full row with all the auxiliary rows; or it is covered by a full continuous row and part of each of the auxiliary rows on either side of it. It results directly from this construction, that even if the gun is not laid to an elevation corresponding to a particular row of perforations; yet, the recoil will be still controlled, and the pressure regulated, although not quite so accurately as before. That is to say, if one row of perforations have been designed for an elevation of 35 degrees, and another for an elevation of 30 degrees, and the gun is fired at an elevation of 32 degrees, the valve will so control the pressure as to make a compromise regulation between recoils belonging to 30 degrees and 35 degrees respectively. In fact, from actual firings, the indicator cards taken on the carriage when the gun was so elevated as to give a compromise regulation of recoil, were barely distinguishable from the others, taken under similar conditions when the gun was so elevated as to bring the proper row of perforations into action. As the gun comes back to battery, the rod 10, and hollow piston rod act as a dash pot, in the manner well known, and the orifices 31, serve as a ready escape for the fluid caught in the end of the cylinder.

In the modification shown in Figs. 9 to 13, the piston moves and the stationary cylinder 5, is provided with a perforated by pass 35, controlled by a perforated rotatable valve 36, in a separate cylinder 37, provided with a stuffing box through which the valve stem 38, operates. On the stem 38, is the gear 39, which meshes with the gear 40, on the shaft 41, (see Fig. 10) which in turn meshes with the gear 14, operated by the movements of the cradle, as above described. Fig. 11, shows a development of the valve 36, the orifices 42, of which are oblong and substantially rectangular, instead of circular as in the case of valve 7. The arrangement of these orifices 42, is also in independent rows, there being one more row than the number of theoretically calculated recoils, and the combined throttling area, at any instant of recoil, in any one row is likewise proportional to the ordinate of the curve representing velocities of retarded recoil as a function of space, for that instant of that particular recoil, as in the case of valve 7. In fact, the two devices are almost the same in construction and operation, except for the differences above noted, and for the elongated slots 43, at the beginning of each row of orifices, and which serve the same purpose as the double short rows of perforations 29 and 30, at the left end of Fig. 4, described above, in connection with valve 7. These slots 43, it will be observed span all three of the by passes 35, 45 and 46, while other slots 44, are only sufficiently long to span the by passes 35 and 45, in the recoil cylinder. Another difference is that as the piston is drawn to the rear, it uncovers the V shaped port 31^a, shown in plan in Fig. 9^a, and in section in Fig. 9. This port gives the constantly increasing opening desired, but is the same for all lengths of recoil while in my preferred form the corresponding openings may be made almost theoretically correct for each calculated length of recoil.

The operation of my recoil check will be clear from the foregoing, but it may be summarized for the preferred form as follows:— Upon firing, the gun and cylinder recoil in the manner well known; and the piston remaining stationary causes the fluid contained in the recoil cylinder to be forced from the one side of the piston head through the by pass and the orifices of the controlling valve, around to the other side of the piston. The throttling orifices are so arranged, and their aggregate area in front of the piston at each instant of recoil is such, that notwithstanding the varying energy possessed by the gun and its recoiling parts at each instant, the pressures in the cylinder will remain substantially constant or uniformly decreasing throughout the entire recoil period as desired. After the gun has finished its recoil, the springs 50, having been compressed thereby, cause the gun to be returned to battery. A reverse action takes place, during this counter recoil, and toward the completion of the same, the throttling rod 10, acts like the plunger of a dash pot to cushion the final movement. When it is desired to shorten any recoil, it is only necessary to rotate the valve to bring into action that row of orifices which correspond to the desired recoil, and the above operations will ensue with a less recoil travel of the gun. When firing at an elevation, the valve is automatically adjusted as the gun is elevated or depressed, and a recoil of a suitable length at all times assured.

It will be observed that it is necessary, in order to attain the above substantially theoretically correct results, to first obtain practically theoretically correct curves of velocities of retarded recoils, each of such curves being of the same general form, as shown in Fig. 14, but differing for each characteristically different recoils, and differing for each piece of ordnance. It is then necessary to so select, space and arrange the perforations 25, or, orifices 42, in the valve, that their combined throttling area for each instant of recoil, and for each recoil differing in kind, will be proportional to the ordinate of the curve for that instant corresponding to the recoil in question. It is evident that the special arrangement and the area of these individual openings may be determined in any suitable manner, but I prefer to employ a suitable formula to attain these ends. It is also evident that the details of construction, arrangement of parts, and method of obtaining my velocity curves, may be widely varied without departing from the spirit of my invention. In fact, the valve need not be capable of rotation through 350 degrees, nor need the cylinder be provided with a single by pass, for it is evident that two, three or more by passes could be equally spaced around the cylinder, and the rotation of the valve correspondingly decreased, without sacrificing the number of rows of perforations, and therefore without decreasing the number of theoretically perfect recoils. Other changes coming within the spirit of my invention will likewise readily suggest themselves to ordnance engineers and others skilled in this art.

Having now described my invention what I claim is:—

1. The combination of a recoil mechanism provided with recoil checking means, and means to control such checking means at each instant of recoil in proportion to the retarded velocity for the instant in question, substantially as described.

2. In a gun mount, the combination of a recoil cylinder and piston provided with a by pass, with means adapted to change said by pass in proportion to the changes in the retarded velocities of the recoiling parts at each instant of recoil, and thereby cause the pressure in the cylinder to remain substantially constant throughout the recoil, substantially as described.

3. In a gun mount the combination of a piston and recoil cylinder containing a fluid and provided with a by pass, and automatic means adapted as the gun recoils to vary the exit of said fluid through said by pass in accordance with the retarded velocities of the recoiling parts at each instant of the recoil, whereby the pressure in said cylinder remains substantially constant throughout the recoil, substantially as described.

4. In a gun mount the combination of a piston and a cylinder provided with a by pass, and means comprising a movable part provided with perforations adapted to automatically control said by pass in accordance with the retarded velocities of the recoiling parts at each instant of recoil, substantially as described.

5. In a gun mount the combination of a recoil cylinder containing a fluid and provided with a by pass; a piston in said cylinder and a cylindrical valve adapted to control the flow of the said fluid through said by pass in accordance with the retarded velocities of the recoiling parts at each instant of recoil, and thereby causing the pressure in the cylinder to remain substantially constant throughout the recoil, substantially as described.

6. In a gun mount the combination of a recoil cylinder provided with a by pass; a piston in said cylinder; means to control said by pass in accordance with the retarded velocities of the recoiling parts at each instant of recoil; and means to adjust said controlling means in proportion to the elevation of the gun, substantially as described.

7. In a gun mount the combination of a recoil cylinder provided with a by pass; a piston in said cylinder; a perforated valve adapted to control said pass in accordance with the retarded velocities of the recoiling parts at each instant of recoil; and means for automatically adjusting said valve in proportion to any change in the elevation of the gun, substantially as described.

8. In a gun mount the combination of a recoil cylinder provided with a by pass; a piston in said cylinder; a rotary valve provided with openings adapted to control said by pass in accordance with the retarded velocities of the recoiling parts at each instant of recoil; an elevating mechanism and connections between the same and said valve adapted to adjust said valve in proportion to the elevation of the gun, substantially as described.

9. In a gun mount adapted to recoils of different lengths, the combination of a recoil cylinder provided with a by pass; a piston in said cylinder and a valve provided with a plurality of rows of openings, one row for each of said recoils, some of said rows being so arranged and of such an area as to cause a substantially constant pressure to be maintained in said cylinder throughout the length of some of said recoils, and other rows being adapted to maintain a uniformly decreasing pressure in said cylinder throughout the length of other recoils, substantially as described.

10. In a gun mount adapted to recoils of different lengths, the combination of a recoil cylinder provided with a by pass, and a rotary cylindrical valve controlling said by pass and provided with a series of rows of throttling perforations, one for each of said recoils, the combined area of the said perforations of some of said rows throttling the said by pass at any instant in certain recoils, being proportional to the retarded velocity of the recoiling parts at that instant, substantially as described.

11. In a gun mount adapted to recoils of different lengths, the combination of a recoil cylinder and a cylindrical valve provided with a series of rows of openings, one for each recoil, and some of said rows adapted to maintain a constant pressure in said cylinder throughout the length of each of some of said recoils, and other rows adapted to maintain a constantly decreasing pressure throughout the length of the other recoils, substantially as described.

12. In a gun mount adapted to recoils of

different lengths, the combination of a piston, a recoil cylinder; a by pass; a valve provided with a series of rows of throttling perforations, one for each of said recoils, the total remaining area of each row while throttling being proportional to the retarded velocity of the recoiling parts at each instant of recoil, said rows being so spaced apart as to prevent the said valve from completely closing said by pass, and means for rotating said valve while the system is at rest through any desired angle, substantially as described.

13. In a gun mount adapted to recoils of different lengths, the combination of a recoil cylinder having a by pass; a cylindrical sliding and rotatable valve therein having independent rows of perforations for each of said recoils; a piston and piston rod in said valve; a gear wheel on said piston rod; a second gear meshing with the same; a rod on which said second gear is mounted; a third gear on said rod; a fourth gear meshing with said third gear; a short shaft on which said fourth gear is mounted; a fifth gear on said shaft; and a curved rack with which said last mentioned gear engages, the whole being so arranged that upon the elevation or depression of the gun, the said valve is so rotated as to bring that row of perforations into register with the said by pass which corresponds to the particular recoil belonging to the elevation in question, substantially as described.

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

LAWSON M. FULLER.

Witnesses.
J. S. GIUSTA,
A. W. NEALE, Jr.