No. 818,730. PATENTED APR. 24, 1906.

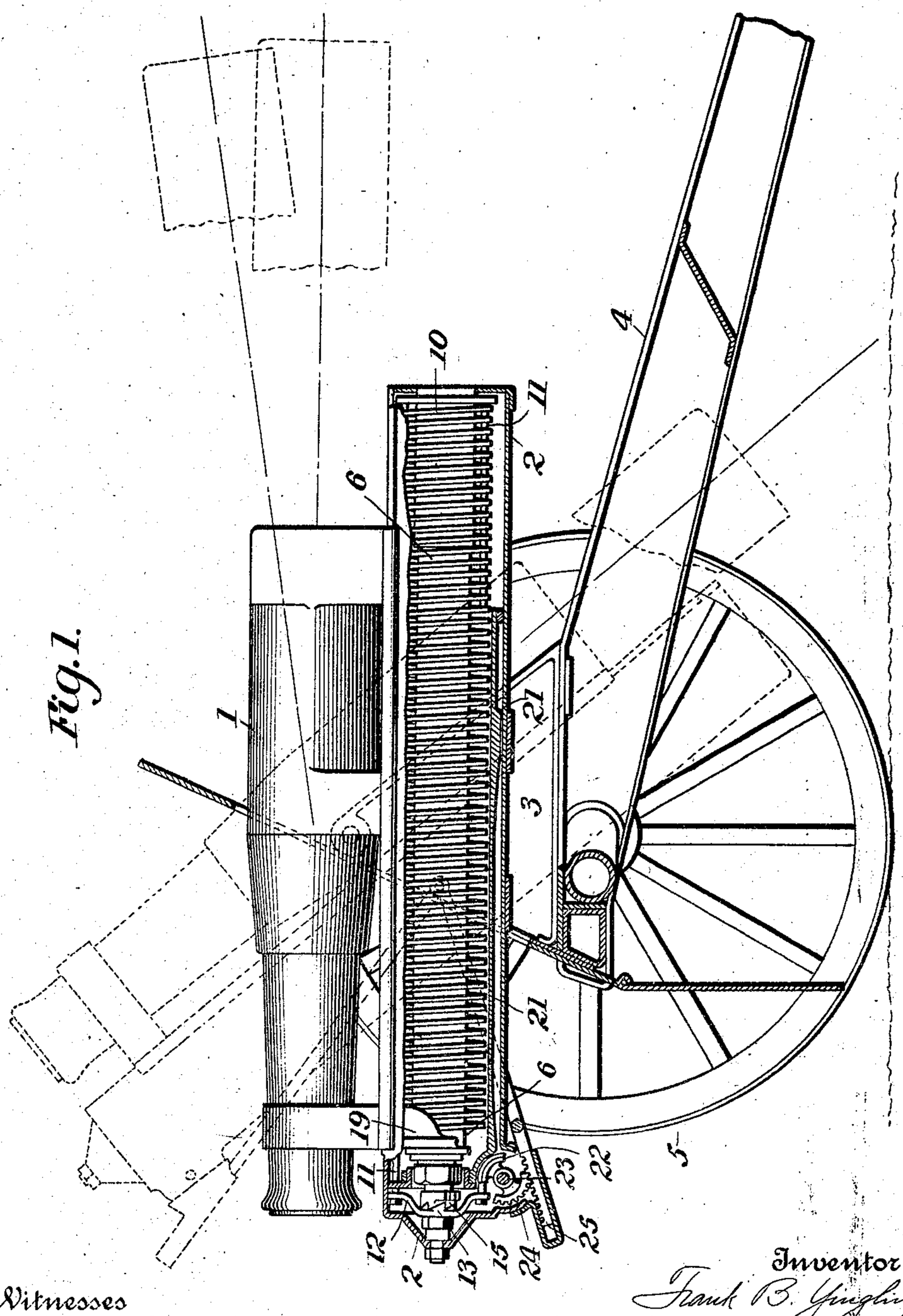
F. B. YINGLING.

RECOIL MECHANISM FOR CANNONS.

APPLICATION FILED DEC. 1, 1904.

5 SHEETS—SHEET 1.

Fig. 1.



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5 SHEETS—SHEET 2.

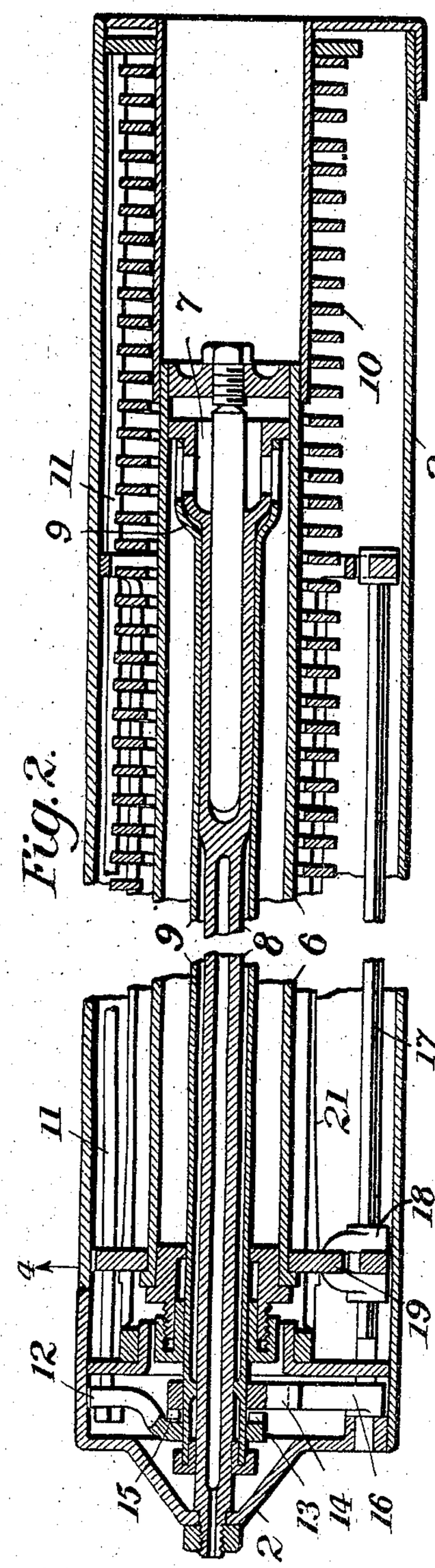

Fig. 2.

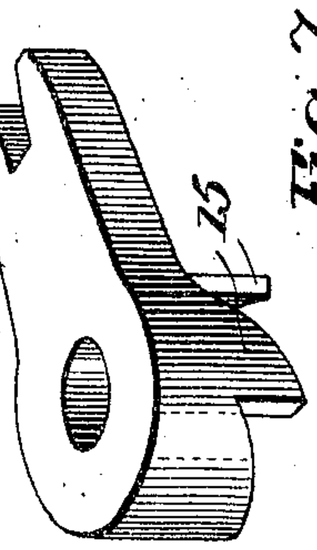

Fig. 6.

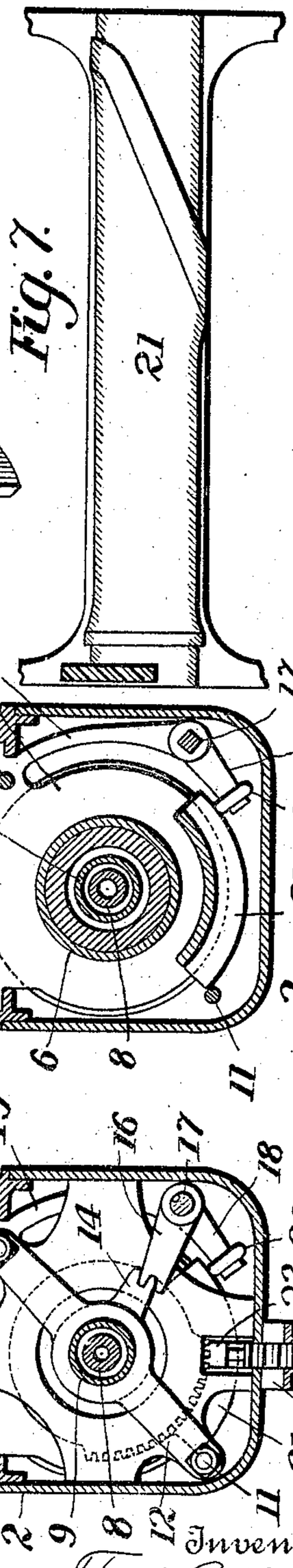

Fig. 7.

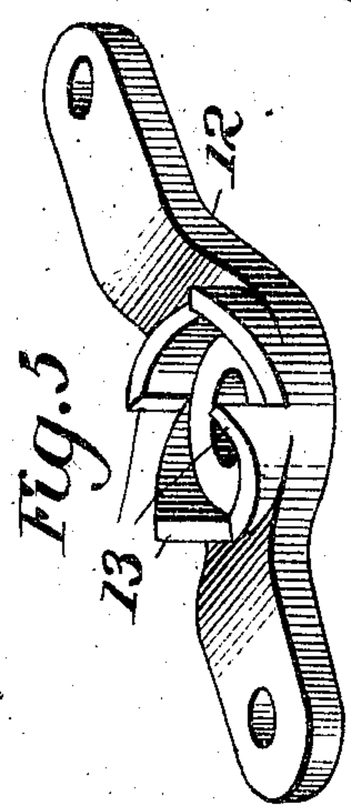

Fig. 5.

Fig. 4.

Fig. 2.

Fig. 3.

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5 SHEETS—SHEET 3.

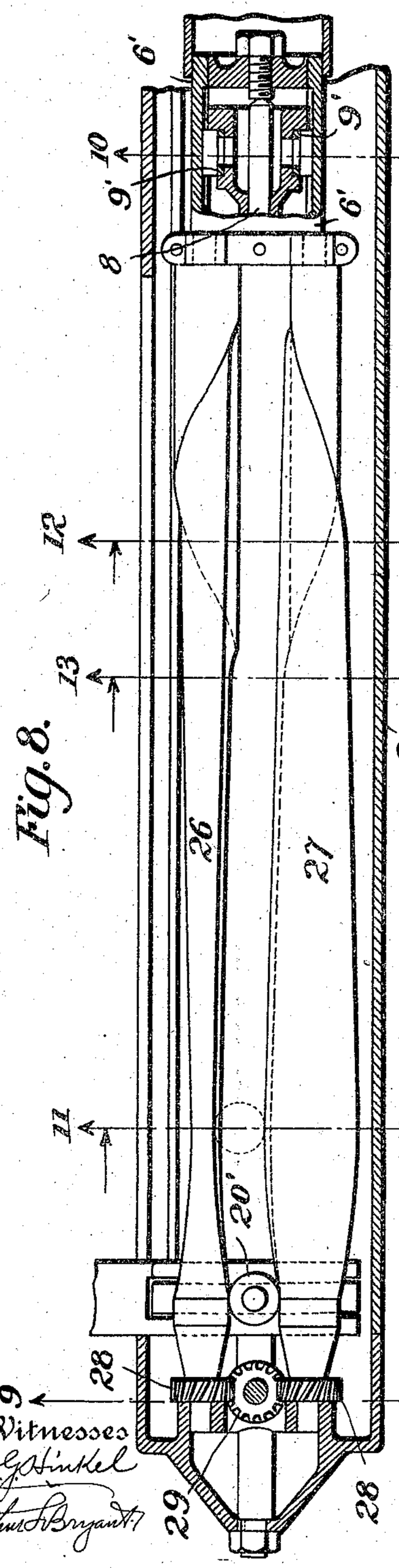

Fig. 8.

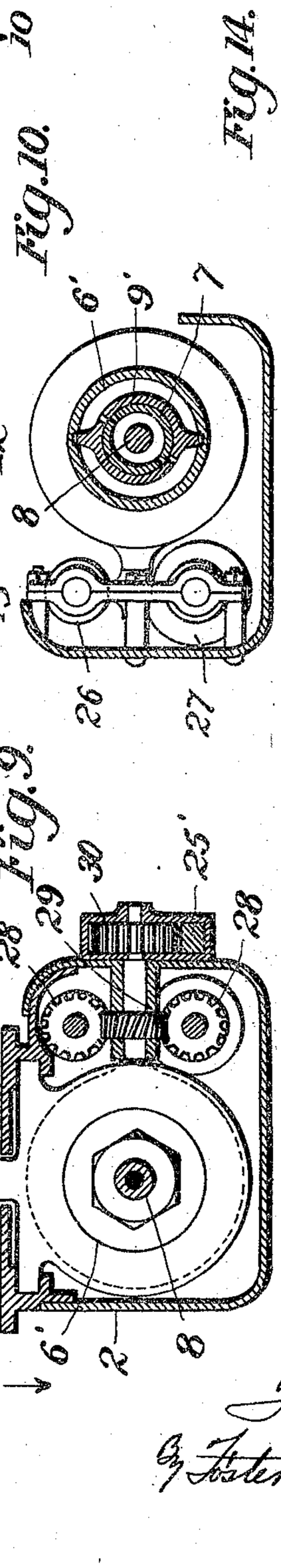

Fig. 10.

Fig. 9.

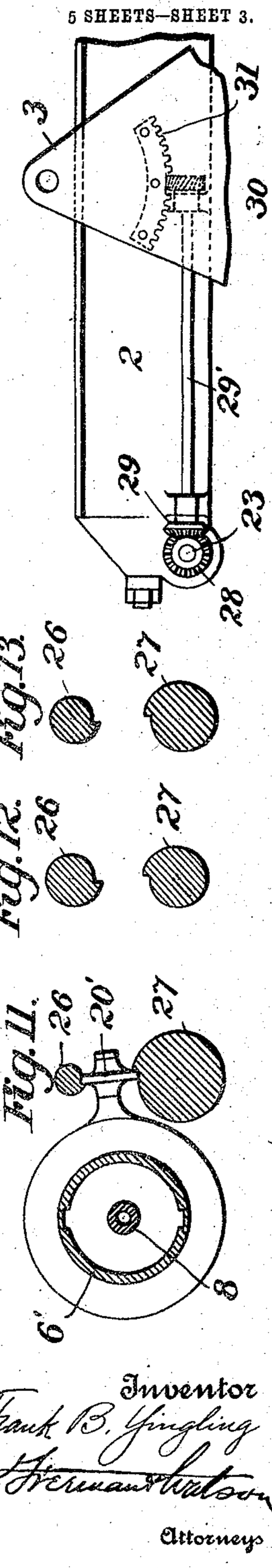

Fig. 14.

Fig. 13.

Fig. 12.

Fig. 11.

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5 SHEETS—SHEET 4.

Fig. 15.

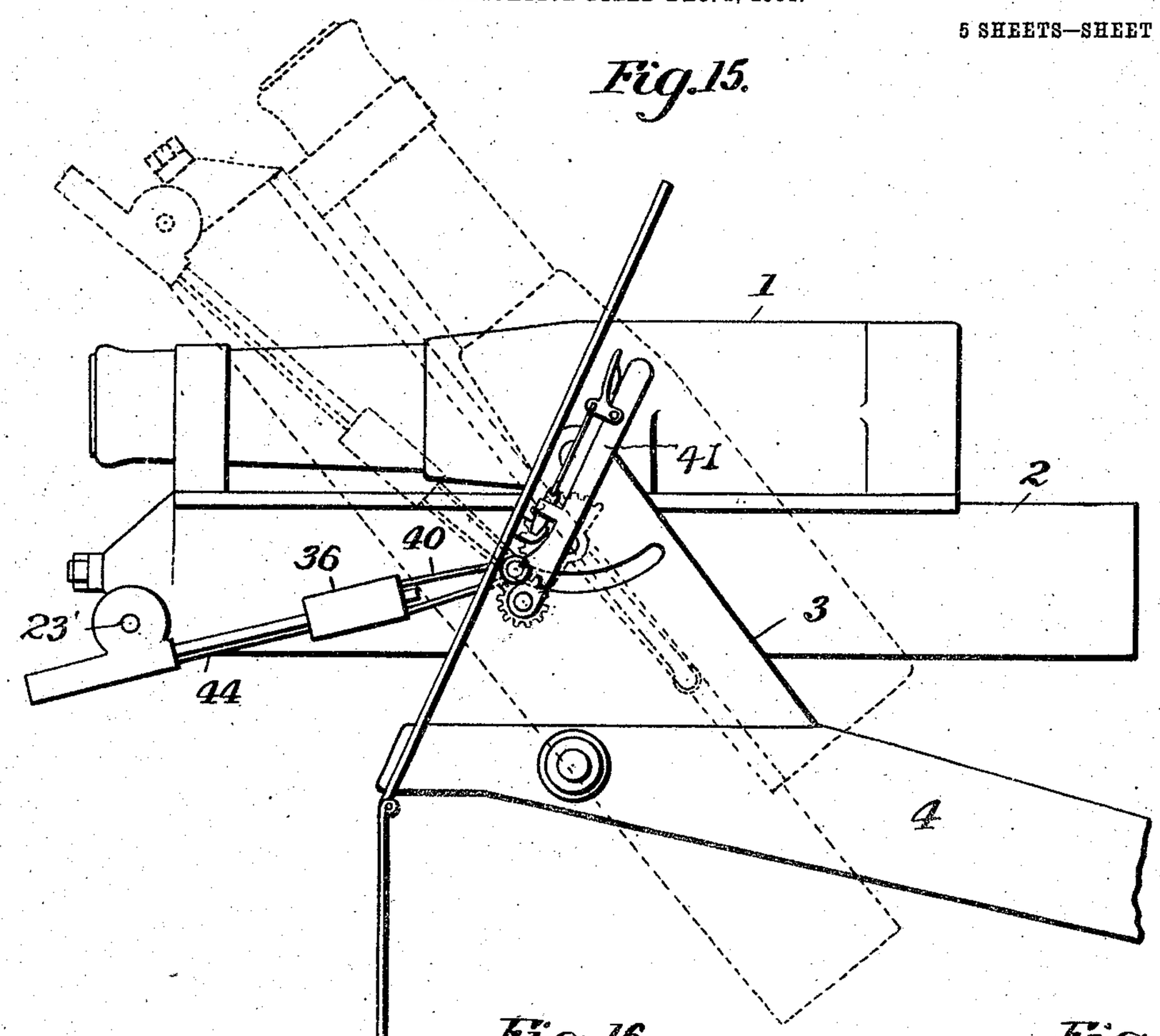


Fig. 16.

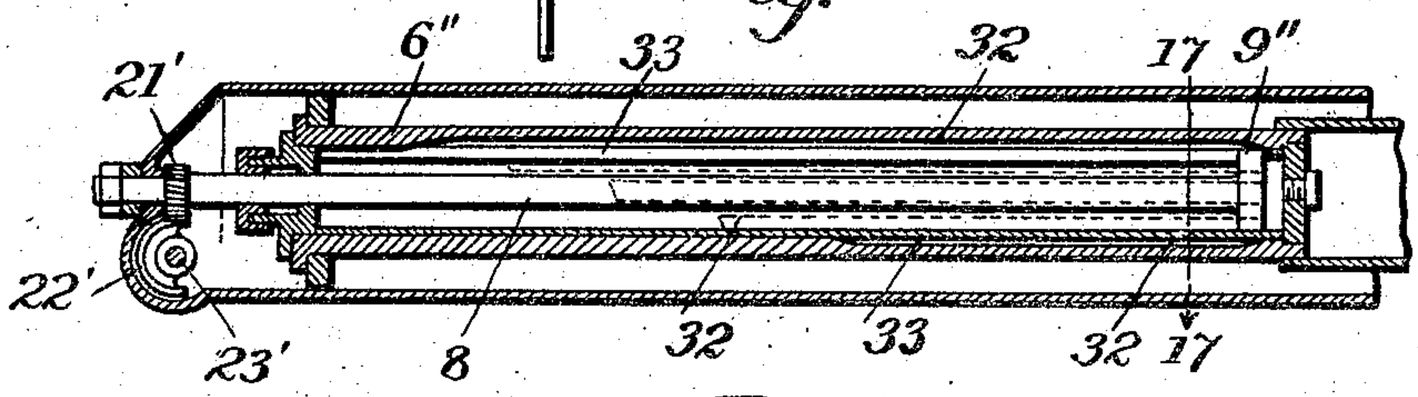


Fig. 17.

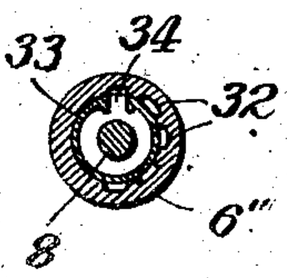


Fig. 18.

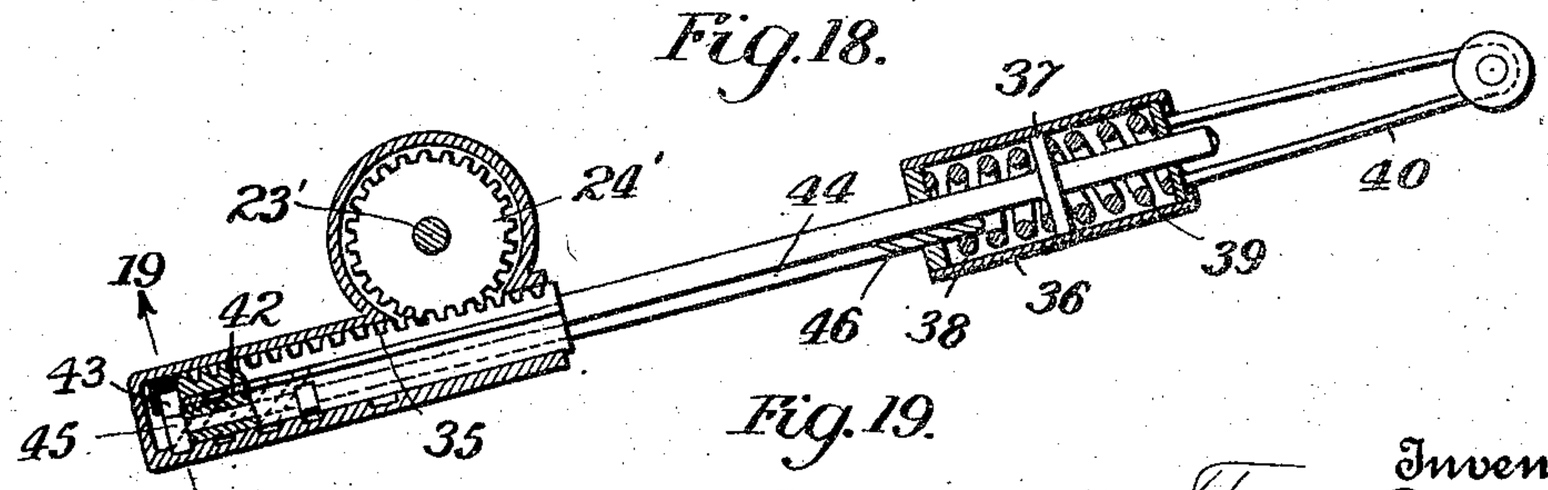
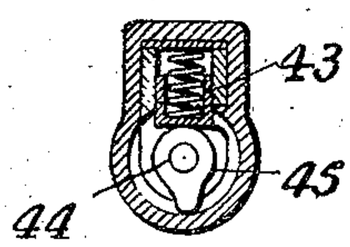


Fig. 19.



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5 SHEETS—SHEET 5.

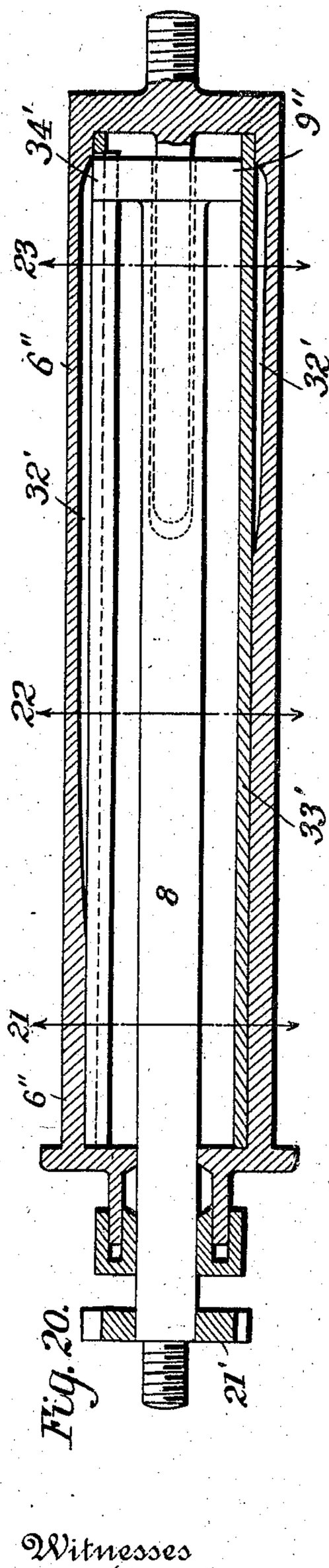

Fig. 20.

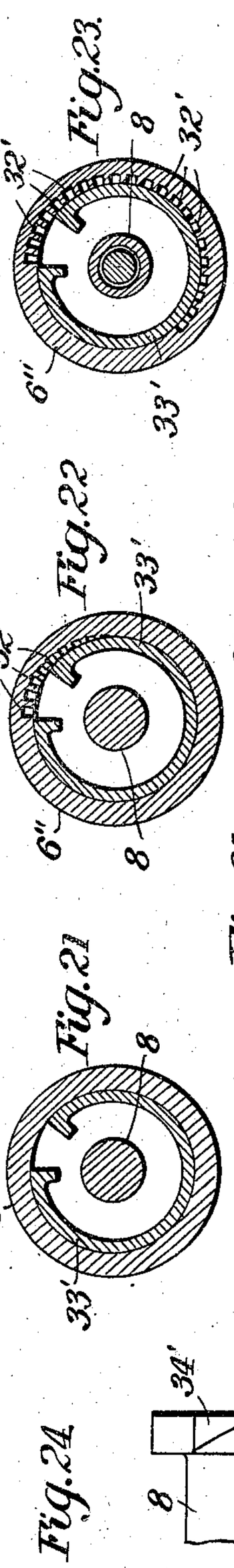

Fig. 23.

Fig. 22.

Fig. 21.

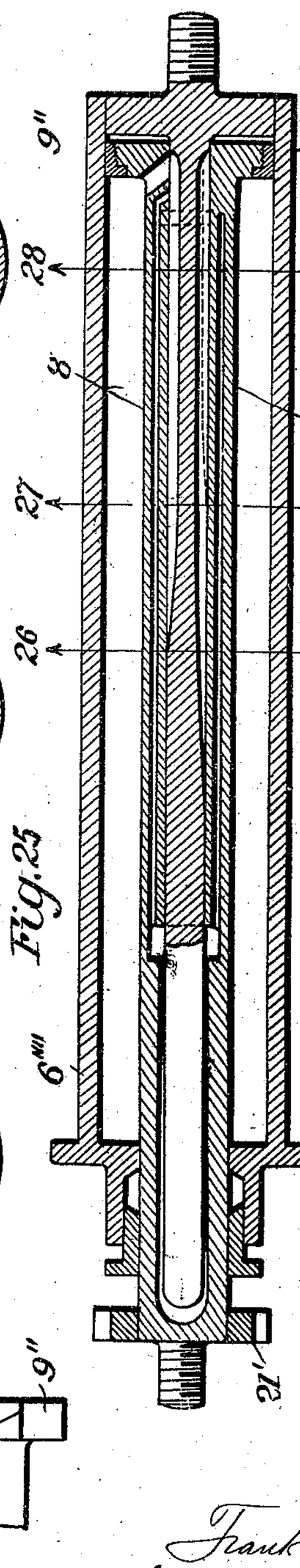

Fig. 25.

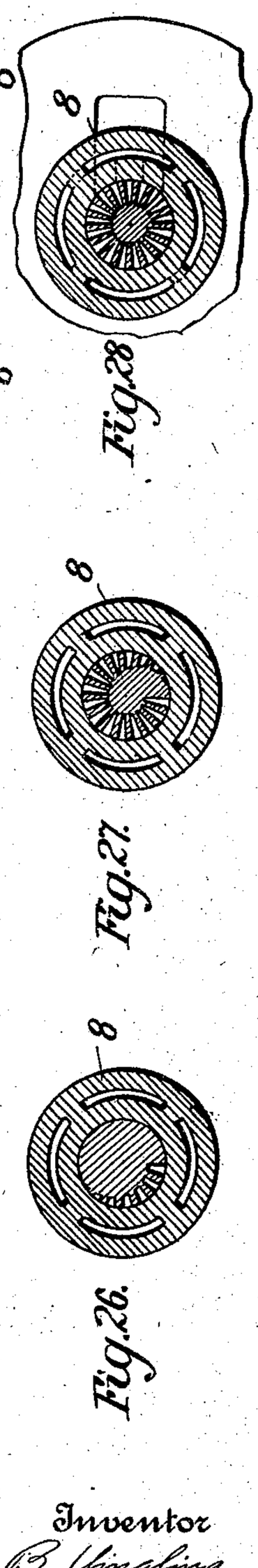

Fig. 28.

Fig. 27.

Fig. 26.

Fig. 24.

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RECOIL MECHANISM FOR CANNONS.

No. 818,730. Specification of Letters Patent. Patented April 24, 1906.

Application filed December 1, 1904. Serial No. 235,055.

To all whom it may concern:

Be it known that I, FRANK B. YINGLING, a citizen of the United States, residing temporarily at Düsseldorf, Germany, have invented certain new and useful Improvements in Recoil Mechanism for Cannon, of which the following is a specification.

The present invention relates to improvements in recoil mechanism for cannon, and particularly to an adjustable brake or controlling device for regulating the recoil. It is customary to check or regulate the recoil of such guns by controlling through the actuation of a suitable valve the passage of liquid from one side of a piston working within a cylinder that recoils with the gun to the other side of such piston. In order to reduce the strains on the carriage in the case of field-guns, it is customary to so arrange the valve that the pressure of the liquid is maintained practically constant or uniformly decreasing a small amount throughout the length of recoil. In changing the elevation of the muzzle of the gun it is necessary to vary the length of recoil—that is, when the muzzle of the gun is elevated the length of recoil must be less than that permitted or necessary for stability when the gun is in a horizontal position to prevent damage to the carriage or to the gun itself.

The object of the present invention is to provide means by which the length of the recoil will be automatically varied with variations in the elevation of the gun and in which the pressure in the recoil-cylinder will be maintained practically uniform or uniformly decreases a small amount throughout the recoil regardless of the position or elevation of the gun.

In the accompanying drawings, Figure 1 is a longitudinal sectional view through a carriage of a field-gun provided with a recoil mechanism embodying the present invention. Fig. 2 is a horizontal sectional view of the supporting-cradle, the recoil-cylinder, and parts contained therein on an enlarged scale. Fig. 3 is a front elevation, partly in section. Fig. 4 is a sectional view on the line 4 4 of Fig. 2. Figs. 5 and 6 are detail views. Fig. 7 is a view of the developed adjustable curved surface. Fig. 8 is a view, partly in section, of the recoil-checking mechism of a gun, illustrating a modified form of the invention. Fig. 9 is a section on the line 9 9 of Fig. 8. Figs. 10 to 13 are sectional views on lines 10 10, 11 11, 12 12, and 13 13 of Fig. 8. Fig. 14 illustrates a modification. Fig. 15 is a side elevation of another modification. Fig. 16 is a longitudinal sectional view of the means for checking the recoil. Fig. 17 is a sectional view on the line 17 17 of Fig. 16. Fig. 18 is a sectional view, on an enlarged scale, of the device connecting the gun-elevating devices with the valve-actuating mechanism of the recoil-cylinder. Fig. 19 is a section on the line 19 19 of Fig. 18. Fig. 20 illustrates a modification of Fig. 16. Figs. 21, 22, 23 are sections through Fig. 20. Fig. 24 is a detail. Figs. 25, 26, 27, 28 are views of a modification.

Referring to the drawings, in which like reference characters designate corresponding parts in the several figures, and particularly to Figs. 1 to 7, 1 designates the gun, which is mounted to slide on a cradle 2, supported to rock about a horizontal axis on a suitable frame 3, provided with a trail 4 and mounted on carrying-wheels 5. As all of the parts before referred to may be of the ordinary or any suitable construction, it is not deemed necessary to describe or illustrate them in detail. Within the cradle 2 is arranged a recoil-cylinder 6, which is connected with the gun-barrel to move therewith longitudinally of the cradle and within which cylinder is arranged a piston 7, carried by a rod 8, secured to the forward end of the cradle. Said piston is hollow or provided with an internal chamber from the rear communicating with the forward end of the cylinder 6 through ports which are controlled by a valve 9. Within the cylinder is arranged a body of suitable liquid, generally oil or water and glycerin, which in passing from one side of the head of the piston 7 to the opposite side thereof within said cylinder acts to check and control the movements of the cylinder in recoil, and therefore of the gun, which is connected therewith. Within the cradle 2 about said recoil-cylinder 6 is arranged the usual counter recoil spring or springs 10, which at the forward end abut against a projection or flange on the cylinder 6, whereby said springs will be compressed during the recoil motion of the gun and cylinder. In the embodiment of the invention illustrated in Figs. 1 to 7 a ring or plate is ar-

ranged at the rear end of said counter-recoil spring 10, to which plate or ring are connected two rods 11, which extend longitudinally of the cradle to points beyond the forward end of the cylinder 6 and are connected at such forward ends by a transverse bar or plate 12 through a suitable aperture, in which extends the rod or stem 8 of the piston with the valve-stem 9. In the embodiment of the invention illustrated in the aforesaid figures the passage of liquid through the ports in the piston-head is controlled by a cylindrical valve 9, consisting of a tube surrounding the piston and provided with suitable openings for communicating with said ports, the length of said cylinder being such that its forward end extends beyond the forward end or head of the recoil-cylinder 6, and to the said valve in advance of the recoil-cylinder is secured a radially-extending arm 14. The inner end or hub-like portion of said arm 14 is provided with a series of teeth 15, which engage with similar teeth 13, formed on the bar or plate 12 about the central opening therein, and the outer end of said arm 14 is adapted to engage with an arm 16, mounted on a rock-shaft 17, extending longitudinally of and journaled in suitable bearings on the cradle 2. Said shaft 17 is preferably made polygonal in cross-section throughout the greater portion of its length, and mounted to slide thereon is a lever-arm 18, which is engaged by an arm 19, projecting laterally from the recoil-cylinder 6. On the other free end of said arm 18 is mounted a roller 20, adapted to bear against and travel longitudinally of a cam plate or surface 21, mounted between the cylinder 6 and the cradle 2. It will be seen that any variation in the radius of the portion of the plate 21 traversed by said roller 20 during recoil of the gun will act to rock the shaft 17 and through the arms 16 14 adjust the valve 9 about the piston, and thus control the passage of liquid in the cylinder 6 from one side of the piston to the opposite side thereof. The pressure exerted by such movement of the roller 20 is in opposition to that exerted by the counter-recoil springs on the bar or plate 12, which tend to hold the valve 9 in the position it occupies prior to firing the gun, said valve and plate being connected, as aforesaid, by the teeth 13 15. The counter-recoil springs, through the rods 11, tend to draw the plate 12 toward the breech or rear end of the cradle. The rods 11 are guided and held against rotation around the axis of the recoil-cylinder by the diaphragm extending across the cradle in front of the recoil-cylinder and serving in the embodiment of the invention illustrated in Figs. 1 to 7 to support the forward end of the cam-plate 21. The tendency of the plate 12 to move rearward under the force of the springs is checked by the arm 14, the inclined surfaces or teeth 13 15 of said parts being in contact. The result of the rearward force exerted on the plate 12 thus tends to rotate the arm 14 about the axis of the cylinder, the direction of which depends on the angles of the curved inclined surfaces 13 15 whether they are right or left hand. As the arm 14 is engaged by the lever-arm 16 the rotative action is transmitted to the shaft 17 and in turn to the roller 20 through arm 18. Therefore the angle of the inclined surfaces or teeth 13 15 are so designed and arranged that the roller 20 is held continuously against the curved surface 21; or the parts are so arranged that if the valve is closed at the position of "in battery," or when the gun is at rest, as the gun begins to recoil the spring 10 would open the valve to the maximum orifice as the roller 20 follows the contour of the curved surface presented, the closing of the valve being effected by the cam-surface pressing the roller 20 outward until the gun is brought to rest. Said plate 21 is curved on its inner face to conform to the adjacent surface of the cylinder 6 and has formed on its outer surface a plurality of longitudinally-extending curves of different lengths and radii, each being of such form as to properly actuate the valve 9 at one of either of the several positions of elevation or depression which the gun may assume. As shown, the plate 21 is provided at its ends with rings that surround the recoil-cylinder, being suitably supported within the cradle 2, and means are provided for rotating said plate 21 about the axis of the cylinder 6 as the elevation of the gun is varied in order to bring into contact with the roller 20 that portion of said plate presenting the proper longitudinal curve to effect the operation of the valve 9 and close the ports in the piston 8 to check the recoil of the gun at the proper time. In the embodiment of the invention shown in said Figs. 1 to 7 the plate 21 is provided at its forward end in advance of the cylinder 6 with an upwardly curved or flaring portion on which are formed suitable teeth that mesh with the teeth of the segmental spiral gear 22, mounted on a transverse shaft 23, journaled in bearings on the cradle 2, said shaft carrying also a gear-segment 24, adapted to mesh with the teeth of a rack-bar 25, the rear end of which is connected to a yoke that is pivotally connected to the supporting-frame of the gun. As the gun is rocked about the horizontal axis on which it is supported to vary the elevation of the muzzle either by raising or depressing the same it will be seen that the rack 25 will be drawn rearwardly or pushed forward, as the case may be, and through the gear 24 the shaft 23 will be rotated and the gear 22 will adjust the plate 21 about the cylinder 6 to bring the proper longitudinal curve thereon into position to act upon the roller 20.

Various modifications of the means for presenting for each adjustment or variation in elevation of the gun a curved surface hav-

ing the configuration required to properly actuate the check-valve of the recoil mechanism may be substituted for that above described and shown in Figs. 1 to 7.

In the form of the invention illustrated in Figs. 8 to 13 the recoil-cylinder 6′ is mounted so as to be free to rotate while moving longitudinally of the cradle with the gun during recoil and counter-recoil, and the valve 9′ is connected to said cylinder to be rotated thereby about the head of the stationary piston, which is of the same form as that previously described. As shown, the valve is provided at diametrically opposite points with suitable radial projections which engage grooves or ways formed in the inner surface of the recoil-cylinder. Instead of employing a single plate with longitudinal cams which is adapted to be rotated about the axis of the recoil-cylinder, rollers 26 27 are mounted on opposite sides of the roller 20′, carried by the cylinder 6′, each of said rollers 26 and 27 having a plurality of longitudinally-extending curves formed on its outer surface and each being mounted to rotate about a longitudinal axis. At one end each of said rollers 26 27 is provided with a spiral gear 28, with which gear meshes a gear 29, mounted on a shaft also carrying a spur-gear 30, which meshes with a rack-bar 25′, similar in function to the rack 25 of the embodiment of the invention illustrated in Figs. 1 to 7. As the elevation of the gun is varied the rollers 26 27 will be rotated to provide between them a way or passage for the roller 20′, which will have the required longitudinal configuration or curve to rotate the recoil-cylinder 6′ during its longitudinal rearward movement to properly operate the valve 9′.

Instead of operating the shaft 23 by the arrangements of gearing heretofore described that illustrated in Fig. 14 may be employed. Referring to said figure, there is secured on the outer end of the shaft 23 a bevel-gear 28, with which meshes a bevel-gear 29 on the forward end of a shaft 29′, that is mounted in suitable bearings secured to the gun-cradle 2. On the rear end of shaft 29′ is secured a spiral gear 30, that meshes with a gear-segment 31, stationarily secured to one of the side plates of the frame 3 and extending concentric with the axis about which the gun is adapted to rock.

Referring to the embodiment of the invention illustrated in Figs. 15 to 18, it will be seen that a series of grooves 32, having their outer walls of the same form as the longitudinally-extending cams 21 of the two first forms and of different lengths, are formed in the inner face of the wall of the recoil-cylinder 6″, and that instead of employing a valve adapted to be rotated about the piston at each recoil operation of the gun the piston-head 9″ itself forms in connection with the outer curved walls of the exposed groove 32 the valve for controlling the movement of fluid in said cylinder. Within the cylinder is arranged a second cylinder 33, having formed therein a longitudinal slot of a width corresponding to the width of each of the grooves 32 and adapted to be adjusted into alinement with either of said grooves in the recoil-cylinder. Said slot does not extend throughout the length of the cylinder 33, but has a solid continuous unbroken wall between the rear end of the recoil-cylinder 6″ and the position which the piston 9″ occupies when the gun is in normal "battery" position. In this form of the invention the recoil-cylinder, like that in the form first described, does not rotate during recoiling of the gun, and the inner cylinder 33 is connected with the piston to be rotated thereby, rotary movement being communicated to the piston rod or stem by means similar to those described for rotating the valve in the form of the invention illustrated in Figs. 1 to 7. As shown, the piston 9″ is provided with a radial projection 34, adapted to enter the slot in said cylinder 33, whereby the piston and said cylinder are connected to rotate together, but the piston is free to move longitudinally of the cylinder. The recoil-cylinder 6″ being held against rotation, it will be seen that if rotary movement be communicated to the piston-rod during variations in the elevation of the gun such movement will be transmitted to the inner cylinder 33 to bring the slot therein into alinement with the groove 32, having the required length and longitudinal configuration to properly check the recoil movement of the gun at the particular elevation. It is clear, however, that it would not be practicable to permit the inner cylinder 33 to rotate continuously as the gun is elevated or depressed, because such elevation or depression might be terminated at a time when the slot in said cylinder was out of alinement with either of the grooves 32. Therefore means are provided for imparting intermittent rotation to the inner cylinder, and the amount or extent of each intermittent rotary movement of such cylinder is equal to the distance separating adjacent grooves 32. One means for effecting this intermittent rotation of said cylinder 33 is illustrated. Instead of employing a rack-bar like that shown in Fig. 1 a two-part bar or link is provided, the toothed section 35 having a stem which extends centrally through a cylindrical shell 36 and provided within said casing with a radially-projecting disk 37, between which and opposite ends of said shell are arranged coiled springs 38 39. The rear end of the shell or casing 36 is connected with a link 40, the other end of which is adapted to be engaged by a hand-lever 41, fulcrumed on the frame of the gun-carriage.

It is customary to facilitate rapid loading to provide means for disconnecting the serv-

ice mechanism for elevating and depressing and bringing the gun to a substantially horizontal position. Such means are operated, according to the present invention, by the hand-lever 41, and as it is not desired to vary the position of the recoil check devices during such movement of the gun to loading position the said hand-lever is adapted to dis connect the inner end of the link carrying the rack 35 when such hand-lever is being used—that is, the lever 41 is geared to a lever which engages the gun and the link 40 is provided at its rear end with means that extend into a curved slot 40ª, formed in a portion of the frame of the gun-carriage. The lever 41 is provided in its forward edge with a seat or recess that receives and acts as an abutment for the rear end of the link 40, which end is thus normally held between the lever 41 and forward end of the slot 40ª. When, however, the hand-lever 41 is operated to bring the gun to loading position, the link 40 is first disconnected from the frame and its rear end moves freely along the slot 40ª as the lever 41 is rocked, the rack 35 being held in fixed relation to the gear 24′ by the stop 43 during such movement.

The casing for the rack 35 is made in the cross-sectional form shown in Fig. 19, having its interior divided into two passages by a web 42. The rack 35 is adapted to move in the upper chamber or passage and is provided at its free end with a spring-pressed stop 43, adapted to engage with either of a series of apertures formed in said web 42. Into the passage below said web 42 projects a shaft 44, having at its forward end a stud or lug 45 and at its rear end a threaded section 46, engaging the walls of an aperture in the front head of the spring-casing 36. The aforesaid apertures in the web 42 are in alinement with circular grooves or ways formed in the rack-casing, and said circular ways are connected by inclined passages. Normally the stop 43 is in engagement with one of the apertures in the aforesaid web 42 and the trip-lug 45 is in the position shown in Fig. 19. The rack 35 is thus locked against movement relative to the gear 24′ engaged thereby, and therefore the shaft 23′ and gears 22′ 21′ cannot be rotated until said stop 43 is withdrawn. When the parts are in this engaged position, if the elevation of the gun is varied the stem of the rack 35 will be moved longitudinally through the casing 36, compressing one or the other of the springs 38 39, according as the muzzle of the gun is being elevated or depressed—that is, the gear 24′ and rack 35 are locked against relative movement by the stop 43 during the variation in elevation of the gun, and as the swinging movement of the gun varies the distance between the shaft 23′ and rear end of link 40 the stem of the rack is moved bodily through the casing 36, placing one of the springs therein under tension. The rod 44 is also moved through the head of the casing 36 engaged thereby and by reason of its threaded section 46 is rotated, causing the lug 45 to release the stop 43 and permitting the springs 38 39, previously put under tension, to actuate the rack 35 and gear 24′, as described. By such longitudinal movement of the rack-bar rotary motion is communicated to the trip-rod 44, and when the lug 45 comes into engagement with the stop 43 such stop is disengaged, and the rack 35 is then actuated by the previously-compressed spring 38 or 39 to rotate the gear 24′ and through the gearing 22′ 21′ turn the inner cylinder 33′ to bring the desired groove 32 into alinement with the slot in said cylinder 33. Such movement is accomplished during the time that the stop 43 is moving from one of the apertures in the web 42 to the next of said apertures with which it engages on coming into alinement therewith, and the trip-lug 45 simultaneously moves through one of the inclined passages into position beneath such stop 43.

In the embodiment of the invention shown in Figs. 20 to 24 it will be seen that the grooves 32′ are made narrow, and the slot in the inner cylinder 33′ extends over two or more of these grooves. The entire series of the longitudinal grooves form on their outer face or wall a curved surface which is substantially the same as that shown in Fig. 7—that is, each element of its surface is proportioned to give the correct area in connection with the sides of the little dividing-walls and the side of the projecting lug 34′ to control the flow of the braking-liquid, as heretofore described. It will be seen that the slot in the inner cylinder can move over a certain number or any part of the curve, and the length of recoil will be controlled accordingly. The movement can be continuous as the elevation of the gun varies.

Figs. 25 to 28 show a modification of the previous form, the curved surface and the little dividing-walls being placed within the piston-rod, which rotates, the curve and roller being retained stationary by the cylinder 6′′′′, the port through the piston-head affording communication from the forward side to the bore of the piston-rod. It is evident that the liquid will be controlled by passing through the orifice formed by the curved surface on one side, the sides of the dividing-walls on the two others, and the sides of the piston on the fourth, a rotation of the piston presenting other portions of the curve and controlling the recoil in consequence.

It will be noticed that an important feature of the present invention is that the braking or checking of the recoil is effected in a manner which is substantially the same as that which is theoretically correct—that is, variations in the elevation of the gun do not vary the dimensions of the passages through

which the fluid passes from one side of the controlling piston to the other prior to the commencement of the recoil movement; but such passages are after the beginning of the recoil movement at all elevations of the gun opened to their maximum extent in a distance equal approximately to one caliber of the gun or at the instant the projectile leaves the gun. The parts are so proportioned and arranged that the orifice or passage for the checking fluid increases in size so long as gas generated by the exploding charge acts within the bore of the gun, the maximum of such orifice being reached as the projectile leaves the gun, and thereafter said orifice is reduced until the gun comes to rest. The maximum orifice varies in size and is located at different points in relation to the origin of the recoil movement, depending on the length of recoil. It can be shown that the length of recoil while the gases generated by the explosion of the charge are acting on the gun is equal to approximately one caliber of the gun. The braking or checking of the recoil is effected by regulating the flow of liquid from one side of the piston to the other, regulating and stopping such flow during recoil at the proper times by means brought into action only when the gun occupies a certain position instead of reducing the size of the passage for such liquid prior to the beginning of the recoil movement. The parts are preferably so adjusted that no variation in the recoil-checking devices is effected by variations in elevation not exceeding ten degrees from the horizontal.

The foregoing description and the drawings illustrate six different embodiments of the invention. It will be evident, however, that other modifications are possible and also that the invention is not limited to use with field-guns of the character illustrated in the drawings, but is applicable to cannon of any class or style.

What I claim is—

1. The combination with a cannon, of fluid recoil-checking devices including means for changing the length of recoil as the elevation of the gun is varied, said means being adapted to provide a fluid-passage of uniform dimensions at the beginning of each recoil.

2. The combination with a cannon, of fluid recoil-checking devices including means for providing a fluid-passage of uniform dimensions at the beginning of each recoil, and means for closing said fluid-passage at different distances of rearward travel of the gun in recoil as the elevation of the gun is varied.

3. The combination with a cannon, of fluid recoil-checking devices including means for providing a fluid-passage of uniform dimensions at the beginning of each recoil, and means adjustable about the axis of the recoil-cylinder for closing said fluid-passage at different distances of rearward travel of the gun in recoil as the elevation of the gun is varied.

4. The combination with fluid recoil-checking devices for cannon, of means operating during the recoil and controlled by variations in the elevation of the gun for regulating the dimensions of the fluid-passage of said checking devices and adapted to vary said passage from its maximum to its minimum size at different distances in the rearward travel of the gun in recoil.

5. The combination with a cannon and fluid recoil-checking devices therefor, of means for varying the dimensions of the fluid-passage of said checking devices during recoil, and guide-surfaces extending longitudinally of the recoil devices and adapted to control the action of said means and cause the length of recoil to vary in accordance with changes in the elevation of the gun.

6. The combination with a cannon and fluid recoil-checking devices therefor including fluid-passages controlled by longitudinally-disposed guide-surfaces, of means arranged outside of the recoiling mechanism for controlling the position of said guide-surfaces and adapted to be adjusted as the elevation of the gun is varied to cause the length of recoil to vary in accordance with changes in the elevation of the gun.

7. The combination with a cannon, and fluid recoil-checking devices therefor including a rotary valve, of means controlled by variations in the elevation of the gun for rotating said valve during the recoil at different speeds, said means being adapted to return said valve to the same normal position at the completion of each counter-recoil movement.

8. The combination with a cannon, and fluid recoil-checking devices therefor including a rotary valve, of means adjustable about the axis of the recoil-cylinder for controlling the closing of said valve, the length of time required to complete a movement of said valve depending on the adjustment of said controlling means, and devices for automatically adjusting said controlling means as the elevation of the gun is varied.

9. The combination with a cannon, and fluid recoil-checking devices, of a roller reciprocating with the gun and movable about an axis extending parallel to the length of the gun, means actuated by said angular movement of the roller for operating the valve mechanism of the recoil devices, and means for changing the extent of said angular movement of the roller during the recoil to vary the time of operating the valve.

10. The combination with a cannon, and fluid recoil-checking devices, of a roller reciprocating with the gun and movable about an axis extending parallel to the length of the gun, means actuated by said angular move-

ment of the roller for operating the valve mechanism of the recoil devices, and means controlled by variations in the elevation of the gun for changing the extent of said angular movement of the roller during the recoil to vary the time of operating the valve.

11. The combination with a cannon, and fluid recoil-checking devices, of a roller arranged outside of the recoil-cylinder and reciprocating with the gun, said roller being movable about an axis extending parallel to the length of the gun, means actuated by said angular movement of the roller for operating the valve mechanism of the recoil devices, and means for changing the extent of said angular movement of the roller during the recoil to vary the time of operating the valve.

12. The combination with a cannon, and fluid recoil-checking devices, of a cam-surface extending longitudinally of the recoil devices, a roller reciprocating with the gun in contact with said cam-surface, means actuated by said roller for operating the valve mechanism of the recoil devices, and means for adjusting said cam-surface to vary the path of movement of said roller, for the purpose described.

13. The combination with a cannon, and fluid recoil-checking devices, of a guide extending parallel to the length of the gun and provided with a plurality of longitudinally-extending curves or cam-surfaces, means for actuating the valve mechanism of the recoil devices including a part adapted to reciprocate with the gun in contact with said guide, and means for adjusting said guide to bring either of the cam-surfaces thereon into operative position.

14. The combination with a cannon, and fluid recoil-checking devices, of a guide adjustable about an axis extending parallel to the length of the gun and provided with a plurality of longitudinally-extending curves or cam-surfaces, means for operating the valve mechanism of the recoil devices including a part adapted to reciprocate with the gun in contact with said guide, and means for rotating the guide to bring any desired one of the cam-surfaces thereon into operative position.

15. The combination with a cannon, and fluid recoil-checking devices, of a guide adjustable about an axis extending parallel to the length of the gun and provided with a plurality of longitudinally-extending curves or cam-surfaces, means for operating the valve mechanism of the recoil devices including a part adapted to reciprocate with the gun in contact with said guide, and means for rotating said guide as the elevation of the gun is varied to bring into operative position the cam-surface thereon that is adapted to cause the desired operation of the valve mechanism of the recoil devices.

16. The combination with a cannon, and fluid recoil-checking devices, of a guide adjustable about an axis extending parallel to the length of the gun and provided with a plurality of longitudinally-extending curves or cam-surfaces, means for operating the valve mechanism of the recoil devices including a part adapted to reciprocate with the gun in contact with said guide, a rack adapted to move longitudinally as the elevation of the gun is varied, and gearing connecting said rack and guide whereby the latter will be rotated as the elevation of the gun is varied to bring into operative position the particular cam-surface on said guide that is adapted to cause the desired operation of the valve mechanism of the recoil devices.

17. The combination with a cannon, a cradle supporting the cannon and on which it is adapted to reciprocate, and fluid recoil-checking devices, of a guide mounted on the cradle and adjustable about a longitudinal axis, said guide having a plurality of longitudinally-extending cam-surfaces formed thereon, means for operating the valve mechanism of the recoil devices including a part adapted to reciprocate with the gun in contact with said guide, a shaft mounted in bearings on the cradle and geared to said guide, a pinion mounted on said shaft, and means for driving said pinion as the elevation of the gun is varied, whereby said guide will be adjusted to bring different cam-surfaces thereon successively into operative position as the elevation of the gun is varied.

18. The combination with a cannon, a cradle supporting the cannon and on which it is adapted to reciprocate, and fluid recoil-checking devices, of a guide mounted on the cradle and adjustable about a longitudinal axis, said guide having a plurality of longitudinally-extending cam-surfaces formed thereon, means for operating the valve mechanism of the recoil devices including a part adapted to reciprocate with the gun in contact with said guide, a shaft mounted in bearings on the cradle and geared to said guide, a pinion mounted on said shaft, and intermittently-acting means for rotating said pinion as the elevation of the gun is varied, substantially as and for the purpose described.

19. The combination with a cannon, of fluid recoil-checking devices including means for providing a fluid-passage of uniform dimensions at the beginning of each recoil, and means for varying the intervals of time elapsing between the commencement of recoil and the instant the maximum passage is provided and the closing of said passage after reaching said maximum, as the elevation of the gun is varied.

20. The combination with a cannon, of fluid recoil-checking devices including means for providing a fluid-passage of uniform dimensions at the beginning of each recoil, and means for varying the maximum size of said

passage and the intervals of time elapsing between the commencement of said recoil and the instant said maximum is reached and the closing of said passage after said maximum as the elevation of the gun is varied.

21. The combination with a cannon and fluid recoil-checking devices, of a roller movable about an axis extending parallel to the length of the gun, means for so moving said roller during the recoil of the gun, means actuated by the rocking movement of said roller for operating the valve mechanism of the recoil-checking devices, and means for changing the extent of said rocking movement during recoil to vary the operation of said valve mechanism.

22. The combination with a cannon and fluid recoil-checking devices, of means including a plurality of elements, each adapted to control the recoil-checking devices and to cause said devices to act in a manner different from either of the others, and means for bringing said elements successively into operative position as the elevation of the gun is varied.

23. The combination with a cannon and fluid recoil-checking devices, of a rack adapted to be moved longitudinally as the elevation of the gun is varied, and means adapted to be actuated by said rack for varying the port area of the valve mechanism of the recoil-checking devices during recoil, whereby the length of recoil will be automatically varied with variations in the elevation of the gun.

24. The combination with a cannon and fluid recoil-checking devices, of intermittingly-acting means for adjusting the valve mechanism of said checking devices in conformity with variations in the elevation of the gun.

25. The combination with a cannon and fluid recoil-checking devices, of a gear adapted to adjust the valve mechanism of the recoil-checking devices to regulate the action of said checking devices in conformity with variations in elevation of the gun, a rack for actuating said gear, and means for intermittingly reciprocating said rack as the elevation of the gun is changed.

26. The combination with a cannon and fluid recoil-checking devices, of means adapted to adjust the valve mechanism of the recoil-checking devices to regulate the action of said checking devices in conformity with variations in the elevation of the gun, said means including a rack geared to said adjusting means and connected by a yielding connection with the frame of the gun-carriage, whereby it is adapted to be reciprocated as the elevation of the gun is changed, means for normally preventing such reciprocation of the rack, and means for intermittingly withdrawing said stop or lock means.

27. The combination with a suitable carriage, a gun mounted thereon, and a variable-recoil mechanism for the gun, comprising means for obtaining constantly-increasing pressures at the moments of recoil as the elevation of the gun is increased, of means for uniformly decreasing the pressure during recoil, whereby the recoil will be properly checked at all angles of elevation of the gun.

28. The combination with a suitable carriage, a gun mounted thereon, and a variable-recoil mechanism for the gun, comprising means for obtaining constantly-increasing resistance at the moments of recoil as the elevation of the gun is increased, of means for uniformly decreasing the pressure during recoil, whereby the recoil will be properly checked at all angles of elevation of the gun

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

FRANK B. YINGLING.

Witnesses:
WILLIAM ESSENWEIN,
PETER LIEBER.