June 20, 1961 S. J. FINN 2,988,962

SHELL-HANDLING MECHANISMS FOR GUNS

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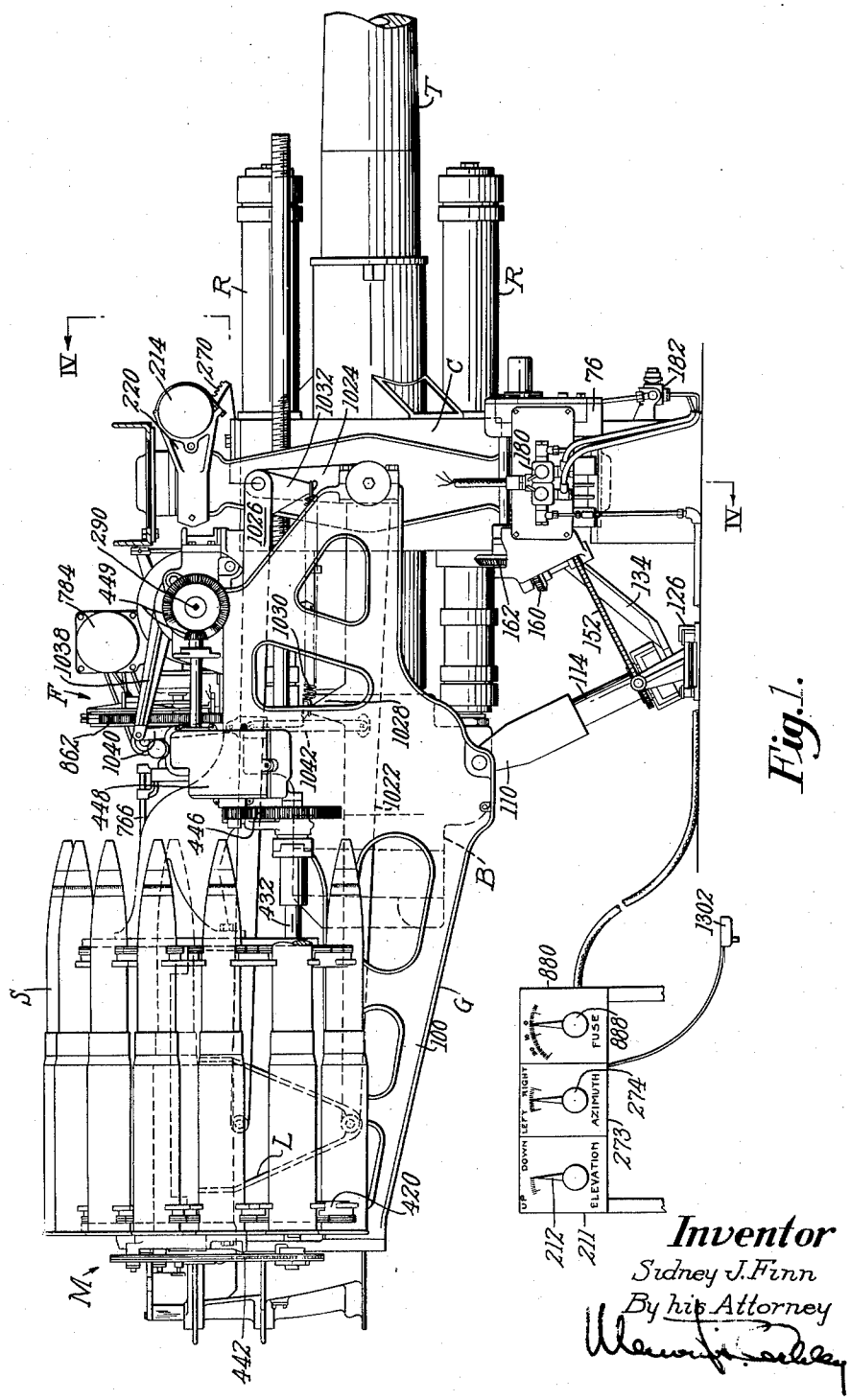


Fig. 1.

Inventor
Sidney J. Finn
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SHELL-HANDLING MECHANISMS FOR GUNS

Filed Feb. 9, 1944 27 Sheets-Sheet 2

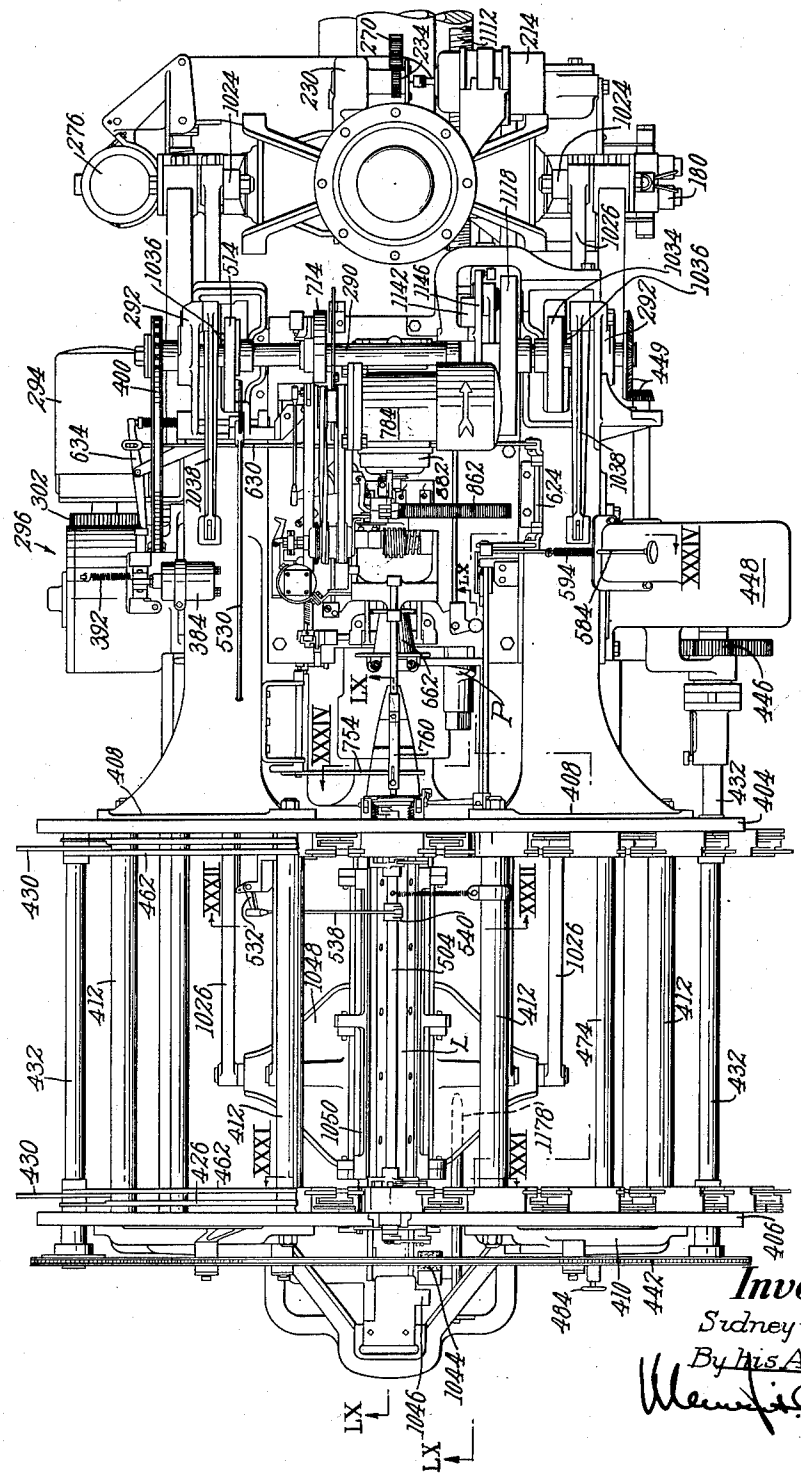


Fig. 2.

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SHELL-HANDLING MECHANISMS FOR GUNS

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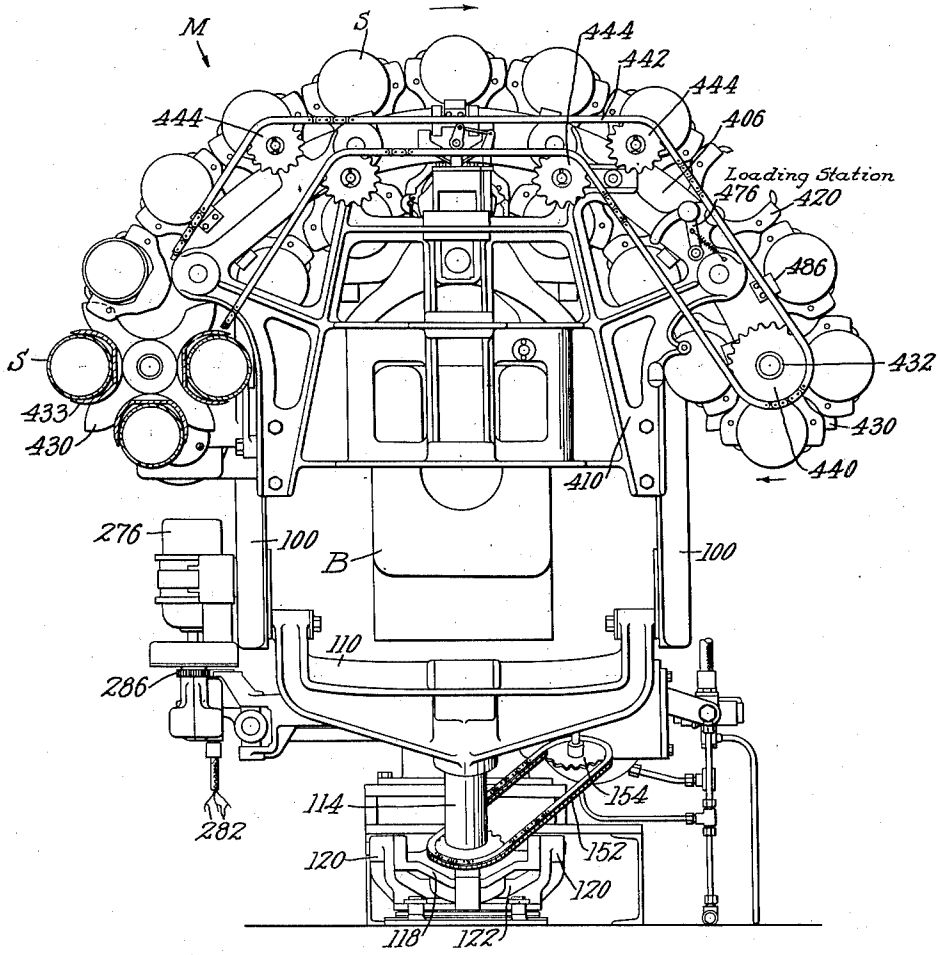


Fig. 3.

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SHELL-HANDLING MECHANISMS FOR GUNS

Filed Feb. 9, 1944 27 Sheets-Sheet 4

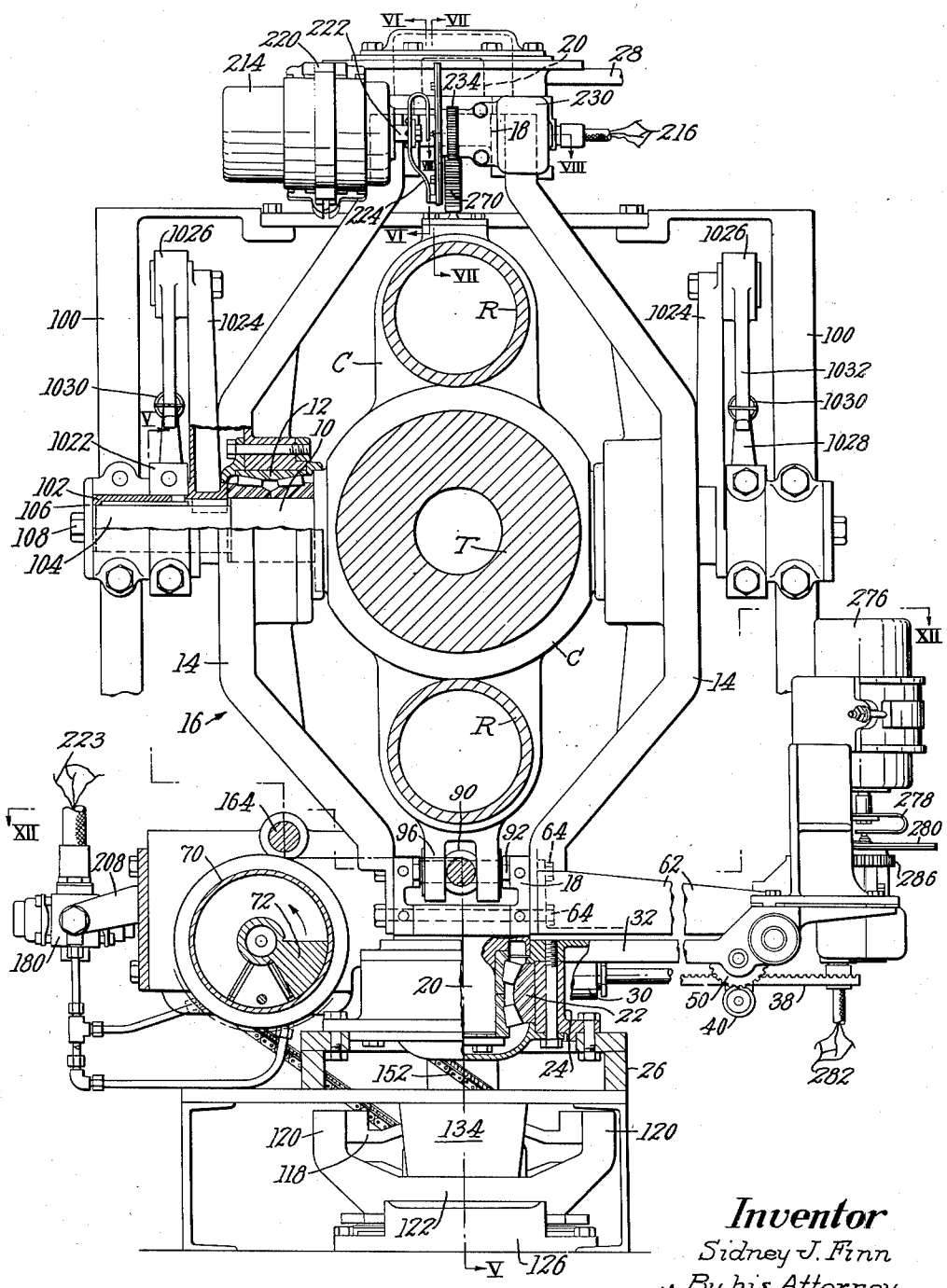


Fig. 4.

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SHELL-HANDLING MECHANISMS FOR GUNS

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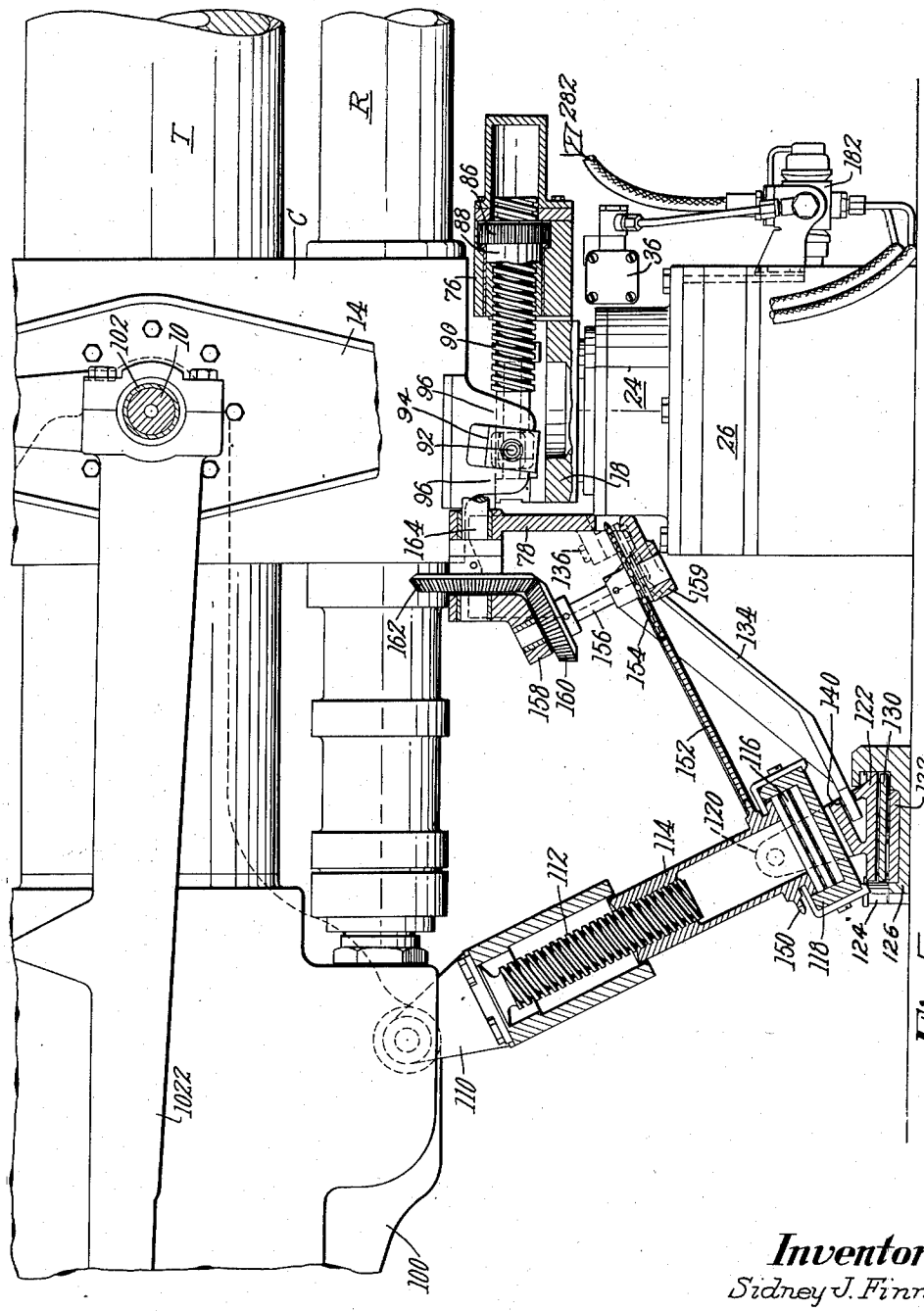


Fig. 5.

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SHELL-HANDLING MECHANISMS FOR GUNS

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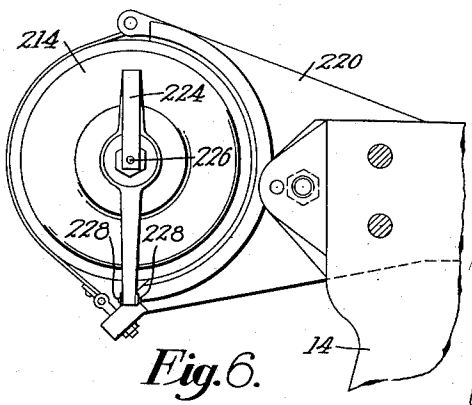


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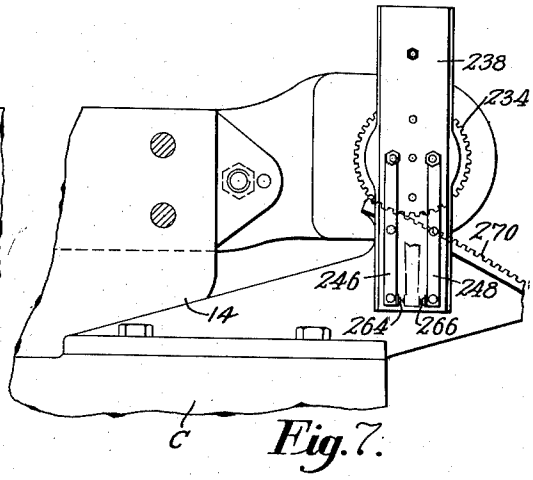


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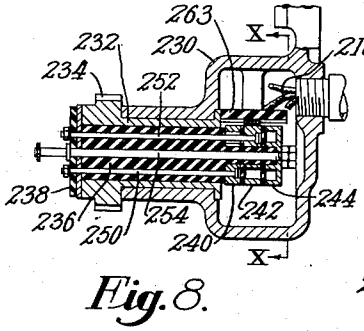


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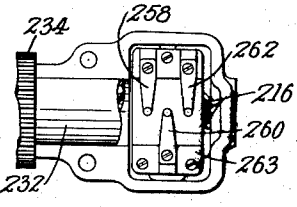


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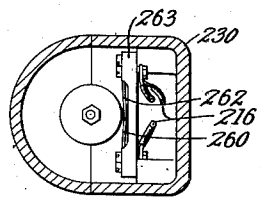


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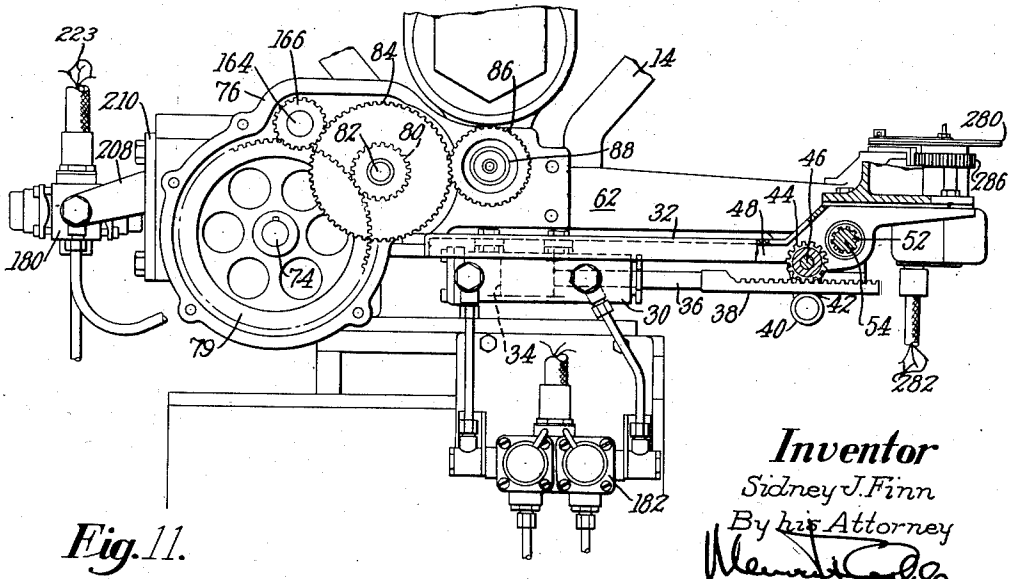


Fig. 11.

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SHELL-HANDLING MECHANISMS FOR GUNS

Filed Feb. 9, 1944 27 Sheets-Sheet 7

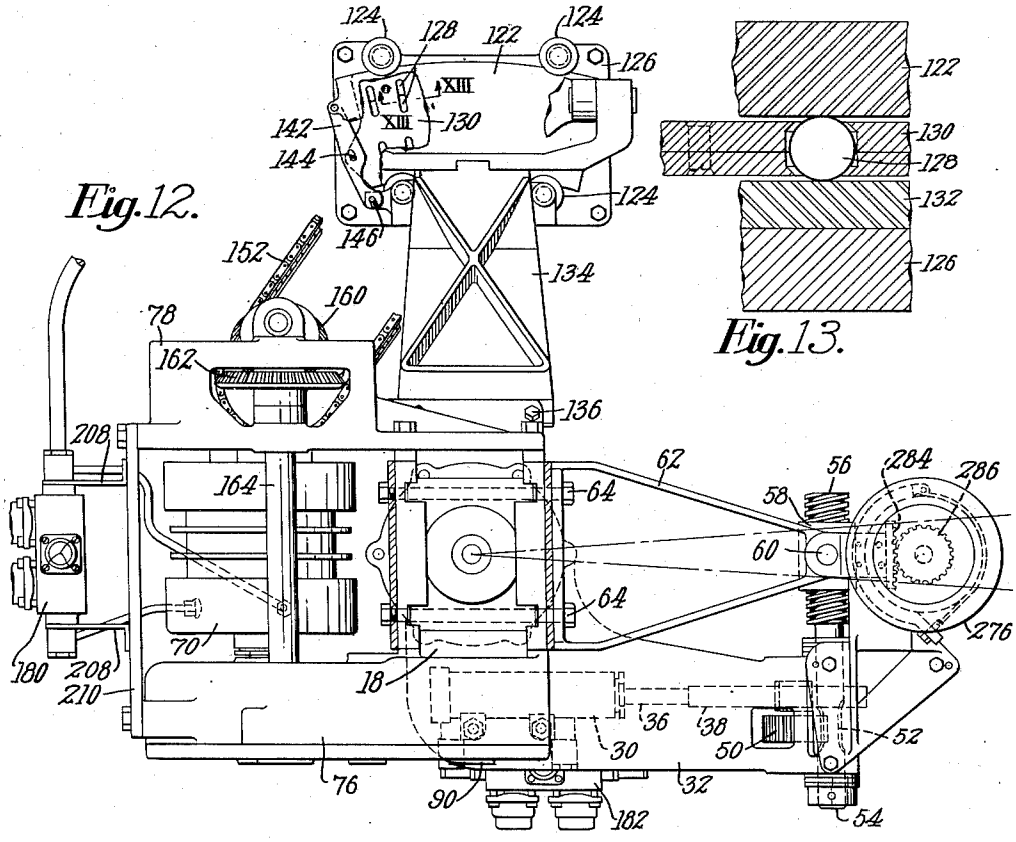


Fig. 12.

Fig. 13.

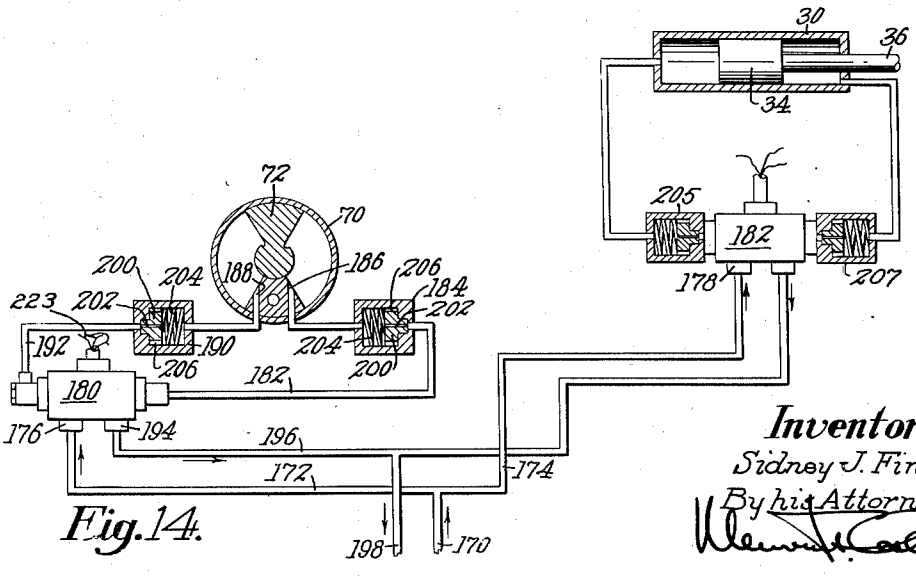


Fig. 14.

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SHELL-HANDLING MECHANISMS FOR GUNS

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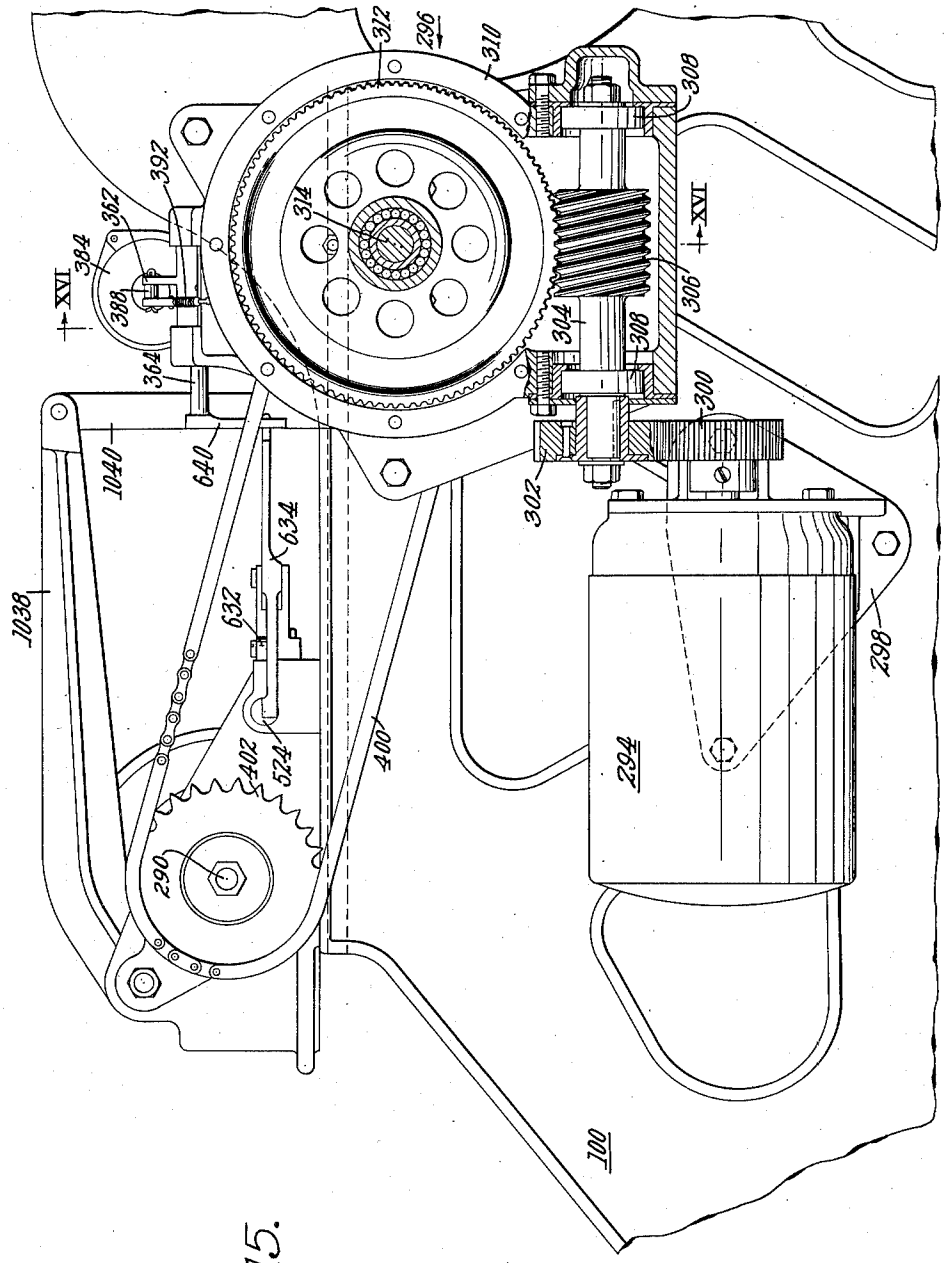


Fig. 15.

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SHELL-HANDLING MECHANISMS FOR GUNS

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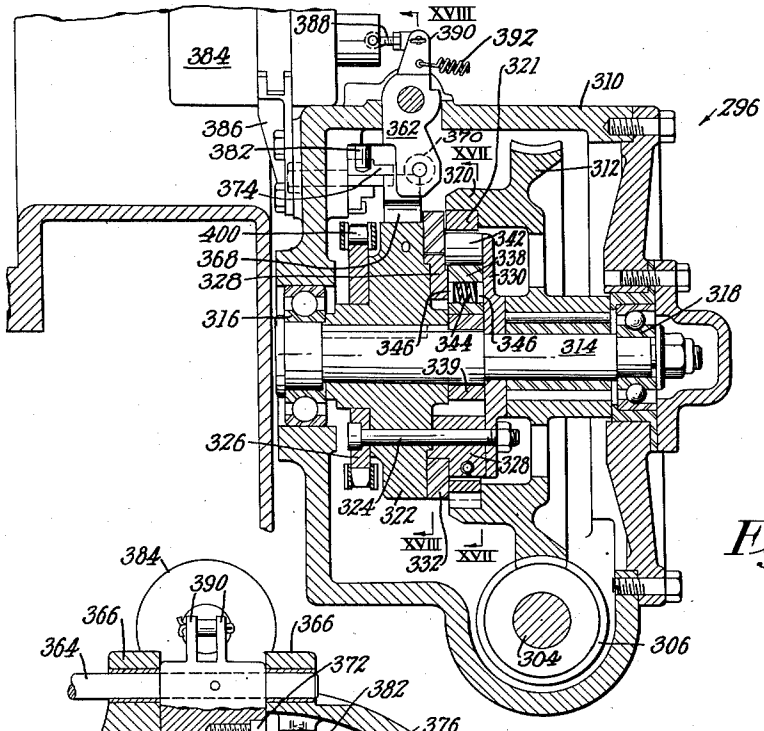


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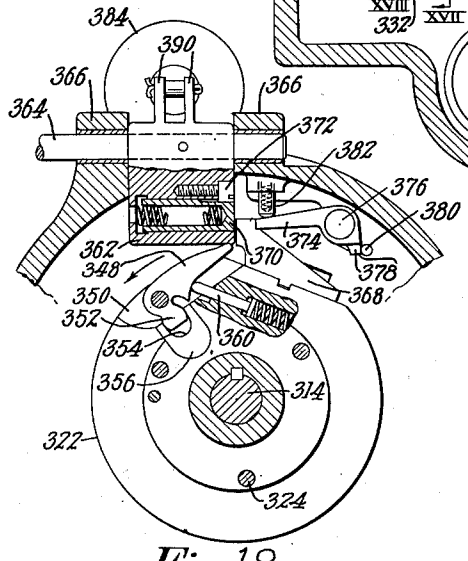


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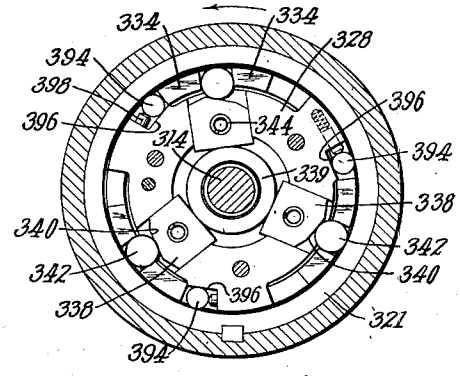


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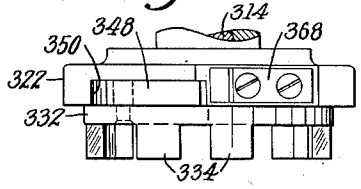


Fig. 19.

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SHELL-HANDLING MECHANISMS FOR GUNS

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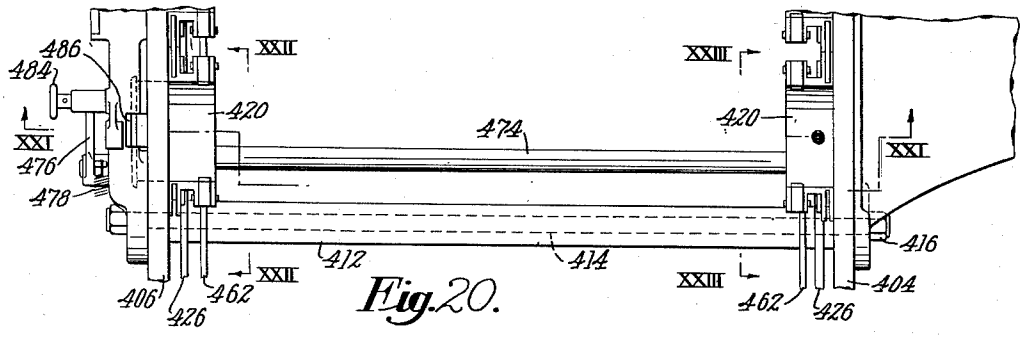


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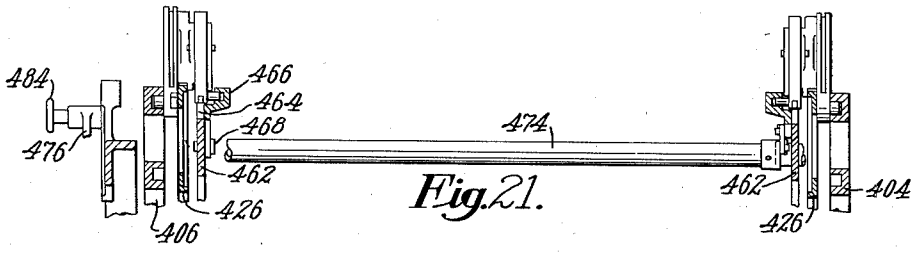


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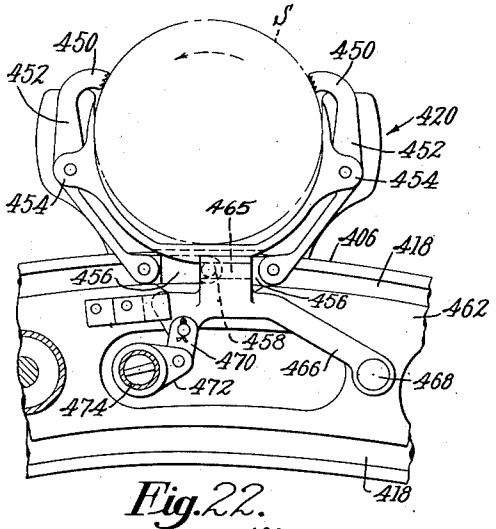


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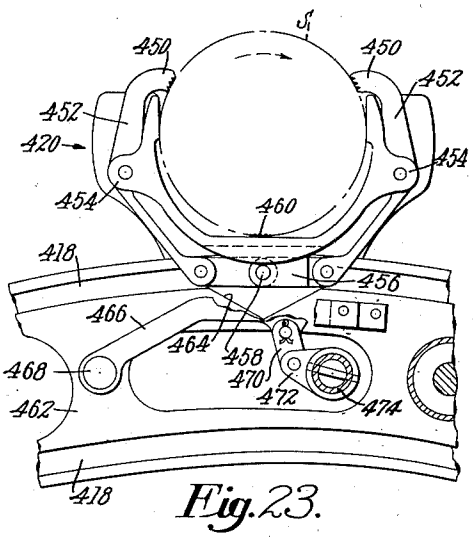


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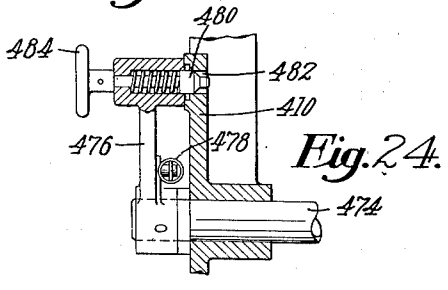


Fig. 24.

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SHELL-HANDLING MECHANISMS FOR GUNS

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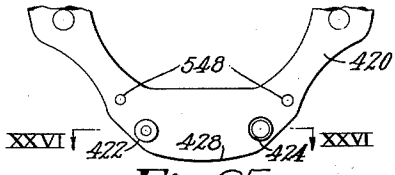


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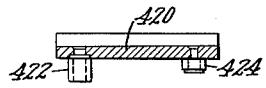


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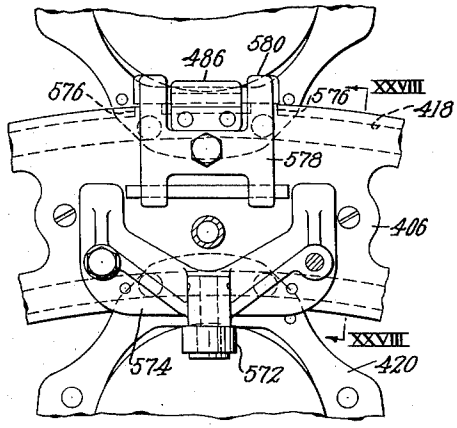


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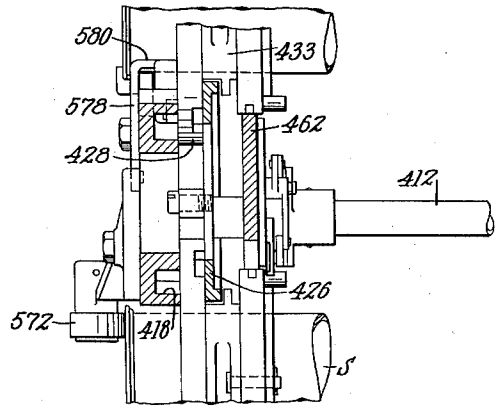


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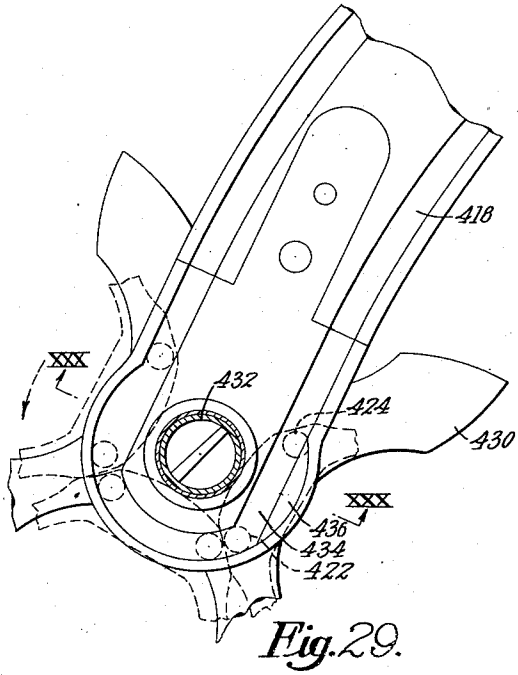


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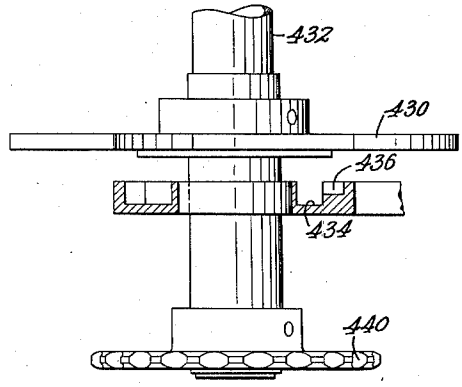


Fig. 30.

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SHELL-HANDLING MECHANISMS FOR GUNS

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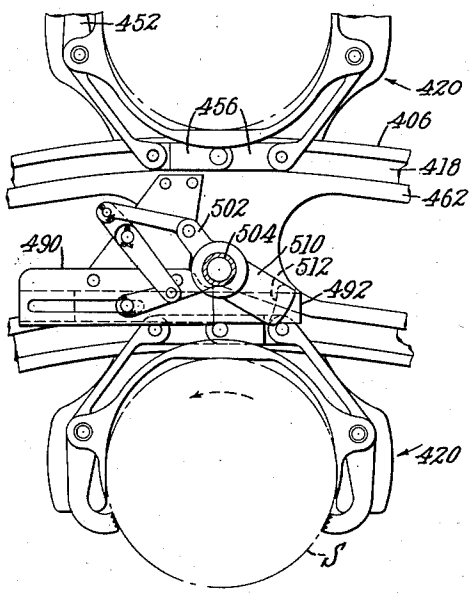


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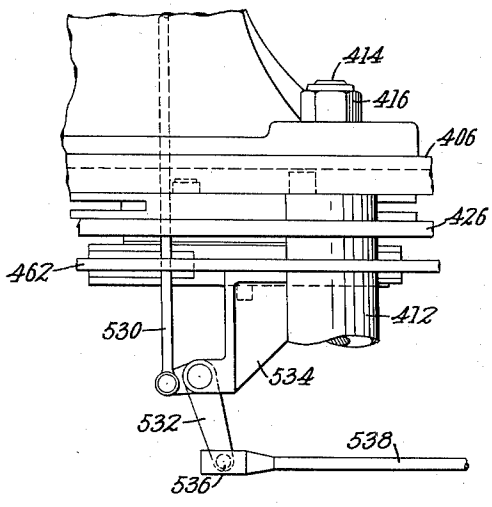


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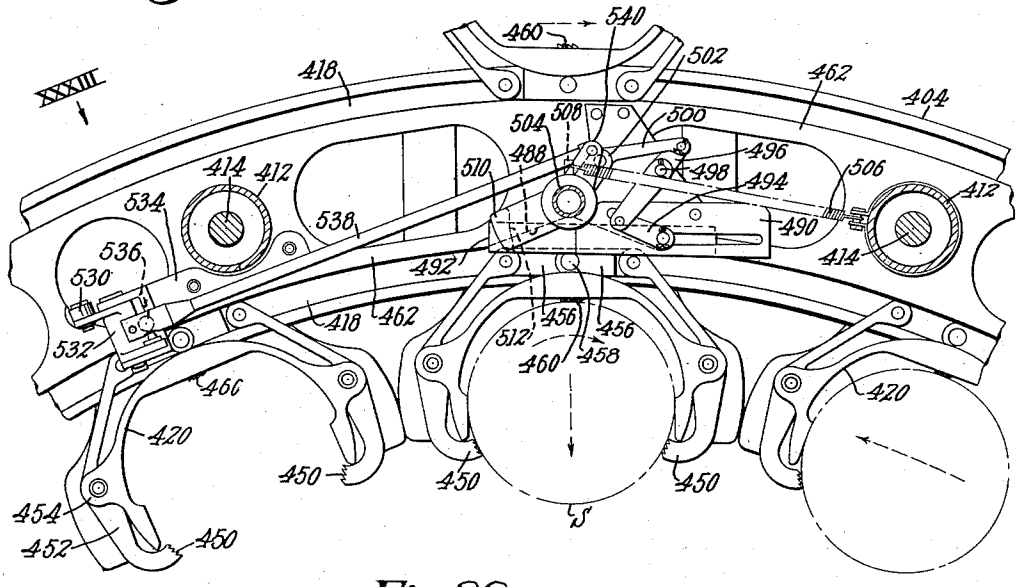


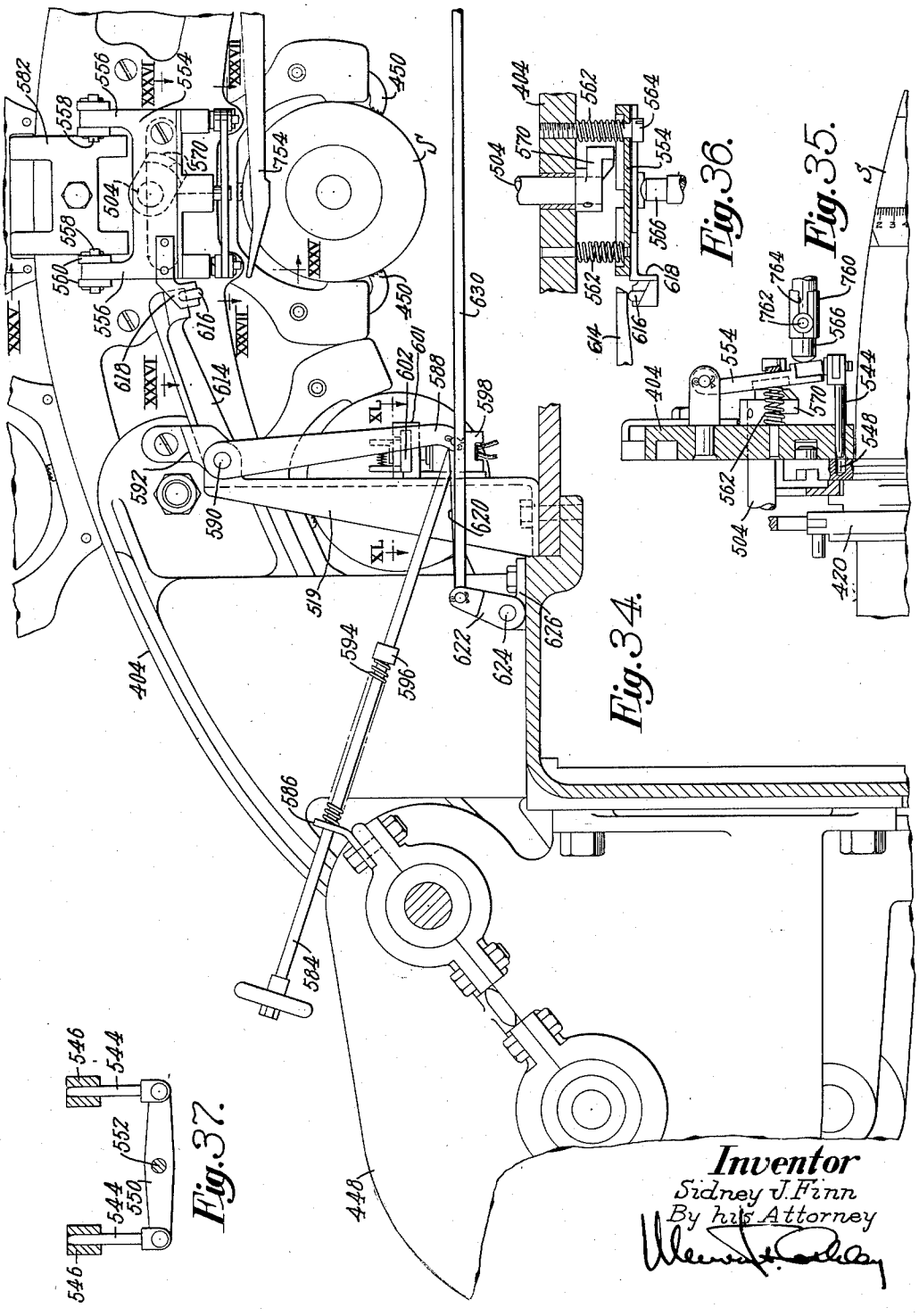
Fig. 32.

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SHELL-HANDLING MECHANISMS FOR GUNS

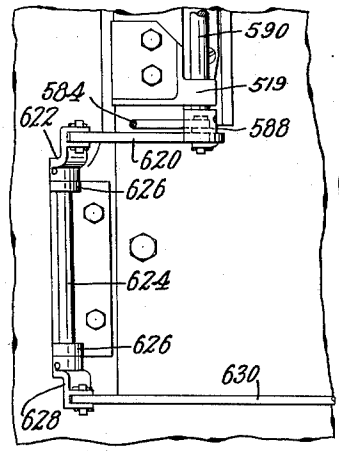
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SHELL-HANDLING MECHANISMS FOR GUNS

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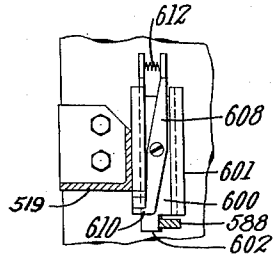


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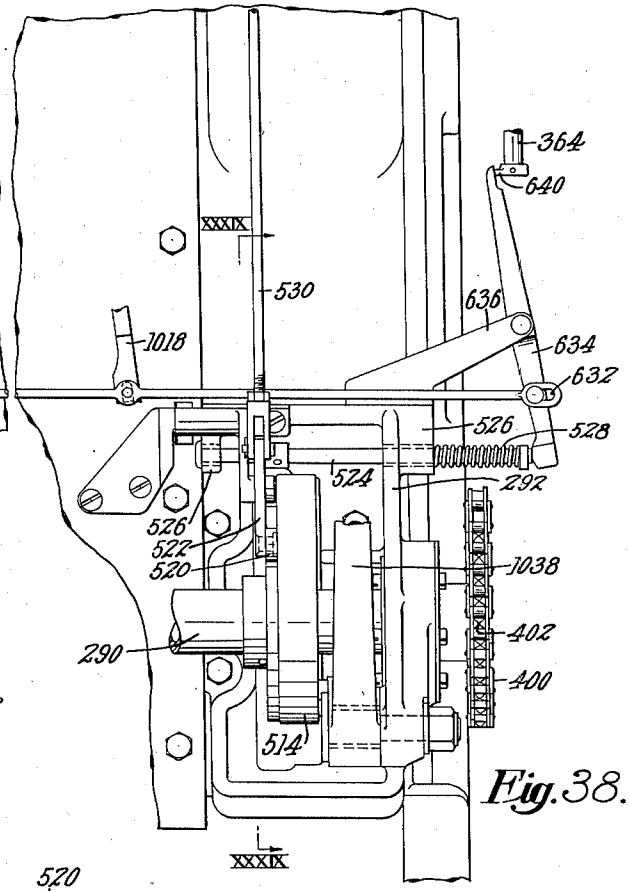


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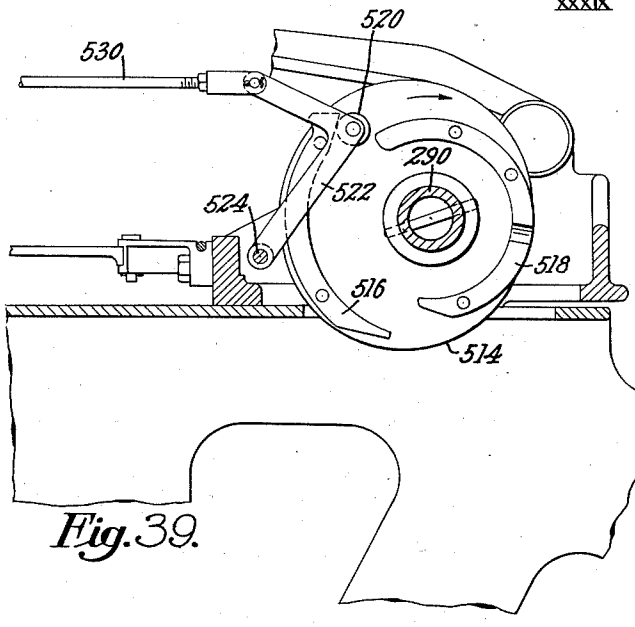


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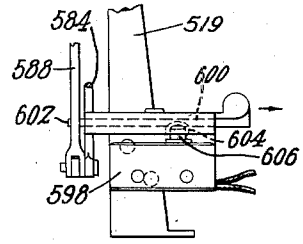


Fig. 41.

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SHELL-HANDLING MECHANISMS FOR GUNS

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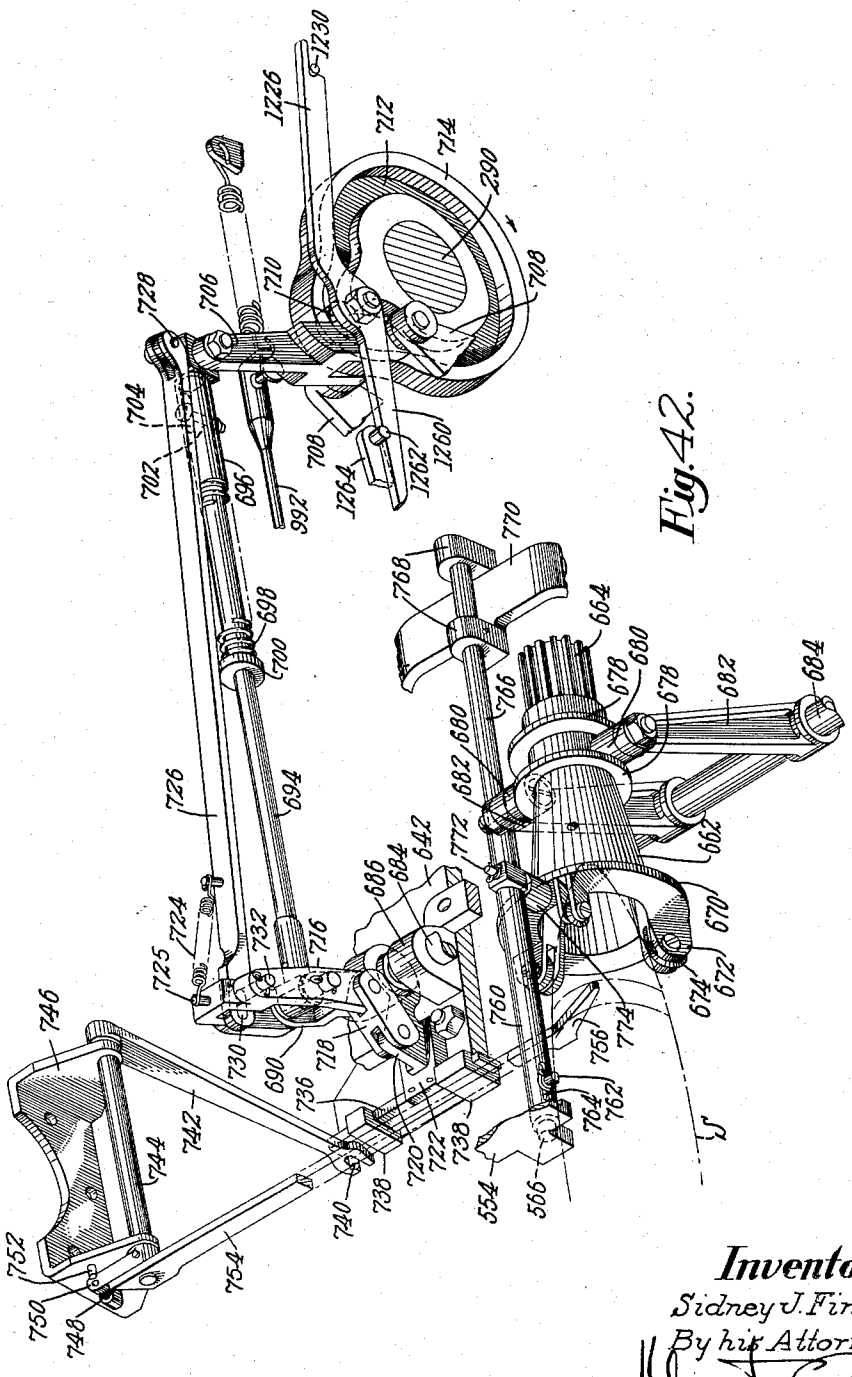


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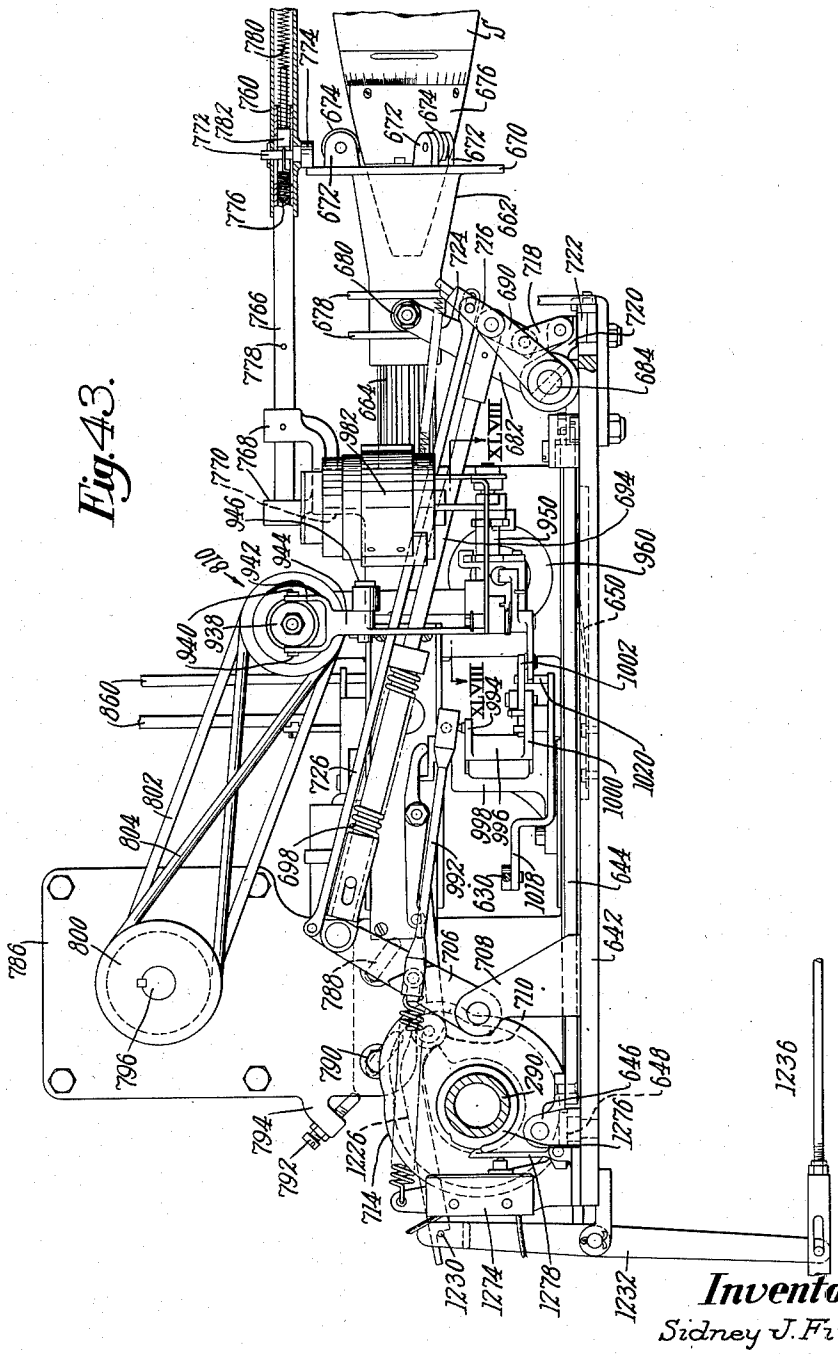
Inventor
Sidney J. Finn
By his Attorney

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Fig. 43.



Inventor

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By his Attorney

Wm. J. Cooley

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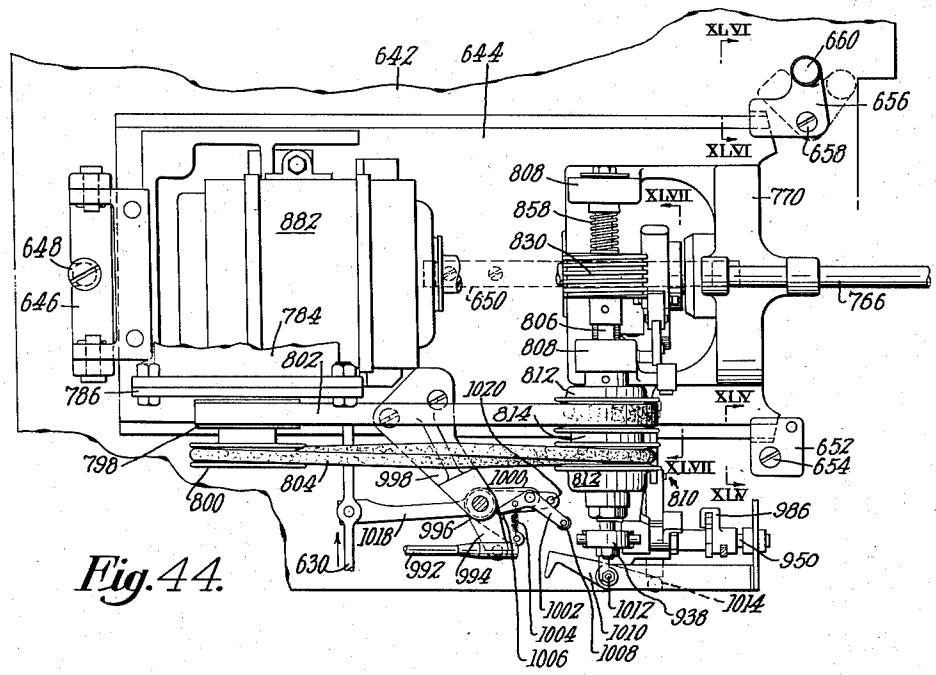


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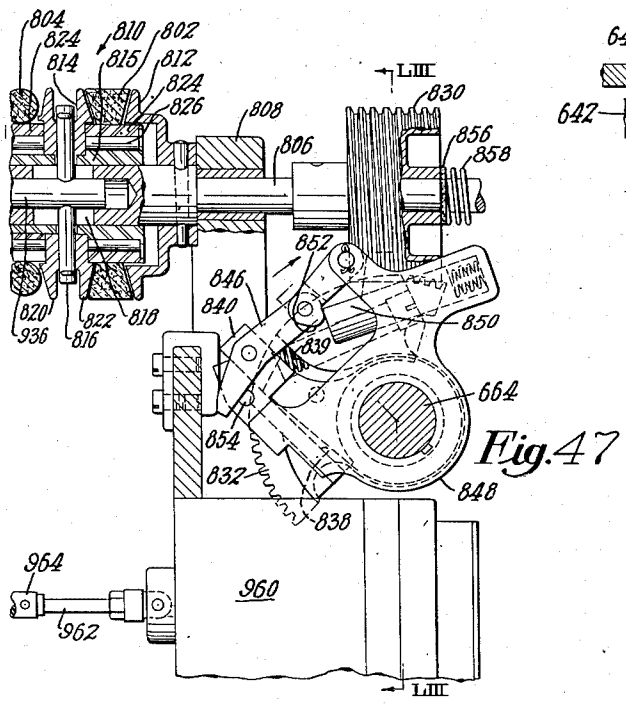


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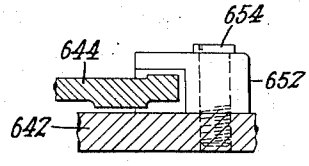


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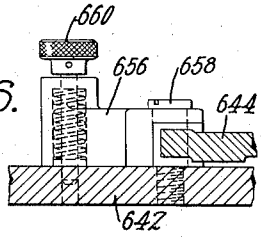


Fig. 46.

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SHELL-HANDLING MECHANISMS FOR GUNS

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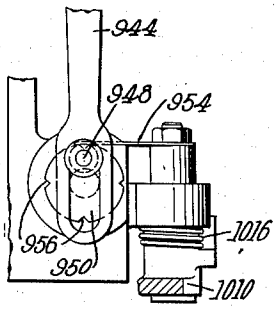


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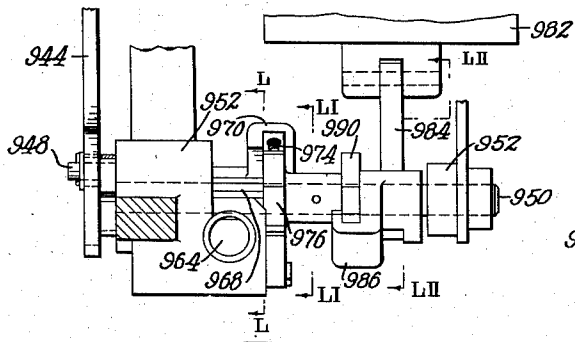


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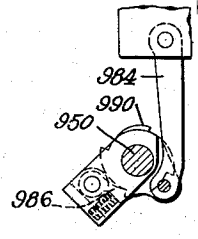


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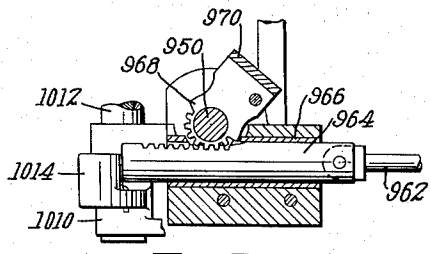


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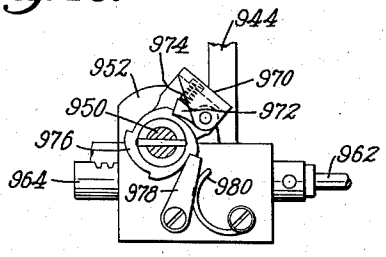


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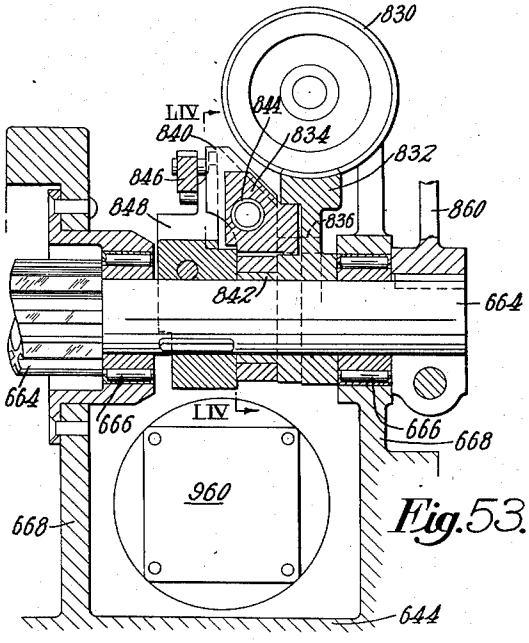


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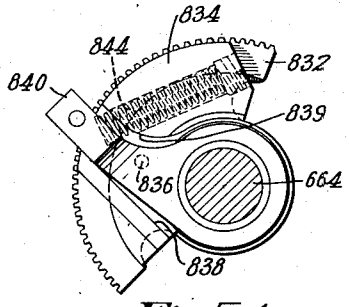


Fig. 54.

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SHELL-HANDLING MECHANISMS FOR GUNS

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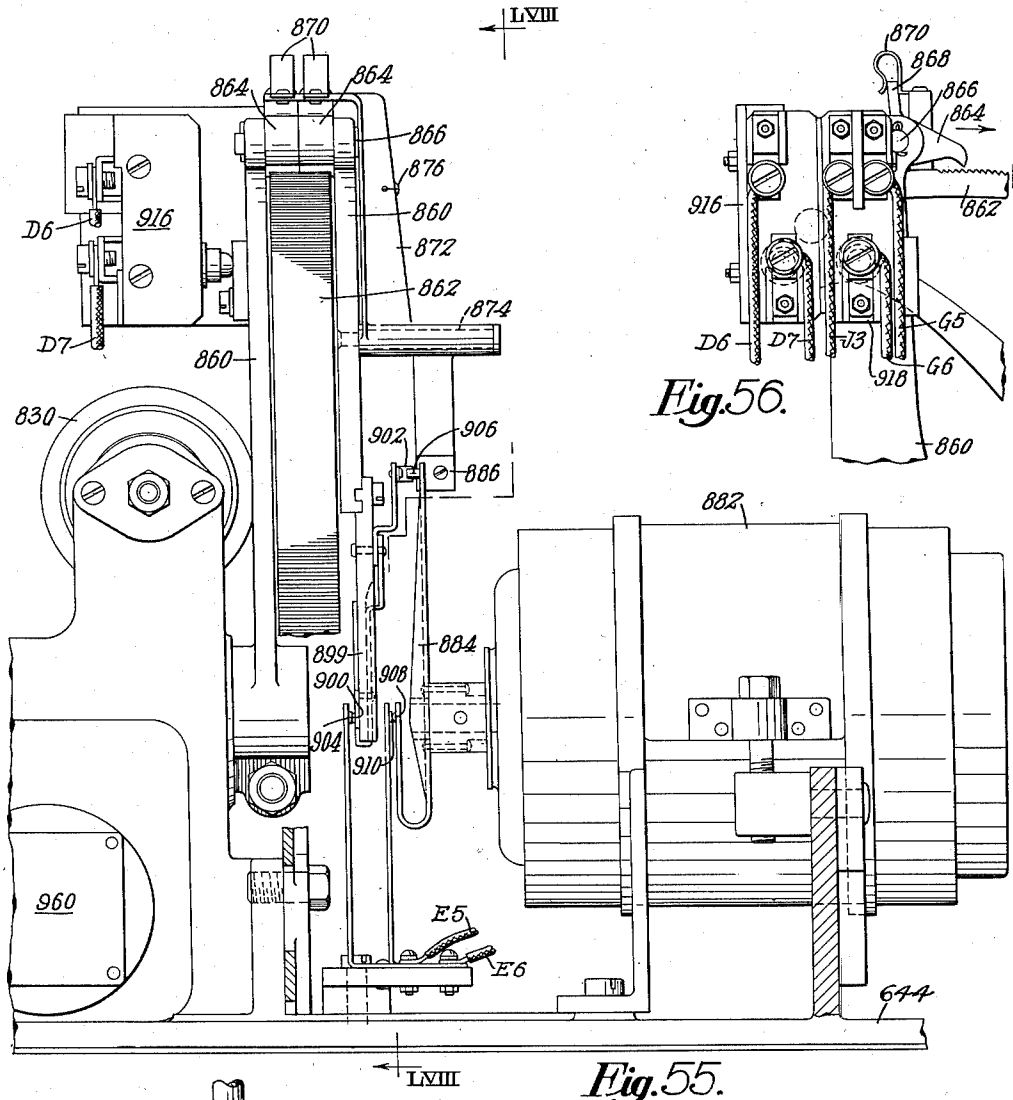


Fig. 55.

Fig. 56.

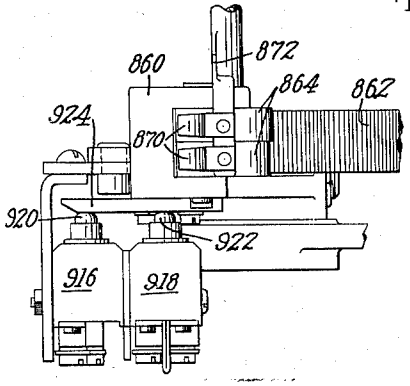


Fig. 57.

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By his Attorney

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SHELL-HANDLING MECHANISMS FOR GUNS

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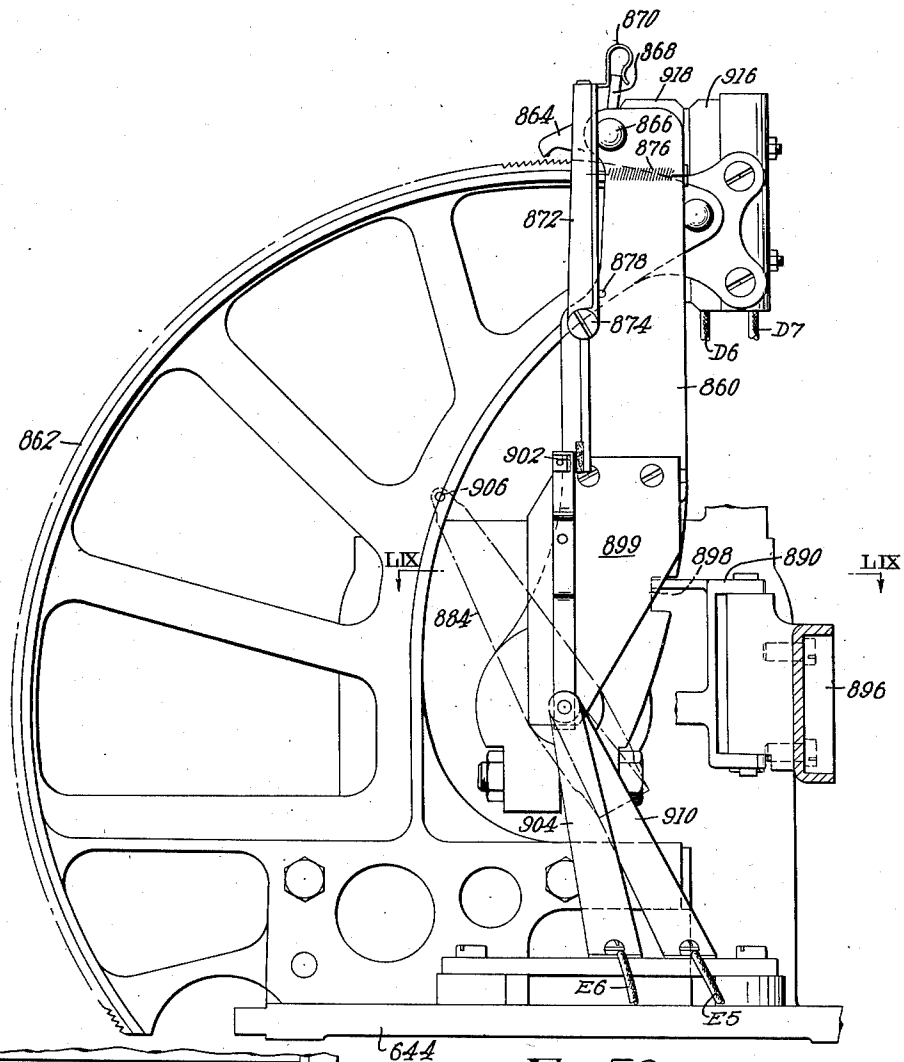


Fig. 58.

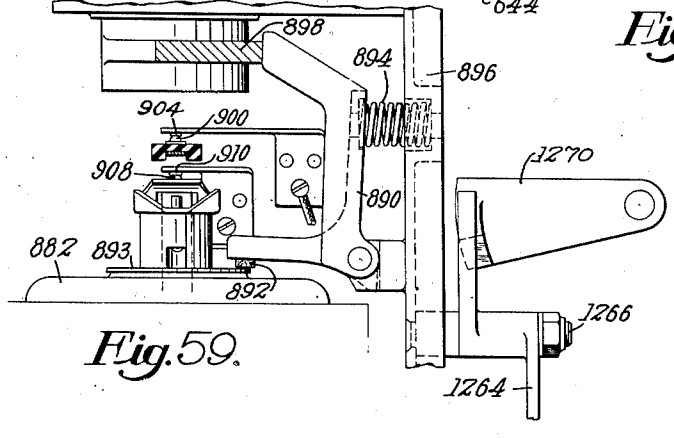


Fig. 59.

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SHELL-HANDLING MECHANISMS FOR GUNS

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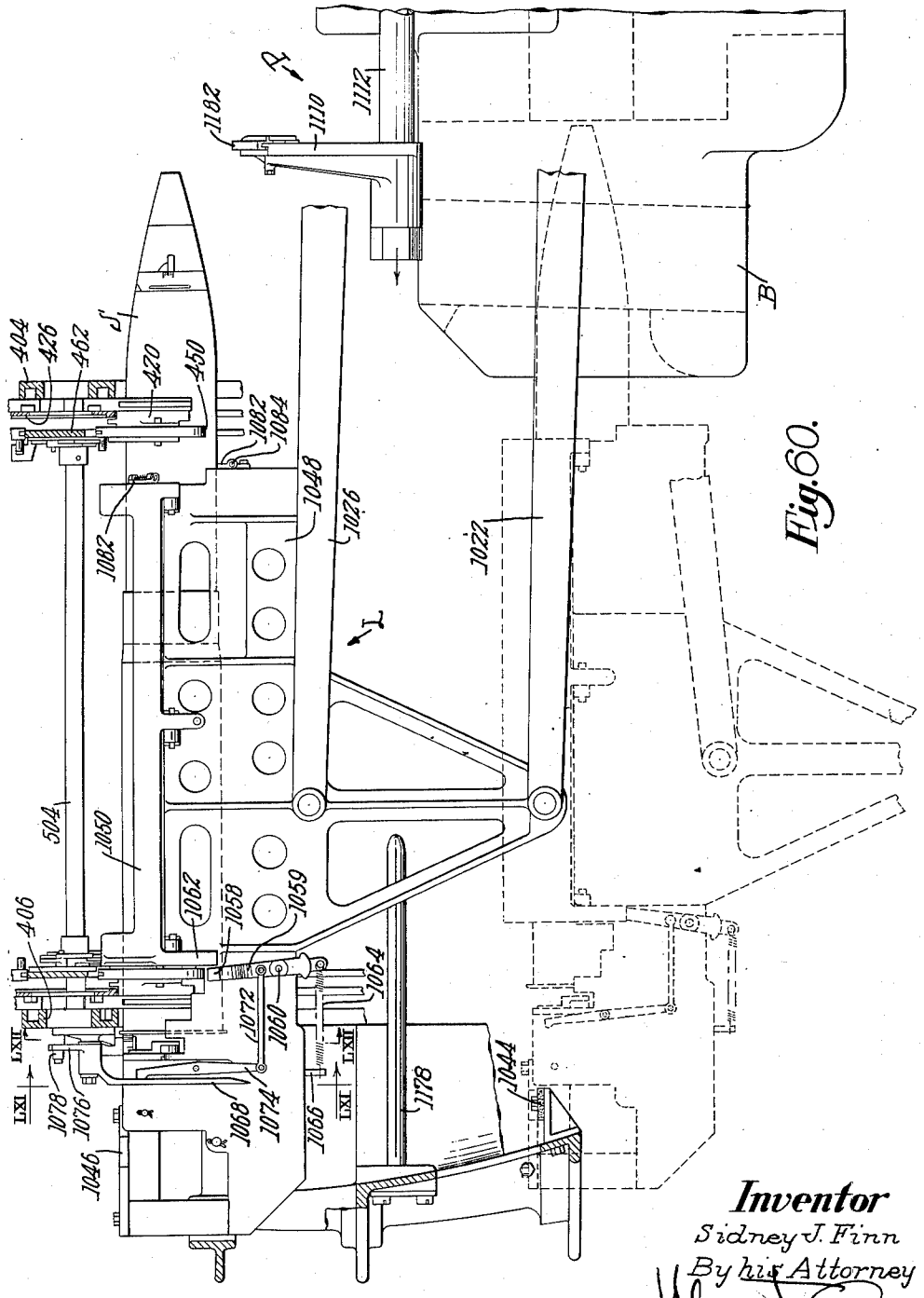


Fig. 60.

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SHELL-HANDLING MECHANISMS FOR GUNS

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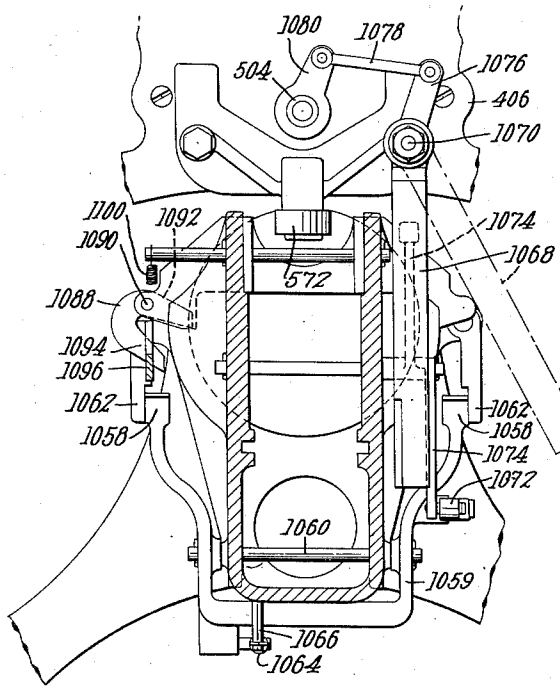


Fig. 61.

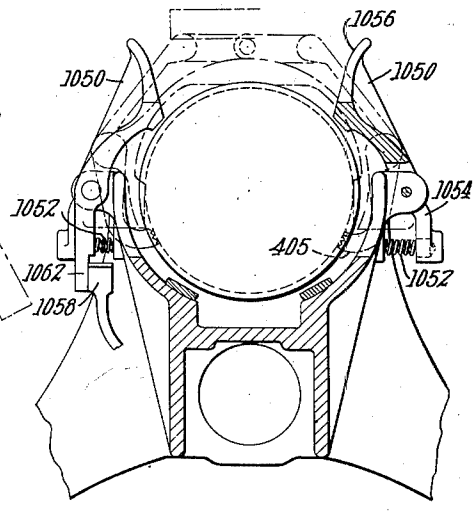


Fig. 62.

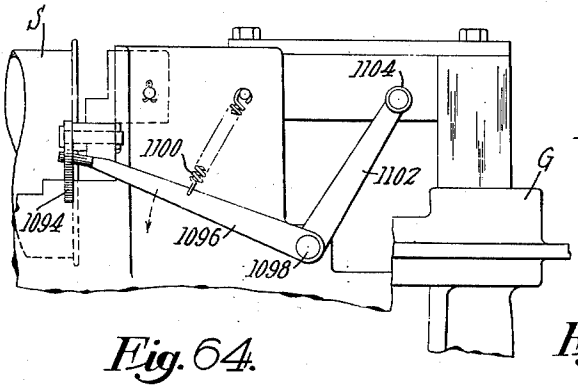


Fig. 64.

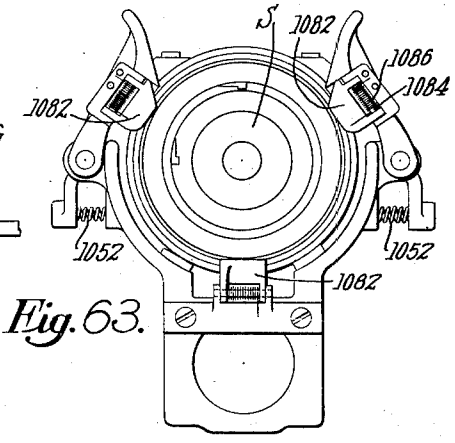


Fig. 63.

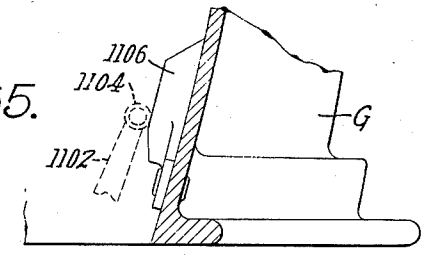


Fig. 65.

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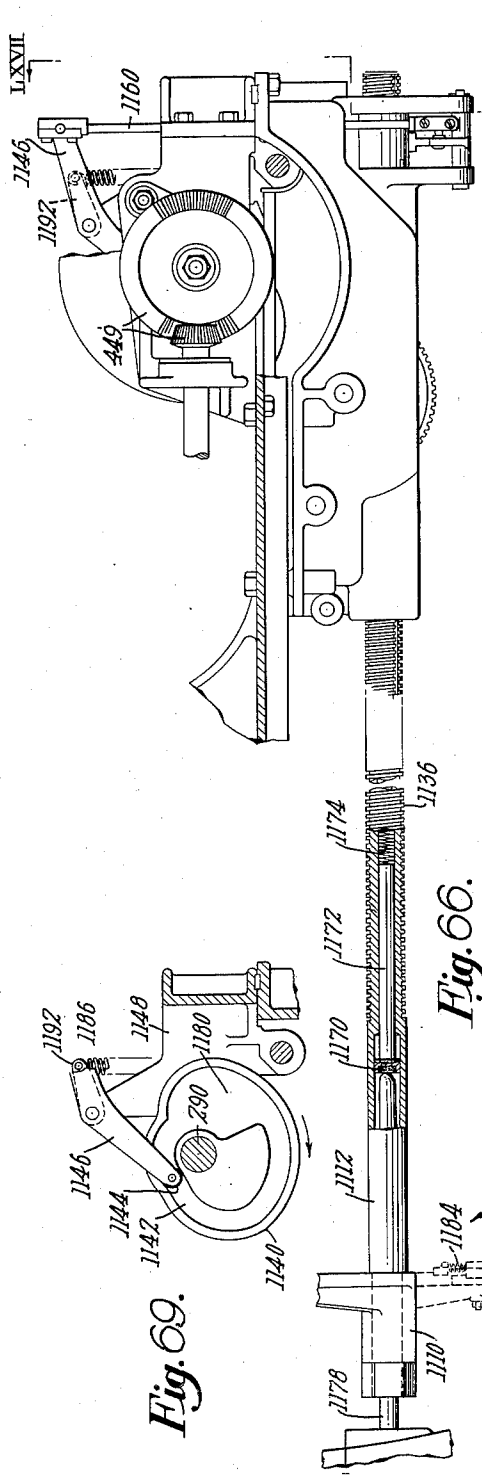


Fig. 66.

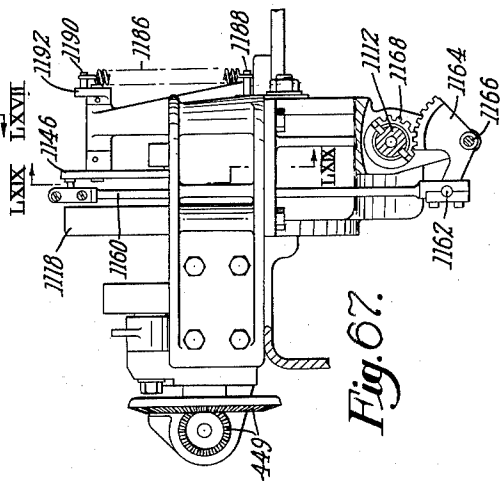


Fig. 67.

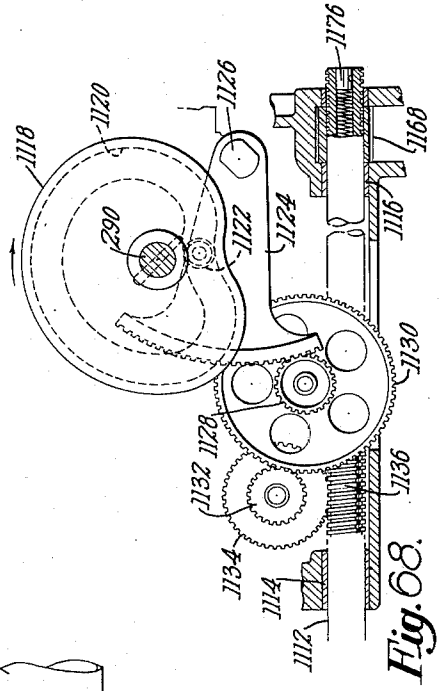


Fig. 68.

Fig. 69.

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SHELL-HANDLING MECHANISMS FOR GUNS

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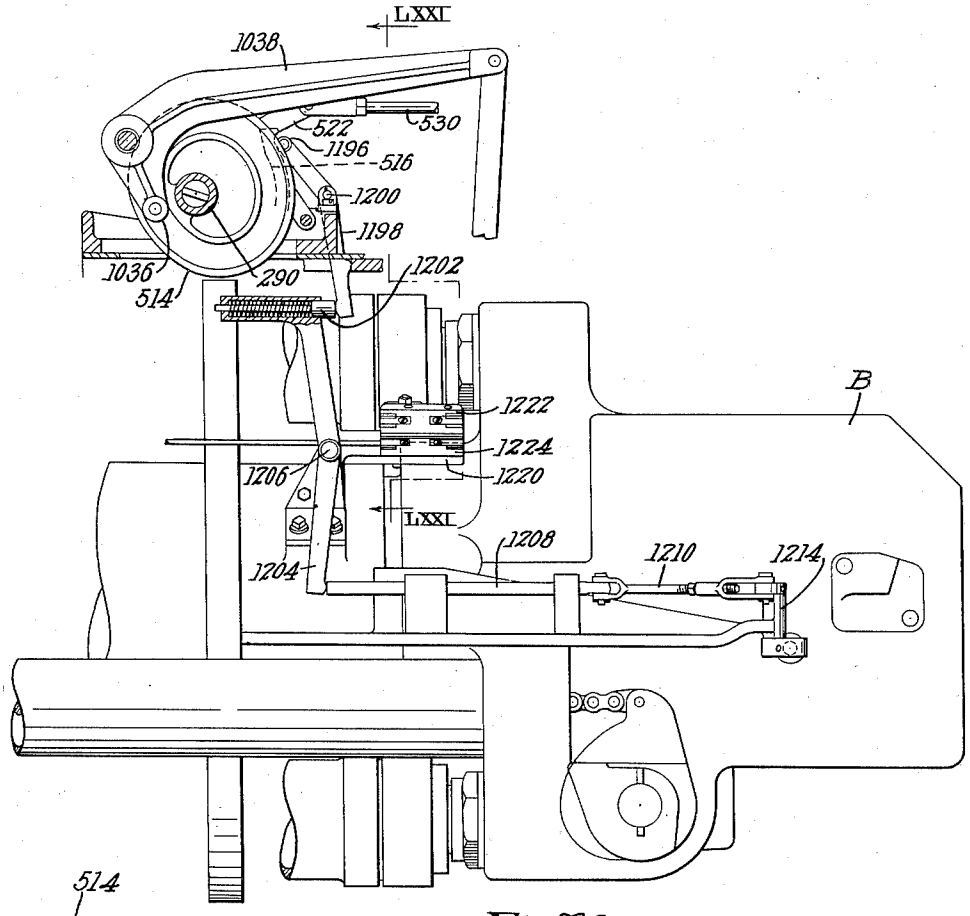


Fig. 70.

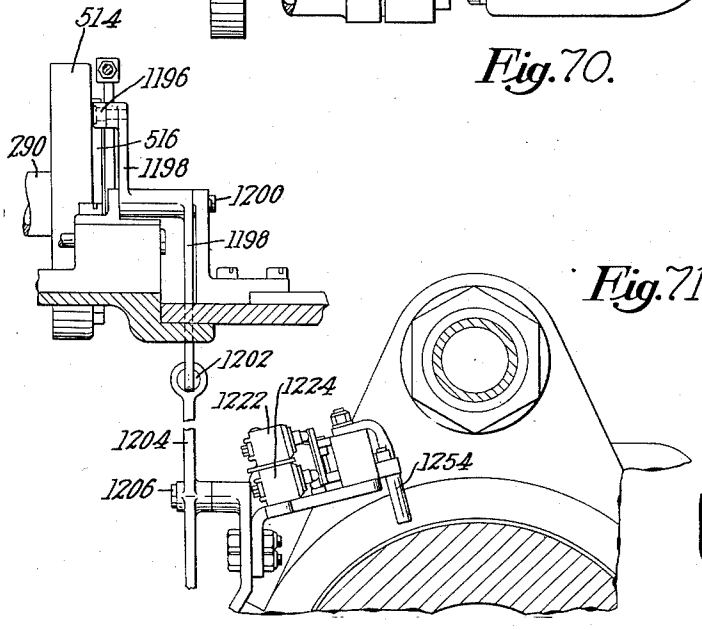


Fig. 71.

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SHELL-HANDLING MECHANISMS FOR GUNS

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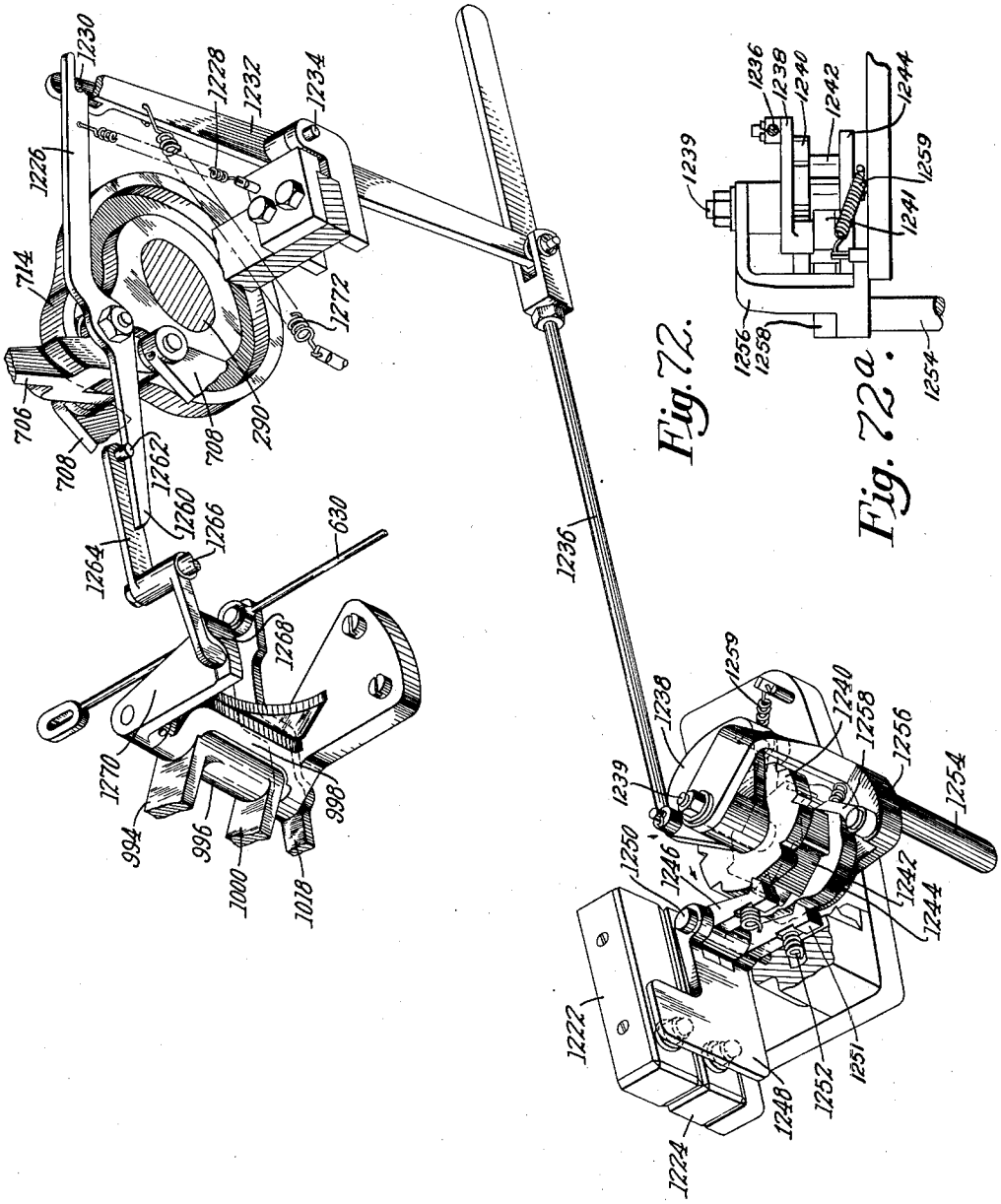


Fig. 72.

Fig. 72a.

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SHELL-HANDLING MECHANISMS FOR GUNS

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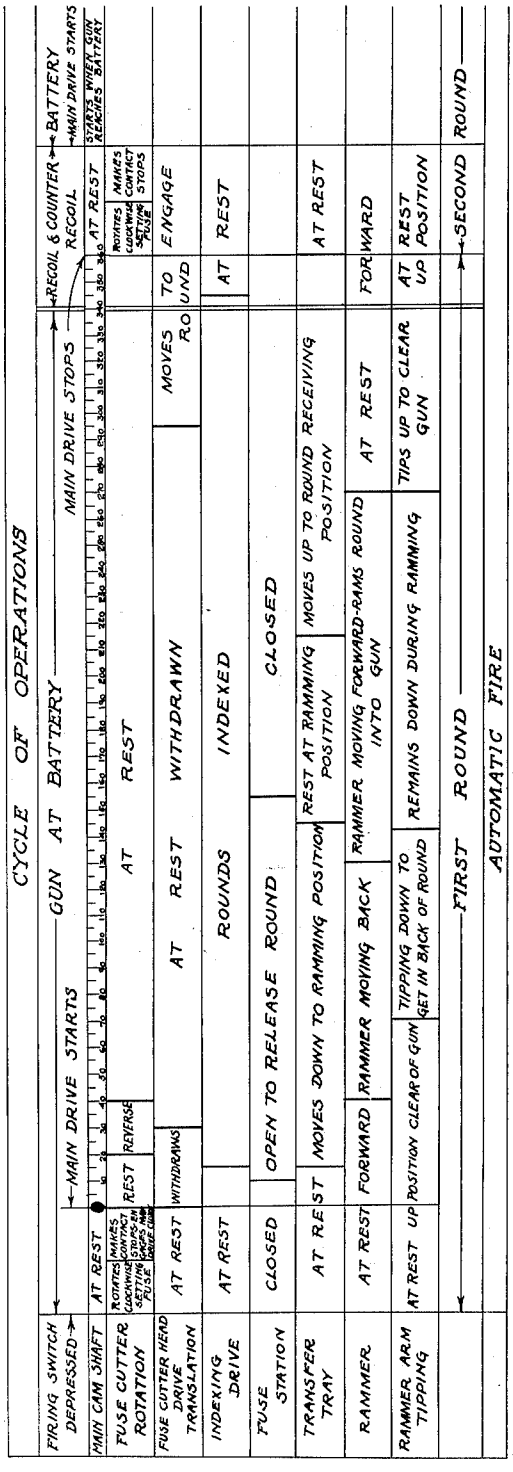


Fig. 73.

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SHELL-HANDLING MECHANISMS FOR GUNS

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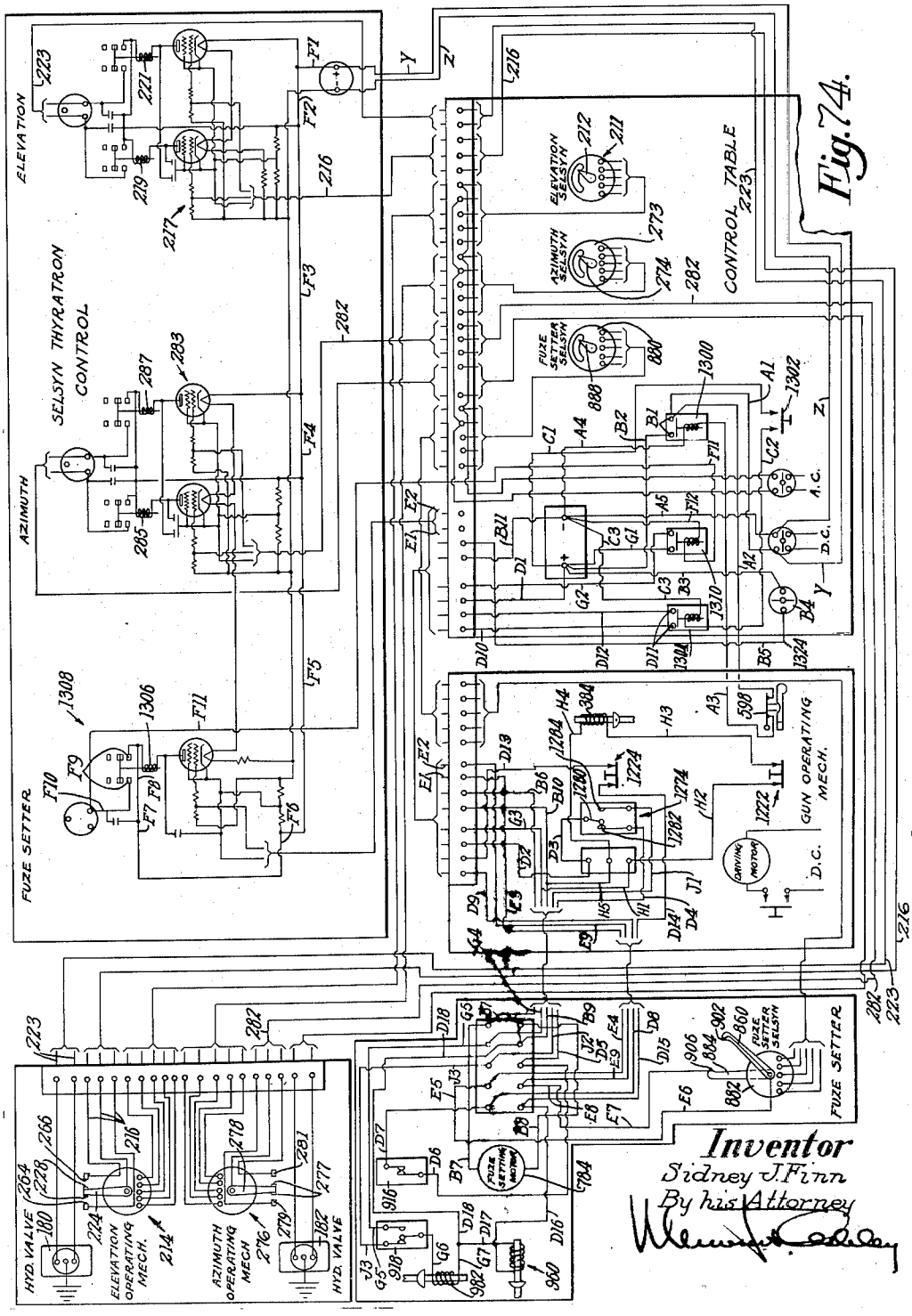


Fig. 74.

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United States Patent Office 2,988,962 Patented June 20, 1961

2,988,962

SHELL-HANDLING MECHANISMS FOR GUNS

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Filed Feb. 9, 1944, Ser. No. 521,668
24 Claims. (Cl. 89—33)

This invention relates to gun-loading mechanisms, and more particularly to mechanisms for automatically setting the fuses of shells and loading the shells in a gun. The invention is illustrated herein as embodied in a mechanism for use with a large caliber gun particularly designed for use in an airplane, although it will be understood that in various novel aspects the invention is not thus limited in its applicability.

An object of the present invention is to provide an improved mechanism for automatically loading, in rapid succession if desired, a plurality of shells in a gun of large caliber. To this end and in accordance with a feature of the invention, a magazine mounted on the gun is arranged to hold a plurality of shells which are indexed step by step into a release station from which each shell is carried by a transfer tray into alignment with the bore of the gun after which the shell is moved by a rammer into the firing chamber of the gun. Because of the fact that the gun is designed to be used in an airplane, provision is made for locking the shell in the transfer tray against accidental displacement therefrom while the shell is being transported to ramming position. As the shell reaches the ramming position the locking means is released to permit ramming of the shell into the gun. To enable the gun to be used, for example, in the limited space available in the nose of an airplane, the shell magazine should be so designed as to occupy a minimum amount of space and thus to permit desired movements of the gun relatively to the plane. For the purpose in view, and in accordance with a feature of the invention, a kidney-shaped shell magazine is provided which is preferably and as illustrated mounted above and rearwardly of the gun and concentrically therewith. The shells are carried by holders movable in the spaced, parallel, kidney-shaped tracks of the magazine and these holders are each provided with means to lock a shell therein and to permit release of it after the shell has been moved to a fuse-setting or release station at the lower central portion of the magazine.

Another feature of the invention relates to the rammer and mechanism for operating the rammer in timed relation to the movement of the transfer tray to carry a shell into ramming position. In the illustrated construction, the rammer is moved rearwardly as the tray descends and is held out of the path of movement of the tray to avoid interference therewith. During the rearward movement of the rammer it is rocked into alinement with the bore of the gun so that upon forward movement of the rammer it engages the shell on the transfer tray. The rammer is operated by a drive shaft, aided by a spring which is compressed during the rearward movement of the rammer.

Other features of novelty relate to mechanism for preventing operation of the gun when the magazine-indexing mechanism is being employed to load the magazine. These mechanisms include means to prevent release of a shell from the magazine at the fuse-setting station and means to prevent operation of the fuse-setting mechanism during loading of the magazine.

The above and other features of the invention, including various novel combinations of parts and details of construction, will now be more particularly described by reference to the accompanying drawings and thereafter pointed out in the claims.

In the drawings,

FIG. 1 is a side elevation of the breech end of a gun illustrating one form of a shell-handling mechanism in which the invention is embodied;

FIG. 2 is a plan view on a larger scale of the mechanism shown in FIG. 1;

FIG. 3 is a rear elevation of the mechanism of FIG. 1;

FIG. 4 is an elevation partly in section on the line IV—IV of FIG. 1 illustrating the mounting of the gun for movement in elevation and azimuth;

FIG. 5 is a section on the line V—V of FIG. 4 illustrating the mechanism for moving the gun in elevation;

FIG. 6 is a view partly in section on the line VI—VI of FIG. 4;

FIG. 7 is a view partly in section on the line VII—VII of FIG. 4;

FIG. 8 is a section on the line VIII—VIII of FIG. 4;

FIG. 9 is a side elevation, with certain of the parts broken away, of the mechanism shown in FIG. 8;

FIG. 10 is a vertical section on the line X—X of FIG. 8;

FIG. 11 is an elevation partly in section of the lower part of the mechanism shown in FIG. 4.

FIG. 12 is a plan view partly in section along the line XII—XII of FIG. 4;

FIG. 13 is a vertical section along the line XIII—XIII of FIG. 12;

FIG. 14 is a diagrammatic view of the fluid-pressure-operated mechanism for moving the gun in elevation and in azimuth;

FIG. 15 is a side elevation partly in section of the main motor drive;

FIG. 16 is a section along the line XVI—XVI of FIG. 15 through the one-revolution clutch;

FIG. 17 is a section along the line XVII—XVII of FIG. 16;

FIG. 18 is a section along the line XVIII—XVIII of FIG. 16;

FIG. 19 is a side elevation of one of the clutch elements;

FIG. 20 is a plan view of the loading station of the shell magazine;

FIG. 21 is a section along the line XXI—XXI of FIG. 20 illustrating the shell holders and tracks by which they are guided around the magazine;

FIG. 22 is a section along the line XXII—XXII of FIG. 20 illustrating the rear inside shell-holder-release mechanism;

FIG. 23 is a section along the line XXIII—XXIII of FIG. 20 illustrating the forward inside shell-holder-release and operating mechanism;

FIG. 24 is a section through the shell-holder-release handle;

FIG. 25 is a fragmentary view in side elevation of one of the shell holders;

FIG. 26 is a section along the line XXVI—XXVI of FIG. 25;

FIG. 27 is a partial side elevation of the rear outside track and shell holders with certain parts removed;

FIG. 28 is a section along the line XXVIII—XXVII of FIG. 27;

FIG. 29 is an inside view of the rear-track-shell-holder guide;

FIG. 30 is a section along the line XXX—XXX of FIG. 29;

FIG. 31 is a section along the line XXXI—XXXI of FIG. 2;

FIG. 32 is a section along the line XXXII—XXXII of FIG. 2;

FIG. 33 is a plan view of a portion of the mechanism shown in FIG. 32;

FIG. 34 is a section along the line XXXIV—XXXIV of FIG. 2;

FIG. 35 is a section along the line XXXV—XXXV of FIG. 34;

FIG. 36 is a section along the line XXXVI—XXXVI of FIG. 34;

FIG. 37 is a section along the line XXXVII—XXXVII of FIG. 34;

FIG. 38 is a partial plan view of a portion of the control mechanism employed during the loading of the magazine;

FIG. 39 is a section along the line XXXIX—XXXIX of FIG. 38;

FIG. 40 is a section along the line XL—XL of FIG. 34;

FIG. 41 is a side elevation of the mechanism shown in FIG. 40 as viewed from the right;

FIG. 42 is a perspective view of the fuse-cutter head and associated mechanism;

FIG. 43 is a side elevation of the fuse-cutter head and driving mechanism;

FIG. 44 is a plan view of a portion of the fuse-cutter head-driving mechanism;

FIG. 45 is a section along the line XLV—XLV of FIG. 44;

FIG. 46 is a section along the line XLVI—XLVI of FIG. 44;

FIG. 47 is a section along the line XLVII—XLVII of FIG. 44;

FIG. 48 is a section along the line XLVIII—XLVIII of FIG. 43;

FIG. 49 is a left end elevation of the mechanism shown in FIG. 48;

FIG. 50 is a section along the line L—L of FIG. 48;

FIG. 51 is a section along the line LI—LI of FIG. 48;

FIG. 52 is a section along the line LII—LII of FIG. 48;

FIG. 53 is a section along the line LIII—LIII of FIG. 47;

FIG. 54 is a section along the line LIV—LIV of FIG. 53;

FIG. 55 is a partial side elevation of the fuse-cutter-control mechanism;

FIG. 56 is an elevation of a portion of the mechanism of FIG. 55 looking from the left;

FIG. 57 is a plan view of the mechanism shown in FIG. 56;

FIG. 58 is a section along the line LVIII—LVIII of FIG. 55;

FIG. 59 is a section along the line LIX—LIX of FIG. 58;

FIG. 60 is a section along the line LX—LX of FIG. 2 illustrating the shell-transfer mechanism in shell-receiving position by full lines and in ramming position by broken lines;

FIG. 61 is a section along the line LXI—LXI of FIG. 60;

FIG. 62 is a section along the line LXII—LXII of FIG. 60;

FIG. 63 is an end elevation of the transfer tray and associated parts looking from the right in FIG. 60;

FIG. 64 is a side elevation of the rear end portion of the transfer tray showing the means for locking a shell therein;

FIG. 65 is a view partly in section of a portion of the mechanism for releasing the shell-locking means;

FIG. 66 is a side elevation partly in section of the rammer and associated mechanism;

FIG. 67 is a section on the line LXVII—LXVII of FIG. 66;

FIG. 68 is a vertical section of a portion of the rammer illustrating the operating mechanism therefor;

FIG. 69 is a section on the line LXIX—LXIX of FIG. 67;

FIG. 70 is a side elevation of the breech end of the gun showing the firing mechanism;

FIG. 71 is a section on the line LXXI—LXXI of FIG. 70;

FIG. 72 is a perspective view of the safety switches associated with the fuse-setter to render the main drive shaft and the fuse setter inoperative during the firing of the gun;

FIG. 72*a* is a side elevation of a portion of the mechanism shown in FIG. 72;

FIG. 73 is a cam chart illustrating the cycle of operation; and

FIG. 74 is a schematic diagram of the electrical system.

The invention is illustrated as embodied in a gun comprising a tube T, a breech B and a cradle C carrying the tube, the cradle also supporting suitable recoil mechanisms R. Carried by the horizontal trunnions of the gun cradle, as will be explained, is a carriage G which supports a magazine M carrying a plurality of shells S. These shells are indexed one at a time into position to be acted upon by a fuse setter F, after which they are carried by a transfer tray L (FIG. 2) into alinement with the bore of the gun. After being moved into this position, the shell with the fuse set for the desired time is loaded into the gun by a rammer P (FIG. 66), after which the gun is fired.

The gun is mounted for movement both in azimuth and in elevation. For this purpose trunnions **10** (FIG. 4) extend horizontally from opposite sides of the cradle C and are supported by bearings **12** carried in vertical arms **14** of a yoke **16**. The arms **14** of the yoke are connected at their upper and lower ends by crossheads **18** carrying vertical trunnions **20**. The lower trunnion **20** is supported by a thrust bearing **22** carried by a cylindrical housing **24** extending upwardly from and secured to the top of a support **26**. The trunnion **20** carried by the upper crosshead is suitably supported by bearings (not shown) carried by a supporting bar **28**. By the above construction the gun is movable in elevation in the yoke **16** which is in turn movable about a vertical axis through the trunnions **20** to permit movement of the gun in azimuth.

For moving the gun in azimuth a fluid-pressure motor **30** (FIGS. 4, 11, 12 and 14) is provided. This motor includes a cylinder secured to the under side of an arm **32** carried by the housing **24** and extending laterally therefrom a considerable distance to support mechanism to be described. A piston **34**, movable within the cylinder **30** has its rod **36** extending outwardly of the cylinder and carrying at its outer end a rack **38**. This rack is supported by a roll **40** carried by a bracket **42** extending downwardly from the arm **32** and the rack engages a pinion **44** carried by a shaft **46** extending between walls **48** depending from the arm **32**. The shaft **46** carries a second pinion **50** (FIGS. 4 and 12) which meshes with teeth **52** in a shaft **54** carried between the walls **48** near the outer end of the arm **32**. The shaft **54** is provided at its rearward end with worm teeth **56** engageable with an internally threaded sleeve **58** connected by a pin **60** to an arm **62** extending laterally from and secured to the lower portion of the yoke **16** by screws **64** passing through the lower crosshead **18**. As the piston of the fluid-pressure motor **30** is moved in one direction or the other, rotative movement is imparted to the shaft **54** by the gearing heretofore described to cause the sleeve **58** to be moved axially of the shaft. Accordingly, the arm **62** connected to the yoke swings the yoke about its vertical pivots, thereby moving the gun in azimuth through a limited angle. The mechanism for controlling the operation of the piston **34** of the cylinder **30** will be explained as the description proceeds.

The gun is moved in elevation within the yoke **16** by a second fluid-pressure motor **70** (FIGS. 4, 12 and 14). This motor is of the rotary vane type and includes a vane **72** (FIGS. 4 and 14) carried by a shaft **74** (FIG. 11) for movement about a horizontal axis. The motor is sup-

ported for movement with the gun in azimuth by a vertical wall of a gear housing **76** (FIG. 12) connected to a forward portion of the lower crosshead **18** and by a bracket **78** secured to the rearward portion of the crosshead **18**. The shaft **74**, carrying the vane of the motor, extends into the gear housing **76** and carries a pinion **79** engageable with a pinion **80** on a shaft **82**. A second pinion **84**, carried by the shaft **82**, engages a pinion **86**, carried by a sleeve **88** (FIG. 5), journaled within the housing **76**. This sleeve is provided with internal threads to receive a worm **90** which extends between the gun cradle C and the lower crosshead **18**. The rearward end of the worm carries a transversely extending pin **92** on which is mounted a pair of blocks **94** received between spaced depending ears **96** carried by the cradle C. Upon rotation of the sleeve **88** by the mechanism heretofore described, axial movement is imparted to the worm **90** through the blocks **94**, thus causing the gun to swing on its horizontal trunnions **10** through a limited angle.

The carriage G, on which the magazine, the fuse-setting mechanism, etc. are mounted, is arranged to be moved with the gun both in azimuth and elevation, thereby to maintain a fixed relationship between these mechanisms and the gun. This carriage includes side walls **100** (FIGS. 1 and 4) the forward ends of which are carried by bushings **102** journaled on reduced extensions **104** of the trunnions **10**. The bushings are held on the extensions **104** by plates **106** secured to the extensions by screws **108**. By so connecting the carriage to the gun, the carriage will move with the gun in azimuth. To move the carriage in elevation with the gun the following mechanism is provided. Connecting the side walls **100** of the carriage and pivoted thereto is a crossarm **110** (FIGS. 3 and 5) to which is secured a depending worm **112**. This worm engages threads formed on the interior of a sleeve **114** supported by bearings **116** carried by a holder **118**. This holder **118** is in turn pivoted between spaced upwardly extending arms **120** of a support **122** arranged for movement along an arc the center of which coincides with the vertical axis of the yoke **16** so that the worm **112** and sleeve **114** may be moved with the gun in azimuth, thereby to maintain a correct relationship between these members and the gun. The forward and rearward edges of the support **122** are curved as indicated in FIG. 12 and are guided for movement along a curved path by rolls **124** carried by a base **126**. The support **122** rests upon a series of pairs of roller bearings **128** carried by a plate **130** which is in turn movable on a hardened steel plate **132** resting in the base **126**. The support **122** is connected to the bracket **78** by a downwardly and rearwardly extending arm **134**, the upper end of which is connected by screws **136** to the bracket **78** and the lower end of which is received by a slot **140** in the support **122**. Accordingly, as the gun is turned in azimuth the arm **134** movable therewith will cause the support **122** to move along an arc on the bearings **128** carried by the plate **130**.

As the support **122** is swung with the gun, it will cause the plate **130** to move with it but at half the rate of speed, and provision is made for insuring that the plate **130** moves at the proper speed and does not accidentally creep out from under the support **122**. Accordingly, one end of the support **122** has connected thereto a lever **142** which is connected intermediate its ends by a pin-and-slot connection **144** to the plate **130** and is pivotally connected at **146** to the base **126**. Thus, as the support **122** is moved during movement of the gun in azimuth, the plate **130** will be moved by the lever **142** at half the speed of the support and the proper relationship between these members will be maintained.

The lower end of the sleeve **114** (FIG. 5) carries a sprocket **150** connected by a chain **152** to a sprocket **154** on a shaft **156** journaled in a downwardly and rearwardly projecting extension **158** of the bracket **78** and by a bearing **159** formed in the upper end of the arm **134**. To the upper end of the shaft **156** is pinned a bevel gear **160** meshing with a bevel gear **162** on a forwardly and rearwardly extending shaft **164** carried between the gear housing **76** and the bracket **78** (FIG. 12). The forward end of the shaft carries a pinion **166** (FIG. 11) engageable with the pinion **84** driven by the fluid-pressure motor **70**. Accordingly, as this motor operates to change the elevation of the gun it will also cause rotation of the sleeve **114** by the gearing just described, which in turn causes axial movement of the worm **112** to adjust the elevation of the carriage concomitantly with the gun, the gear ratios between the carriage and the motor being such that the carriage maintains a fixed position relatively to the gun.

The fluid-pressure system for operating the motors **30** and **70** is illustrated diagrammatically in FIG. 14. Pressure fluid flows from a pump (not shown) through a pipe **170** into the pipes **172** and **174** which are connected respectively to inlets **176** and **178** of valves **180** and **182**. These valves are four-way solenoid-operated valves having a neutral position. In one extreme position of the valve **180**, fluid under pressure flows from the inlet **176** through pipe **182**, a restriction **184**, and an opening **186** of the motor **70** into the space at one side of the vane **72** to operate the motor. Fluid at the other side of the vane **72** exhausts through opening **188**, restriction **190**, pipe **192** which leads to the valve **180** and exhausts from the valve through the discharge opening **194**, pipes **196** and **198**. With the valve in the other extreme position, the fluid flows from the valve **180** through pipe **192** to the motor **70** by way of the opening **188** and fluid exhausts from the motor through pipe **182** and valve **180** from which it flows through discharge opening **194** through the pipes **196** and **198**. In the neutral position of the valve the flow of fluid through each of pipes **182** and **192** is cut off. This valve is of conventional construction and accordingly has not been shown in detail but it will be understood that it is controlled by a pair of solenoids, selective energization of which causes the fluid to flow through openings **186** or **188** to the motor to drive the vane **72** in a corresponding direction. The restrictions **184** and **190** are provided to prevent too rapid movement of the gun by limiting the exhaust of fluid from the motor **70**. These restrictions are similar in construction and each comprises a valve element **200** having a restricted passageway **202** through the center thereof through which the fluid must flow when discharging from the motor. The valve elements are held in the positions shown by springs **204** which permit the valve elements to be moved off their seats when the fluid is flowing to the motor. When the valve elements are thus moved, the fluid may flow not only through the restricted passageway **202** but also through passageways **206** provided by recesses formed in the peripheries of the valve elements. The operation of the motor **30** is similarly controlled by the valve **182** and restrictions **205** and **207**.

The valve **180** controlling the operation of the motor **70** is connected by brackets **208** (FIGS. 11 and 12) to a plate **210** extending between the gear housing **76** and the bracket **78**. Selective energization of the solenoids controlling the operation of the valve **180** is effected by a self-synchronous transmitter system embodying a transmitter **211** (FIGS. 1 and 74) operated by a control handle **212** (FIG. 1), and a repeater **214** (FIGS. 4, 6 and 74). The operation of such a system is well known, the transmitter and repeater each including an armature and so connected electrically that upon movement of the armature of the transmitter to any desired position the armature of the repeater is moved to a corresponding position. The repeater **214** is utilized herein to control the flow of current through wires **216** to an electronic control device **217** operating relays **219** and **221** which in turn control the selective energization of the solenoids of the valve **180** through one of two wires **223**.

The repeater **214** is mounted on a bracket **220** (FIGS. 4 and 6) secured to the upper end of one of the arms **14** of the yoke **16**. For controlling the flow of current through the wires **216**, the armature shaft **222** of the

repeater carries a spring contact arm **224** provided with a contact **226** (FIG. 6) coaxial with the shaft 222 and a pair of contacts **228** at its lower portion. Also mounted at the upper end of the yoke **16** is a switch box **230** in which is journaled a sleeve **232**, (FIG. 8) carrying at its outer end a gear **234**. Carried within the sleeve **232** is a block **236** of electrical insulating material to the outer end of which is secured a rectangular contact-carrying plate **238** of electrical insulating material. The inner end of the block **236** is reduced in diameter and carries three metal rings **240**, **242** and **244** separated from each other by strips of insulating material. Contact-carrying strips **246** and **248** (FIG. 7) are secured to the plate **238** and are connected electrically to the rings **240** and **242** by rods **250** and **252** respectively. The ring **244** is connected to the contact **226** of the spring contact arm **224** of the repeater by a rod **254**.

The wires **216** leading to the repeater are connected to three contacts **258**, **260** and **262** (FIG. 9) carried by a plate **263** mounted within the housing **230** adjacent to the rings **240**, **242** and **244**. These contacts are maintained in engagement with the three rings respectively at all times. The contacts **228** on the contact arm of the repeater are located between contacts **264** and **266** (FIG. 7) at the lower end of the arms **246** and **248**. Upon movement of the controller **212** (FIG. 1) to change the elevation of the gun the armature of the repeater **214** will move in a direction corresponding to the direction of movement of the controller to cause the arm **224** to move into engagement with one of the contacts **264** or **266** whereupon one of the solenoids of the valve **180** is energized through one of the relays **219**, **221** of the electronic control device **217**. Accordingly, fluid under pressure flows to the motor **70** to drive it in one direction or the other in accordance with the direction of movement of the controller **212**. This operation of the motor **70** continues until the elevation of the gun corresponds to that of the setting of the control **212**.

For thus determining the amount of movement of the gun in elevation a gear segment **270** (FIGS. 4 and 7), secured to the upper portion of the cradle C of the gun, engages the gear **234** carrying the contacts-supporting plate **238**. Accordingly, this plate is turned during movement of the gun in elevation to move the contacts **264** and **266** about the axis of the repeater. This movement will continue until the armature of the repeater has moved to a position corresponding to the position of the armature of the transmitter as determined by the setting of the controller **212** after which the movement of the armature of the repeater, together with the arm **224**, stops. Immediately after this happens, the contact **264** or **266**, depending upon which way the gun is moving, will move out of engagement with the adjacent contact **228** of the arm **224**, thus opening the circuit to the solenoid of the valve **180** through the relay **217** or **219**, whereupon the flow of fluid to the motor **70** stops. It will thus be seen that the valve **180** controlling the flow of fluid to the motor **70** is readily controlled by the electrical system described, whereby the elevation of the gun will correspond to the setting of the control arm **212** (FIG. 1).

A similar self-synchronous transmitter system is provided for controlling the fluid-pressure motor **30** by which the gun is moved in azimuth. A transmitter **273** (FIGS. 1 and 74) is provided having a control handle **274**, and a repeater **276** (FIGS. 4 and 74) is mounted on the extreme outer end of the arm **32**. A contact arm **278**, carrying a pair of contacts **277**, carried by the armature of the repeater **276** cooperates with a pair of spaced contacts **279**, **281** carried by a plate **280**, the various contacts being connected to wires **282** in a manner similar to the contacts of the elevation repeater, these contacts being in turn connected to an electronic control device **283** including relays **285**, **287** which in turn control the energization of the solenoids of valve **182**. A follow-up mechanism for the contacts on the plate **280** is provided by a gear segment **284** (FIG. 12) on the outer end of the arm **62**, the segment being engageable with a gear **286** by which the contact-supporting plate **280** is carried. Accordingly, after the gun has been moved in azimuth to a position corresponding to the setting of the controller **274** the circuit, to the solenoids in the valve **182** is interrupted and the flow of pressure fluid to the moor **30** is cut off, whereupon the gun comes to rest in its desired position.

Main drive

The various mechanisms for handling the shells and firing the gun, with the exception of the fuse setter, are all operated from a cam shaft **290** (FIGS. 1, 2 and 38) journaled in bearings **292** secured to the side walls **100** of the carriage G. The cam shaft is driven by a motor **294** (FIGS. 2 and 15) through a one-revolution clutch **296**. The motor **294** is mounted on a bracket **298** secured to one of the side walls **100** of the carriage and is connected through gears **300**, **302** to a shaft **304** carrying a worm **306**.

The shaft **304** is journaled in bearings **308** in the lower part of a housing **310** of the clutch **296**. This worm engages a worm gear **312** journaled on a shaft **314** rotatably supported by bearings **316** and **318** (FIG. 16) within the clutch housing. The worm gear **312** includes a flange **320** (FIG. 16) within which is keyed a hardened steel ring **321**. Keyed to the shaft **314** is a driven member **322** to which is secured by bolts **324** a sprocket **326**, a wedge-supporting member **328** and a plate **330**. Confined between the driven member **322** and the wedge-supporting member **328** is a cage **332** rotatable with respect thereto and including ears **334** which project between the wedge-carrying member **328** and the hardened steel ring **321** carried by the worm gear **312**, as shown in FIG. 17.

The member **328** is recessed, as shown in FIG. 17, to receive wedges **338** confined between the member **328** and the plate **330**. These wedges are provided with surfaces **340** engageable with rolls **342** confined between the ears **334** of the cage **332**, these rolls constituting driving members between the wedges **338** and the worm gear **312**. When the cage **332** is turned in a counterclockwise direction, as viewed in FIG. 17, relatively to the driven member **322**, the surfaces **340** of the wedges force the rolls into engagement with the ring **321** carried by the worm gear so that the wedge-carrying member **328** is moved with the worm gear, causing rotation of the driven member **322** to which it is connected. In order to compensate for slight inaccuracies in machining, the wedges **338**, so that they will all be effective in driving the member **332**, bear against a bushing **339** loosely mounted for slight radial movement on the shaft. This provides a self-equalizing construction for insuring that each roll absorbs its proportionate share of the load, as illustrated and described in greater detail in Letters Patent of the United States 2,158,192, granted May 16, 1939, on an application of V. H. Meyer. In order that the wedges will not move too freely within the member, springs **344** within the wedges act on friction disks **346** to force them into engagement with the member **328** and the plate **330**.

Relative movement between the cage **332** and the driven member **322** is effected by mechanism shown in FIGS. 18 and 19. Pivoted to the cage **332** is an arm **348** received within a recess **350** of the member **322**. The arm **348** includes a generally spherical depending portion **352** received within a recess **354** of a hardened steel insert **356** carried by the member **322**. When the arm **348** is in the position shown in FIG. 18, the cage is positioned relatively to the member **322** so that the rolls **342** are not held against the ring **321** of the worm gear **312**. Upon movement of the arm in a counterclockwise direction from the position shown in FIG. 18, the cage is moved in a direction to wedge the rolls **342** between the ring **321**

of the worm gear and the wedges **338** to rotate the driven member **322**. The arm **348** is urged in a counterclockwise direction by a spring-pressed plunger **360** carried by the member **322**. For holding the arm **348** in the position shown in FIG. 18 a trip arm **362** carried by a shaft **364** journaled in bearings **366** extending upwardly from the clutch housing **310** is provided. With the arm **362** in the position shown in FIGS. 16 and 18, it holds the arm **348** in the position shown; but upon counterclockwise movement of the arm **362**, as viewed in FIG. 16, the arm **348** is moved outwardly by the spring-pressed plunger **360**, thereby to cause rotation of the driven member **322**. The arm **362** is returned to the position shown after the driven member has started rotating, and after one complete revolution the arm **348** engages the arm **362** and is forced back to the position shown in FIG. 18, whereupon the driven member comes to rest. To insure against further rotation of the driven member because of its momentum, a stop **368** carried by the driven member engages the right end of the arm **362**. The arm carries a spring-pressed plunger **370** which moves outwardly of the arm when the arm is moved out of engagement with the stop **368** and provides means for reducing the shock between the stop **368** and the arm **362** when the driven member comes to rest. Outward movement of the spring-pressed plunger with respect to the arm is limited by a screw **372**, the head of which is received by a recess in the plunger and is engageable with the shoulder at the bottom of the recess. To prevent any back-lash of the driven member as it comes to rest, a latch **374** is provided. This latch is pivoted on a pin **376** within the clutch housing **310** and includes a depending arm **378** normally held against a stop pin **380** by a spring-pressed plunger **382** acting on the upper surface of the latch. This latch cooperates with the rearward surface of the stop **368** to hold it against rearward movement as the driven member comes to rest.

During the normal operation of the gun the arm **362** is operated to initiate operation of the driven member **322** by a solenoid **384** secured by a bracket **386** to a vertical wall of the clutch housing. The armature of the solenoid is connected by a link **388** to upwardly extending ears **390** of the arm **362**. The arm is normally held in position to stop the rotation of the driven member after one complete revolution, by a spring **392** secured at one end to the arm **362** and at its other end to the top of the housing **310**.

Among other things, this clutch controls the operation of the tray by which the shells are transferred from the fuse-setting position to the ramming position. In order that the tray will not descend too fast because of the weight of the shell thereon, provision is made to prevent over-running of the clutch. For this purpose, rolls **394** (FIG. 17) are provided between the ring **321** of the worm gear **312** and surfaces **396** of the wedge-supporting member **328**. Spring-pressed plungers **398** carried by the member **328** act on the rolls **394** to wedge the rolls between the trailing edges of the surfaces **396** which are more closely disposed with respect to the ring **321** than are the forward portions of these surfaces. Consequently, if the driven member **322** should attempt to move faster than the worm gear **312** by reason of the weight on the transfer tray, the wedge-supporting plate **328** will become locked by the rolls **394** to the worm gear **312**, thereby to prevent this member from turning any faster than the worm gear.

From the foregoing, it will be seen that upon energization of the solenoid **384** the arm **362** moves out of engagement with the arm **348** carried by the cage **332** and out of the way of the stop **368**, whereby the driven member **322** is turned with the worm gear **312** through one complete revolution, after which the driven member is disconnected from the driving gear **312**, assuming the arm **362** is returned by the spring **392** to the position shown; whereupon the driven member immediately comes to rest by engagement of the stop **368** with the arm **362** and back-lash is prevented by the latch **374**. The driven member **322** is connected to the cam shaft **290** by a sprocket chain **400** (FIG. 15) connecting the sprocket **326** on the driven member **322** adn a sprocket **402** carried by the cam shaft.

Shell magazine

The magazine M in which the shells are carried and in which they are indexed one at a time into fuse-setting position is supported by the carriage G. In order to conserve space when the gun is used in the nose of an airplane, while permitting movement of the gun in elevation, the magazine is kidney-shaped, and is mounted above and rearwardly of the gun and concentrically with respect to the barrel, as indicated in FIG. 3. The magazine includes arcuate forward and rearward plates **404** and **406** (FIGS. 2 and 3). The plate **404** is carried by walls **408** extending upwardly from the side walls **100** of the carriage and the plate **406** is carried by a vertical wall **410** connecting the side walls **100** at their rearward ends. Tubes **412** extend between the inner surfaces of the plates **404** and **406**, to form a unitary structure, the tubes and plates being secured to the carriage by bolts **414** (FIGS. 20 and 33) passing through the tubes and secured by nuts **416**. The inner surfaces of the arcuate plates **404** and **406** are provided with grooves **418** (FIGS. 22, 23, 28 and 32) which extend around but inwardly of the periphery of the plates, thereby to provide endless kidney-shaped tracks for a plurality of shell holders **420**. The shell holders **420** include spaced arms which are arranged partially to surround a shell and rolls **422** and **424** (FIGS. 25 and 26) arranged to be received by the tracks. As shown in FIG. 3, each shell holder **420** is in engagement with the two adjacent ones so that upon imparting movement to one of the holders along the track all the holders are moved about the track by their engagement with one another. For maintaining the holders within their respective tracks, plates **426** (FIG. 28) carried by the tubes **412** are associated with the forward and rearward tracks and engage the inner surfaces of flanges **428** depending from the holders **420**.

For moving the holders around the tracks to index the shells, sprockets **430** are associated with each end of the plates **404** and **406** and are mounted on shafts **432** extending between the plates at the ends thereof. These sprockets, as shown in FIG. 3, are engageable with generally cylindrical portions **433** (FIG. 28) of the shell holders and are received between the corresponding surfaces of a pair of the holders as they traverse the sharply curved ends of the tracks. It will be noted in FIG. 26 that the track-receiving roll **422** of each shell holder is shorter than the other roll **424**. This is to cause the shell holders to be guided around the ends of the tracks in such manner that they will remain in proper engagement with the next adjacent shell holders, as will be described. As shown in FIG. 29, the lower portion of the track **418** has a straight portion **434** extending nearly to the end thereof and being of a depth to accommodate the long roll **422** of the shell holder. Adjacent to the straight portion **434** is a curved portion **436** of lesser depth to accommodate only the shorter roll **424**. As the shell holder moves in the direction of the arrow (FIG. 29) due to the sprocket turning in a counterclockwise direction, the leading roll **424** which is the shorter roll of the shell holder moves in a curved path about the axis of rotation of the sprocket. However, the longer trailing roll **422** is confined to a straight path after it has traversed the end of the track to the portion **434**. With the track continued in a curve corresponding to the curve at the top of the track, of sufficient depth to accommodate both rolls, the trailing portion of the shell holder would move out of engagement with the leading edge of the next shell holder because of the longer distance to be traversed due to the curvature of the track at this location. Thus, by

forming the track in the manner shown with portions of different depths and providing guide rolls of corresponding lengths, the sharply curved portion is properly traversed while maintaining the desired relationship between the shell holders.

The shafts **432** carrying the drive sprockets **430** are provided at their rearmost ends with sprockets **440** (FIGS. 3 and 30) connected by a chain **442** guided over idler sprockets **444** carried by the vertical frame member **410**. The shaft **432** at the right end of the magazine, looking from the rear, extends forwardly and is connected through gearing **446** (FIGS. 1 and 2) to a variable speed transmission **448** which is in turn connected by bevel gearing **449** to the cam shaft **290**. The variable speed transmission **448** is arranged to move the shaft **432** at varying velocity during each cycle of operation, the velocity at the beginning and end of each cycle being zero and the acceleration substantially zero. This makes possible smooth operation of the magazine drive at high speeds and reduces and eliminates strains on the equipment due to sudden acceleration. One form of mechanism which may be used for this purpose is illustrated in Letters Patent of the United States 2,309,595, granted January 26, 1943, on an application filed in the name of L. E. James. The gear ratios between the transmission **448**, the cam shaft **290** and the shaft **432** are such that the shaft **432** is rotated 90° upon one complete rotation of the cam shaft, this being sufficient to index one round into fuse-setting position.

The shells are normally held within the shell holders **420** by a pair of grippers **450** (FIGS. 22 and 23) associated with each of the shell holders **420**. These grippers are formed at the upper ends of arms **452** pivoted between ears **454** extending outwardly from the arms of the shell holders. The lower ends of the arms **452** are connected by toggle links **456** which are in turn connected by pins **458**. When these links are mutually in alinement, the grippers **450** engage the shell, thereby effectively holding it within the shell holders. The forward shell holders, as shown in FIGS. 23 and 32, are provided with toothed supporting members **460** engageable with that portion of the shell nearest the track. These members cooperate with the grippers **450** effectively to hold the forward portion of the shell which is of reduced diameter to prevent rotation of the shell during the fuse-setting operation.

For holding the toggle links **456** in straightened positions during the indexing of the shells, the links rest on curved plates **462** (FIGS. 20 and 21) mounted on the tubes **412** inwardly of the plates **426**. The curvature of the plates **462** is such that they hold the toggles straight with the grippers in engagement with the shells in all positions of the shells with the exception of the loading station and the fuse-setting or release station, as will be described.

The loading station is indicated in FIGS. 3 and 20 to 24. At this station the plates **462** are provided with recesses **464** which permit the toggle links to be broken so that a shell may be inserted within the holders **420**. At this station the pins **458** connecting the toggle links enter grooves **465** in levers **466** pivoted at **468** to the plates **462** associated with the forward and rearward holders. The levers are connected by links **470** to arms **472** connected to a shaft **474** extending forwardly and rearwardly between the forward and rearward tracks of the magazine. The shaft **474** extends rearwardly beyond the plate **406** and has connected thereto an arm **476** (FIGS. 3 and 24), urged by a spring **478** in a clockwise direction, as viewed in FIG. 3 to turn the shaft **474** to move the grooved portions of the levers **466** upwardly to straighten the toggle links **456**. The arm **476** is held in this position by a spring-pressed detent **480** having a reduced end portion engageable with a hole **482** formed in the frame member **410**. Upon retraction of the detent **480** by means of a handle **484** the arm **476** may be swung downwardly, thereby to turn the shaft **474** and move the grooved portions of the levers **466** downwardly to break the toggle links **456** and open the grippers **450** both at the forward and rearward shell holders to permit insertion of a shell therein. Upon release of the handle **484**, the spring **478** returns the shaft **474** to its original position in which the toggle links are straightened and the shell is firmly held within the shell holders. In order to insure the correct position of the shell lengthwise within the holders, the rearward plate **406** is provided with a flange-engaging member **486** (FIG. 20) provided with a groove arranged to receive the flange at the rearward end of the shell. Each of the stations, or positions in which the shells stop, are provided with similar members thereby to hold the shells against shifting within the holders during firing of the gun.

The mechanism for releasing the grippers from the shell at the fuse-setting or release station at the completion of a fuse-setting operation is illustrated in FIGS. 31, 32 and 33. This station is at the under side of the tracks at their central portions and, as at the loading station, the plates **462** which normally hold the grippers locked are provided with recesses **488** arranged to permit breaking of the toggles. Mounted on the inner surfaces of the plates **462** are guides **490** for slides **492** arranged normally to form a continuation of the curved edge of the plates **462** at the fuse-setting station. These slides **492** are connected by links **494** to the lower ends of levers **496** pivoted at **498** to the plates **462**. The upper ends of the levers are connected by links **500** to arms **502** mounted on a shaft **504** (FIG. 2) journaled in bosses extending inwardly from the plates **462**. The shaft **504** is normally held in the position shown in FIGS. 31 and 32 by a spring **506** secured to a pin **508** extending upwardly from the shaft and to an adjacent tube **412**. Upon moving the shaft against the force of the spring **506** the slides **492** are retracted, thereby to uncover the recesses **488** and to permit breaking of the toggles. For thus breaking the toggles, the shaft **504** is provided with arms **510** having cam surfaces **512** extending laterally thereof, arranged to engage beneath the pins **458** to move them upwardly as the shaft **504** is turned against the force of the spring **506**.

For moving the shaft **504** to release the grippers **450** at the proper time during the operation of the machine, the shaft is operatively connected to the cam shaft **290**. The cam shaft carries a cam **514** (FIG. 39) provided on one face with curved plates **516** and **518** forming a track for a cam roll **520** carried by an arm **522**. This arm is mounted on a pin **524** mounted for axial movement in bosses **526** (FIG. 38) whereby the rod may be forced against the action of a spring **528** to carry the cam roll **520** out of engagement with the cam **514** for a purpose to be described. The upper end of the arm **522** is connected by a rod **530** to a bell-crank lever **532** (FIGS. 2 and 32) pivoted in a bracket **534** mounted on the forward plate **462**. The bell-crank lever is connected by a ball-and-socket joint **536** (FIG. 32) to a rod **538** which is in turn connected to an arm **540** secured to the shaft **504**. Upon a complete rotation of the cam **514** on the cam shaft **290** the shaft **504** is oscillated to retract the slides **492** and by the action of the cam surfaces **512** of the arms **510** to break the toggle links **456** and open the grippers to permit release of the shell from the shell holders, after which the parts are returned to the positions shown in FIGS. 31 and 32.

Provision is made for locking the forward shell holder at the fuse-setting station against accidental movement within the magazine during the fuse-setting operation, as illustrated in FIGS. 34 to 37. This means comprises a pair of pins **544** passing through holes in ears **546** depending from the forward plate **404** of the magazine and arranged to enter recesses **548** in the shell holder. The pins are pivotally connected to the end of an arm **550** which is in turn pivotally secured by a pin **552** to the lower portion of a plate **554**. This plate has upwardly

extending arms **556** pivoted at **558** between ears **560** secured to and extending forwardly from the plate **404**. Springs **562** act between the plate **404** and the pins-carrying plate **554** to swing the plate outwardly and withdraw the pins from the path of movement of the shell holders in the magazine. The position to which the plate **554** is moved by the springs is limited by a screw **564** passing through the plate and threaded into the plate **404**. After a shell holder has been moved into the position shown at the right of FIG. 34 with the shell in fuse-setting position, the plate **554** is swung rearwardly to carry the pins **544** into the recesses **548** of the shell holder by a plunger **566** operated by the fuse setter, as will be hereinafter described. At the conclusion of the fuse-setting operation the plunger **566** is withdrawn, thus permitting the plate **554** to be moved forwardly to retract the pins **544**. To ensure that the plate will be thus moved, the shaft **504**, which is rocked to release the grippers **450** to permit the shell to be transferred into ramming position, extends forwardly through the plate **404** and carries a cam **570** which acts upon the rearward surface of the plate **554** to move this plate forwardly during the operation of the shaft **504** to release the grippers. The springs **562** maintain the plate in this forward position until the plunger **566** is again operated by the fuse setter.

In order firmly to hold the shell against rearward movement within the shell holders as the fuse setter is moved into engagement with the nose of the shell, a roll **572** (FIG. 27) is provided for engagement with the rear of the shell. This roll is carried by a bracket **574** secured to the rear plate **406** of the magazine.

In order to assemble the forward and rearward shell holders in their respective tracks the plates **404** and **406** have vertical grooves formed in their inner surfaces which communicate with the grooves **418**. These vertical grooves are indicated at **576** in the rearward plate **406** (FIG. 27) and provide for the reception of the rolls **422** and **424** of the shell holders. A bracket **578** secured to the rearward surface of the plate **406** has forwardly extending ears **580** (FIG. 28) for closing the vertical grooves **576** after the shell holders have all been assembled in the track. A similar bracket **582** (FIG. 34) is provided on the forward plate **404**.

During the loading of the shells in the magazine at the loading station described above, provision is made for indexing the shells one space following the insertion of each shell within the shell holders at the loading station. This indexing must be effected without operating the fuse setter, without permitting the locking pins **544** described above to enter the recess in the shell holders and without permitting the grippers **450** at the fuse-setting station to be opened, thus preventing the shell at this station from dropping into the transfer tray.

The indexing of the shells in the magazine during the loading operation is effected by manual operation of a rod **584** (FIGS. 2, 34 and 38) passing through a hole in a bracket **586** secured to the transmission housing **448** and being pivotally connected at its inner end to the lower end of an arm **588** (FIG. 41) connected at its upper end to a shaft **590** journaled at one end in a bracket **519** secured to the carriage near the housing of transmission **448**, and at the other end in a bracket **592** secured to the front of the forward plate **404** of the magazine. The rod **584** is held in the position shown in FIG. 34 by a spring **594** acting between the bracket **586** and a collar **596** secured to the rod. The rod is pulled outwardly by the operator against the force of the spring **594** in order to index the shells in the magazine, as will be explained. Before the rod can be thus moved, it is necessary for the operator to open a switch **598** carried by the bracket **519**, which switch controls the circuit to the fuse setter motor, thereby rendering the fuse-setter apparatus ineffective. For insuring that the switch **598** is open before the rod **584** can be pulled outwardly, a slide **600** (FIGS. 40, 41) is mounted in a slideway **601** carried by the top of the housing of the switch **598** and has a portion **602** engageable with an edge of the arm **588** when the switch is in closed position, thereby holding the arm against movement by the rod **584** at this time. The lower surface of the slide **600** (FIG. 41) has a recess **604** arranged to receive a button **606** of the switch **598** when the slide is in locking position relatively to the arm **588**. Upon retraction of the slide, the button **606** is depressed to open the circuit through the switch. This movement of the slide is normally prevented by a latch **608** pivoted on the slide and having a lateral extension **610** engageable with an end of the slideway **601**. The latch **608** is held in this position by a spring **612** which permits movement of the latch **608** out of locking position, whereupon the slide can be retracted to open the switch **598** and permit movement of the arm **588**.

With the switch **598** properly opened, it is now possible for the operator to pull the rod **584** outwardly, thus rocking the arm **588** in a clockwise direction, as viewed in FIG. 34. The shaft **590** to which the arm **588** is secured also has secured to it an arm **614** (FIG. 34) engageable with a roll **616** on a bracket **618** secured to the plate **554**. The inner end of the arm **614** has a cam surface arranged to move the plate **554** forwardly to insure that the pins **544** are retracted from the shell holder at that station in order to permit the indexing of the shells at this time. This may be necessary in view of the fact that the shaft **504** carrying the cam **570** is immobilized during the loading of the magazine in order that the grippers **450** at the fuse-setting station will not be opened.

For thus immobilizing the shaft **504**, the arm **522** (FIGS. 38 and 39) carrying the cam roll **520** is shifted to carry the roll out of operative engagement with the cam. This is also effected by the movement of the rod **584** by the operator. The inner end of the rod is connected by a link **620** to an arm **622** carried by a countershaft **624** journaled in brackets **626** secured to the carriage. The countershaft **624** is provided with a second arm **628** (FIG. 38) connected to a rod **630** which is in turn connected by a pin-and-slot connection **632** to a lever **634** pivoted on a bracket **636**. The forward portion of this lever acts upon the outer end of the rod **524** carrying the arm **522** and through the aforedescribed connections the rod **524** is moved to the left, as viewed in FIG. 38, upon outward movement of the control rod **584**. Thus the cam **514** is ineffective to operate the shaft **504** to release the grippers at the fuse-setting station while the shells are being indexed during the loading of the magazine.

This outward movement of the rod **584** is also utilized to trip the one-revolution clutch **296** so that the drive sprockets **430** by which the shells are indexed are turned through a quarter revolution. For this purpose the lever **634** (FIGS. 15 and 38) at its rearward end engages an arm **640** on the shaft **364** carrying the solenoid-operated trip arm **362** (FIG. 18). The outward movement of the control rod **584** thus acts through the lever **634** to move the trip arm **362** of the clutch in a counterclockwise direction, as viewed in FIG. 16, whereupon the sprocket **326** driven by the clutch makes one complete revolution and the shells are indexed one space.

Fuse-setting mechanism

The mechanism F for setting the fuse of a shell at the fuse-setting station is supported by a plate **642** (FIG. 44) extending between and secured to the side walls **100** of the carriage G. The fuse-setting mechanism is mounted on a plate **644** arranged for limited movements on the plate **642** to permit self-alinement of the fuse-setting mechanism with the shell at the fuse-setting station. For this purpose a hinge **646** is secured to the forward end of the plate **644** (FIGS. 43 and 44), the hinge being

pivotally connected by a screw 648 to the plate 642 thereby providing a universal connection between the plates. A leaf spring 650 secured within a recess in the plate 642 acts upon the rearward portion of the plate 644 to support it slightly above the plate 642. Movements of the rearward end of the plate 644 are limited by a recessed holddown 652 (FIGS. 44 and 45) secured to the plate 642 by a screw 654 and a second holddown 656 (FIGS. 44 and 46) pivotally secured by a screw 658 to the plate 642. The holddown 656 is movable into the dotted line position shown in FIG. 44 to permit the fuse-setting apparatus to be removed from the carriage and into the full-line position in which the plate 644 is held for limited movement relatively to the plate 642. As noted in FIG. 44 slight clearance is provided between the holddowns and the plate 644 to permit the plate to be swung about the axis of the screw 648 to a limited extent and also to permit some vertical movement of the plate so that the fuse setter may be accurately alined with the nose of the shell. The holddown 656 is provided with a spring-pressed plunger 660 engageable with a hole in the plate 642 to lock it in the full line position.

The fuse setter includes a fuse-cutter head 662 (FIGS. 42 and 43) which is splined on a shaft 664 journaled in bearings 666 (FIG. 53) in walls 668 extending upwardly from the plate 644. The fuse-cutter head is hollowed to receive the nose of a shell, as shown in FIGS. 42 and 43, and at its outer end has a flange 670 provided with spaced rearwardly extending ears 672 between which are journaled fuse-cutter knives 674. The head 662 is movable along the shaft 664 from the position shown in FIG. 2, in which it is located forwardly of the nose of a shell, into the position shown in FIGS. 42 and 43, in which the knives 674 are in engagement with the fuse ring 676 of a shell S. The inner end of the head 662 is provided with spaced flanges 678 between which are received rolls 680 (FIG. 42) at the upper ends of arms 682 carried by a rockshaft 684 journaled in bearings 686 on the plate 642. Upon movement of the rockshaft by mechanism to be described, the fuse-cutter head 662 is moved along the shaft 664 into or out of engagement with the nose of a shell in accordance with the direction of movement of the rockshaft.

The mechanism for thus operating the shaft 684 is best illustrated in FIGS. 42 and 43. Secured to the shaft is a crank 690, the upper end of which is pivoted to a rod 694 which is telescopically received by a sleeve 696. The rod is urged outwardly of the sleeve by a heavy compression spring 698 acting between the end of the sleeve 696 and a collar 700 on the rod 694. The rod 694 carries a pin 702 which extends through slots 704 in the sleeve 696, thereby to maintain the rod and sleeve in assembled relationship, while permitting limited sliding movement of the rod within the sleeve. The outer end of the sleeve 696 is pivotally connected to a lever 706 fulcrumed between brackets 708 extending upwardly from the plate 642. The lever 706 carries a cam roll 710 received by a groove 712 in a cam 714 carried by the cam shaft 290. The upper end of the crank 690 is also connected to one link 716 of a toggle, the other link 718 of which is pivoted to an arm 720 journaled on the shaft 684. This arm has a depending portion arranged for engagement with a block 722 when the parts are in the positions shown in FIGS. 42 and 43 with the fuse-cutter head in engagement with the nose of the shell. The toggle links 716 and 718 are urged toward straightened positions by a spring 724 acting between a pin 725 extending upwardly from the link 716 and an arm 726 pivoted at 728 to the outer end of the sleeve 696. The rearward end of the arm 726 has a slot 730 to receive a pin 732 carried by the toggle link 716.

The solenoid 384 (FIG. 16) is energized, as will be described, at the termination of a fuse-setting operation to place the shaft 290 in rotation, whereupon the cam roll 710 drops from a high portion of the cam track 712 causing the lever 706 to pivot in a clockwise direction, as viewed in FIG. 42, thereby to move the rod 694 toward the right. The arm 726 is also moved toward the right by the lever 706, whereupon the spring 724 acts to straighten the toggle links 716 and 718 and the crank 690 is moved rapidly in a clockwise direction to turn the rockshaft 684 and move the fuse-cutter head 662 out of engagement with the nose of the shell. At the end of a firing cycle and after a new round has been indexed to the fuse-setting station, the head 662 is moved into engagement therewith in readiness for the next cycle of operation. The lever 706 is moved by the cam 714 in a counterclockwise direction and operates through sleeve 696, rod 694 and crank 690 to move the shaft 684 in a counterclockwise direction. At the same time, the arm 720 supporting the lower toggle link rotates on the shaft 684 from a position in which it is out of engagement with the block 722 until it strikes the block, the toggle links during this time being in straightened positions. Upon further movement of the lever 706 the spring 698 is compressed but additional movement of the crank 690 is prevented by the toggle links which are in alinement at this time. During this compression of the spring 698 the arm 726 moves relatively to the crank 690. After sufficient movement of this arm the end of the slot 730 engages the pin 732 in the upper toggle link 716 and breaks the toggle. This allows the heavy spring 698, which has been compressed, to snap the crank 690 toward the round in the magazine, whereupon the cutter head 662 is snapped with considerable force over the nose of the round causing the knives 674 to cut deeply into the fuse ring.

To prevent wear on the various parts which would otherwise take place, mechanism is provided to prevent loading of the spring 698 and the snapping of the cutter head in the event that no round is positioned at the fuse-setting station, which condition may be encountered during loading of the magazine. For this purpose, mechanism is provided for moving the block 722 to such a position that it is out of the path of movement of the arm 720 supporting the lower toggle link 718. When this block is so moved, the supporting arm 720 is insufficiently limited in its movement around the shaft 684 to cause compression of the spring on the rod 694. Accordingly, the rod 726 is not moved relatively to the toggle links to break them and the fuse-cutter head is not snapped toward the magazine. The block 722 is carried by a slide 736 movable in guides 738 carried by the plate 642. The slide 736 is provided with a pin 740 engageable by the forked end of an arm 742 carried by and depending from a shaft 744 journaled in a bracket 746 supported by one of the side walls 100 of the carriage. The shaft 744 is normally moved in a direction to cause withdrawal of the block 722 by a spring 748 acting on an arm 750 secured to the shaft 744, the movement of which arm is limited by a pin 752 in the bracket 746. A feeler arm 754 is secured to the shaft 744 and is normally held in a depressed position by the action of the spring 748 on the shaft. This feeler arm has a portion 756 engageable with and cammed upwardly by the shell when the shell is moved into the fuse-setting station, thereby to rock the shaft 744 against the force of the spring 748, whereby the block 722 is moved under the toggle-supporting arm 720. With no shell in the fuse-setting station the spring 748 maintains the shaft 744 in a position in which the block 722 is not engageable by the toggle arm 720.

The plunger 566 (FIGS. 35 and 42), by which the plate 554 carrying the locking pins 544 is moved against the force of the springs 562, is slidably carried within the rearward end of a sleeve 760 and carries a pin 762 received by a slot 764 in the sleeve to limit the relative movement between the plunger and the sleeve. The sleeve 760 is slidable on a hollow rod 766 (FIG. 43) carried by spaced bosses 768 extending upwardly from

a U-shaped arm **770** carried by the plate **644**. The sleeve **760** carries a pin **772** provided with a roll **774** engageable by the flange **670** of the fuse-cutter head, whereby the sleeve **760** with the plunger **566** is moved toward the plate **554** during movement of the fuse-cutter head toward the shell. The pin **772** extends through slots in the rod **766** and a tension spring **776**, acting between the pin **772** and a second pin **778**, normally maintains the sleeve **760** in the position shown in FIGS. 35 and 36.

A compression spring **780** acts between a block **782** in the rod **766** and the plunger **566** at the outer end of the sleeve to soften the blow delivered by the plunger to the plate **554** when the fuse-cutter head is moved onto the nose of the shell at high velocity.

The fuse-cutter head is in engagement with the nose of the shell at the beginning of a cycle of operations, as stated above, and the cycle is initiated upon the depression of a firing button, as will be explained, which causes rotation of the shaft **664** a predetermined amount to set the fuse of the shell to a predetermined time. The shaft **664** is rotated in one direction or the other by a motor **784** (FIGS. 2 and 44) mounted on a plate **786** (FIG. 43) having at its lower portion inclined slots **788** to receive screws **790** by which the plate and motor are adjustably supported on a wall extending upwardly from the plate **644**. A screw **792** threaded through a bracket **794** on the plate **786** engages the wall supporting the plate and facilitates adjustment of the plate and motor when the screws **790** are loosened, thereby to adjust the tension on belts which are driven by the motor. The motor includes a shaft **796** on which are mounted a pair of drive pulleys **798** and **800** to receive respectively a V-belt **802** and a crossed round belt **804**. These belts drive a shaft **806** journaled in bearings **808** carried by the plate **644**, the shaft being connected selectively to the belts for rotation in one direction or the other through a reversing clutch **810**, the construction of which is shown in FIGS. 44 and 47. This clutch includes a pair of outer plates **812** pinned to the shaft **806** and a central member **814** slidable along the shaft. This central member is mounted on a slide **815** and is splined to the shaft by a pin **816** passing through a slot **818** in the shaft. The central member **814** includes a pair of inner plates **820** and **822** arranged to be moved into engagement respectively with either the round belt **804** or the V-belt **802**. These belts ride on idlers **824** mounted on roller bearings **826** slidable with the central member **814** along the shaft **806**. When the member **814** is in its neutral position, as shown in FIG. 47, the plates **820** and **822** are out of engagement with the belts **802** and **804** and no movement is imparted by either of the belts to the shaft **806**. Upon movement of the member **814** axially along the shaft in one direction or the other, one or the other of the belts is squeezed against the adjacent outer plate keyed to the shaft so that rotative movement is imparted to the shaft by one or the other of the belts. Since the round belt **804** is crossed, as shown in FIG. 44, the shaft **806** may be turned in either direction, depending upon which belt is acted upon by the member **814**.

The shaft **806** carries a worm **830** which drives the shaft **664** carrying the fuse-cutter head in one direction or the other, depending upon which belt is engaged by the member **814** of the clutch **810**, by the following mechanism. Rotatably mounted on the shaft **664** is a worm gear segment **832** (FIGS. 47, 53 and 54) which meshes with the worm **830**. Within a recess in the gear segment is secured an insert **834** by means of a pin **836**. This insert is recessed to provide shoulders **838** and **839** between which is received a crank **840** rotatably mounted on a hub **842** of the gear segment **832**. A spring **844** carried by the insert **834** acts upon the crank **840** normally to hold it against the shoulder **838**. The crank **840** is connected by toggle links **846** (FIG. 47) to a second crank **848** keyed to the shaft **664**. The toggle links are normally maintained in nearly straightened positions by a spring-pressed plunger **850** carried by the crank **848** and acting upon a depending portion **852** of one of the toggle links. A pin **854** carried by the crank **848** limits the movement of the toggle links by the plunger **850**. When the gear segment **832** is turned in the direction of the arrow of FIG. 47 the shoulder **838** acts upon the crank **840**, which drives the crank **848** through the toggle links **846** to turn the shaft **664** in a direction to set the fuse of a shell engaged by the fuse-cutter head. As soon as the fuse has been set the desired amount the shaft **664** is stopped positively, as will be described, and the member **814** of the clutch **810** is shifted into neutral position. During this time, overrunning of the worm **830** is permitted, as the toggle links **846** will be broken by the crank **840** against the force exerted by the spring-pressed plunger **850**. During the reverse rotation of the shaft **806**, during which the fuse-cutter head is returned to initial position, the crank **840** is driven by the shoulder **839** of the insert **834** of the gear segment through the spring **844** (FIG. 54). When the shaft **664** reaches the limit of its reverse travel the spring **844** is compressed, thus allowing a slight amount of overtravel of the worm **830**. A dragging action is exerted upon the worm **830** by a friction brake **856** held against the hub of the worm by a spring **858** acting between the brake and one of the bearing members **808**.

For stopping the rotation of the shaft **664** carrying the fuse cutter head, the mechanism illustrated in FIGS. 55 to 59 is provided. The shaft **664** extends outwardly of the forward bearing **668**, as shown in FIG. 53, and carries a timing arm **860** which is substantially U-shaped to embrace a toothed timing segment **862** extending upwardly of and secured to the plate **644**. A pair of pawls **864** are pivoted on a pin **866** at the upper portion of the arm **860** and are arranged to be moved at the proper time into engagement with the teeth of the segment **862**. These pawls are spaced a half a tooth apart so that one or the other will engage between a pair of teeth of the segment **862** whenever they are moved into engagement with the segment, thereby stopping the shaft **664** carrying the arm **860** almost instantly. The pawls include upwardly extending arms **868** received by spring hooks **870** at the upper end of an arm **872** pivoted at **874** on the timing arm **860**. A spring **876** (FIG. 58) acts upon the arm **872** to hold it in engagement with a pin **878** on the arm **860** in which position the pawls **864** are out of engagement with the segment **862**. When the arm **872** is rocked in a counterclockwise direction relatively to the arm **860** the pawls are moved into engagement with the ratchet teeth on the segment **862** to lock the arm **860** thereto and to stop rotation of the shaft **664**.

For thus operating the arm **872** at the desired time during the fuse-setting operation, a self-synchronous transmission system is employed embodying a transmitter **880** on the control panel (FIG. 1) and a repeater **882** (FIG. 55) on the plate **644**. The shaft of the repeater carries a contact arm **884** the upper end of which is engageable with a stop **886** at the lower end of the arm **872**. It will be understood that when the armature of the transmitter is set by operation of a control handle **888**, the arm **884** of the repeater will be turned to a corresponding position. Accordingly, upon operation of the clutch **810** to rotate the shaft **664**, the shaft will rotate to set the fuse until the stop at the lower end of the arm **872** engages the upper end of the arm **884** of the repeater, whereupon the pawls **864** are moved into engagement with the segment **862**. Provision must be made for preventing movement of the repeater shaft when the arm **884** is engaged by stop **886** on the arm **872** inasmuch as the repeater is incapable of exerting sufficient torque unless such provision is made. Mechanism for this purpose is illustrated in FIG. 59 and is shown to comprise a lever **890** carrying a brake pad

892 urged into engagement with a disc 893 on the repeater shaft by a spring 894 acting between an arm of the lever and a frame member 896. When the fuse setter is in zero position, which is illustrated in FIG. 58, the brake pad is held out of engagement with the repeater shaft by a cam surface 898 on the timing arm 860. This permits initial setting of the repeater by the transmitter, but at the beginning of the fuse-setting operation the arm 860 carries the cam surface 898 out of engagement with the lever 890, whereupon the spring 894 moves the brake pad 892 into engagement with the disc 893 on the repeater shaft, to hold the arm 884 in fixed position to act upon the lower end of the arm 872 after the fuse has been set in accordance with the setting of the repeater.

A plate 899 (FIG. 55) carried by the timing arm 860 carries contacts 900, 902 for engagement respectively with a fixed contact 904 and a contact 906 on the repeater contact arm 884. The contact arm 884 also carries a contact 908 engageable with a fixed contact 910, the fixed contacts 904 and 910 being connected to wires E5 and E6, respectively. The contacts 900 and 908 coincide with the axes of the shaft 664 and the repeater shaft, respectively, so that they always remain in engagement with the fixed contacts 904 and 910. Before the fuse-setting operation the contact 906 is moved away from the contact 902 carried by the arm 860, as indicated by the broken lines in FIG. 58, to a position depending upon the desired fuse-setting time, determined by the setting of the transmitter. After the fuse has been properly set the contact 902, carried by the timing arm 860, moves into engagement with the contact 906, thereby to connect the wires E5 and E6 and thus to establish a circuit through an electromagnet which shifts the clutch 810 (FIG. 47) into neutral position, as will be described, to interrupt the drive to the shaft 664.

Carried by the upper extremity of the segment 862 are switches 916 and 918 (FIGS. 56 and 57). These switches are controlled by buttons 920 and 922, respectively, which are in turn acted upon by a plow 924 carried by the upper end of the timer arm 860. With this arm in its initial position, which is the zero fuse-setting position, both buttons are depressed by the plow. In this position of the timing arm, wires D6 and D7 of the switch 916 are electrically connected, but the circuit through these wires is broken upon movement of the timing arm at the beginning of the fuse-setting operation. The switch 918 is a double-throw switch in which wires J3, G6 are connected when the timing arm is in its initial position, but upon movement of the arm away from this position during the fuse-setting operation the circuit through these wires is interrupted and a second circuit is closed through wires G5 and G6. The purpose of these switches will appear as the description proceeds.

For shifting the clutch 810, the pin 816, by which the central member 814 is splined to the shaft 806, passes through a stub shaft 936 slidable in the shaft 806 and extending outwardly thereof. The outer end of the stub shaft 936 carries a collar 938 (FIGS. 43 and 44) from which extend pins 940 embraced by the bifurcated upper ends of spaced arms 942 of a lever 944 pivoted at 946 on a portion of the fuse-setter frame. The lower end of the lever 944 is slotted to receive a crank pin 948 (FIGS. 48 and 49) carried by a shaft 950 journaled in bearings 952 and extending forwardly and rearwardly of the fuse setter. This shaft is arranged to be indexed in steps of 90° and always in the same direction. Upon the first step the clutch is shifted from a neutral position into position to squeeze one of the belts and drive the fuse-setter shaft 664 in a direction to set the fuse of a shell. Upon the next 90° of movement of the shaft 950 the clutch returns to neutral position, and upon the third 90° of rotation the clutch is reversed to squeeze the other belt and rotate the shaft 664 to return the fuse-cutter head back to zero position, after which the shaft 950 is rotated another 90° back to its original position thus shifting the clutch back to neutral position. For holding the shaft 950 exactly in its four different positions of rest, a spring detent 954 (FIG. 49) is arranged to engage V-shaped recesses 956 in the shaft 950.

The shaft 950 is turned 90° from its initial position to effect the fuse-setting operation by a solenoid 960 (FIG. 53) carried between spaced walls 668 extending vertically from the plate 644. The armature of the solenoid is connected by a link 962 (FIG. 50) to a rack 964 slidable in a sleeve 966 directly below the shaft 950. The rack 964 engages teeth of a gear segment 968 rotatable on the shaft 950 but provided with an upwardly extending U-shaped bracket 970 between the parallel walls of which is pivoted a pawl 972 (FIG. 51). This pawl is pressed by a spring 974 into engagement with a ratchet 976 pinned to the shaft 950. Upon energization of the solenoid 960 the rack 964 is moved to the right, as viewed in FIGS. 50 and 51, whereupon the pawl 972 acts upon the ratchet 976 to turn the shaft 950 through 90° of rotation. Rearward movement of the shaft 950 is prevented by a pawl 978 carried by the housing of the bearing 952 and moved into engagement with the ratchet by a spring 980. Thus upon energization of the solenoid 960, in a manner to be described, the shaft 950 is turned 90° thereby to shift the clutch 810, causing rotation of the shaft 664 to set the fuse of the shell engaged by the fuse-cutter head.

After the fuse has been properly set, the circuit closed by the contacts 902, 906 (FIG. 55) energizes a solenoid 982 (FIGS. 43 and 48). The armature of this solenoid is connected by a link 984 (FIGS. 48 and 52) to a member 986 carrying a pawl 988 spring-urged into engagement with a ratchet 990 fixed to the shaft 950. Thus the shaft is again turned 90° to move the crank pin 948 (FIG. 49) into its lowermost position, thus shifting the clutch back to neutral position.

The third movement of the clutch-operating shaft 950, in order to move the fuse-timing arm 860 back to its initial position, is effected by the cam 714 (FIG. 43) after the fuse cutter head 662 has been withdrawn by operation of this cam, as heretofore described. The arm 706 carrying the cam follower 710 is connected by an adjustable link 992 to an arm 994 of a lever 996 carried by a bracket 998 supported on the plate 644. The lever 996 includes a second arm 1000 on the outer end of which is pivoted a latch 1002 (FIG. 44), one end of which is held, by a spring 1004, in engagement with a pin 1006 on the arm 1000 of the lever. The other end of the latch 1002 carries a roll 1008 adapted upon movement of the lever 996 in a clockwise direction by the cam 714 to engage the end of a lever 1010 pivoted at 1012 to the fuse-setter frame, and having an end 1014 engageable with the outer extremity of the rack 964 (FIG. 50) operated by the solenoid 960. The lever 1010 is normally held in the position shown in FIG. 44 by a torsion spring 1016 (FIG. 49). Shortly after the main cam shaft 290 starts rotating and the fuse-cutter head 662 is withdrawn from the nose of the shell, the lever 996 is turned sufficiently to cause the roll 1008 of the latch 1002 to act upon the lever 1010, thereby moving the armature of the solenoid 960 inwardly, thus rotating the shaft 950 90° in the manner heretofore explained. This causes the clutch 810 to be shifted to cause rotation of the shaft 664 in a reverse direction, thus moving the fuse-timer arm back to its original zero position. The roll 1008 carried by the latch 1002 is permitted to ride past the end of the lever 1010 by the yielding of the spring 1004 after the clutch-operating shaft has been turned the proper amount. This allows the arm of the lever 1010 to return to its starting position under the action of the torsion spring 1016 and the spring latch 1002 allows the lever 996 to be moved by the cam 714 back to its starting position without causing further movement of the lever 1010. After the fuse-timer arm 860 has returned to its starting position the

solenoid **982** is again energized by the operation of the switch **918**, as will be described, which causes the shaft **950** (FIG. 48) to move 90° back to its starting position with the clutch in neutral position. A complete description of the circuits through the solenoids **960** and **982** will be given in the detailed description of the operation of the gun.

As previously noted, the switch **598** (FIG. 41) must be opened before the magazine can be loaded, thus opening the circuit to the fuse-setter motor **784** and the solenoids **960** and **982**. In order that the latch **1002** (FIG. 44) will be rendered ineffective at this time to shift the clutch **810** during the operation of the cam shaft **290**, this latch is held in inoperative position by the rod **584** (FIG. 34) when the rod is pulled outwardly to index the shells in the magazine. The link **630** operated by the rod **584** is connected to a lever **1018** (FIG. 44) pivoted on the plate **642**. The outer end of the lever **1018** carries a pin **1020** engageable with the latch **1002** to move this latch in a clockwise direction as viewed in FIG. 44 against the force of the spring **1004**, whereby the roll **1008** is prevented from engaging the lever **1010** during the operation of the cam shaft **290**.

Shell-transfer mechanism

At the completion of the fuse-setting operation the shell at the fuse-setting station is carried by the transfer tray L into alinement with the bore of the gun, whereupon the shell is rammed into the gun and the gun fired. The transfer tray then returns to receive another shell which has been indexed in the meantime into the fuse-setting station. For thus moving the tray it is carried by a parallel linkage system supported by the extensions **104** of the trunnions **10** (FIG. 4). This parallel linkage system includes a pair of links **1022** journaled on the bushings **102** and vertically extending arms **1024** keyed to the extensions **104** of the trunnions. To the upper ends of the arms **1024** are pivoted links **1026** which are parallel to the links **1022**. These links are connected at their rearward ends to the transfer tray L, as shown in FIG. 60. The lower links **1022** are formed with vertically extending ears **1028** (FIG. 1) to which are attached one end of tension springs **1030** the other ends of which are secured to depending ears **1032** of the upper links **1026**. These springs act upon the links to assist in the upward movement of the transfer tray and to counterbalance the weight of a shell S in the tray.

Vertical movements of the links to carry the tray from the fuse-setting station into ramming position are effected by cams **514** and **1034** (FIG. 2) on the cam shaft **290**. Cam followers **1036** operated by the cams are carried by levers **1038** the forward ends of which are pivoted on the housings of bearings **292**. The rearward ends of these levers are connected by links **1040** and **1042** (FIG. 1) to the links **1026** and **1022**, whereupon the loading tray is moved vertically upon rotation of the cam shaft **290**. The position of the transfer tray with respect to the gun, as the gun is moved in elevation, is maintained constant due to the fact that the arms **1024**, are keyed to the trunnions of the gun. Alinement between the transfer tray and the bore of the gun upon downward movement of the tray to carry the shell into ramming position is assured by a cushion stop **1044** (FIGS. 2 and 60) mounted on the carriage in a position to be engaged by a projection **1046** on the rearward portion of the tray.

The transfer tray comprises a shell-supporting member **1048** (FIG. 60) to the opposite sides of which are pivoted doors **1050** arranged to hold the shell in place during its transport from fuse-setting to ramming position. These doors are spring-urged inwardly by compression springs **1052** (FIG. 62) acting between depending portions **1054** of the doors and the adjacent surface of the transfer tray. The upper portions of the doors are formed as cam surfaces **1056** engageable with the shell as the tray moves into its upper position so that they are automatically opened against the springs **1052**. For holding the doors in their shell-engaging positions during downward movement of the transfer tray, locks **1058** are provided. These locks are formed at the upper ends of vertical arms of a U-shaped lever **1059** pivoted at **1060** on the tray and are normally held in locking engagement with depending portions **1062** of the doors **1050** by a spring **1064** (FIG. 60) acting between a pin **1066** on the tray and the lever **1059**. These locks **1058** are moved into inoperative positions as shown in FIG. 60 during upward movement of the transfer tray, thereby to permit the doors **1050** to be swung apart to receive a shell. For this purpose a cam **1068** (FIGS. 60 and 61) is provided, the cam being pivoted at **1070** on the rearward plate **406** of the magazine. The lever **1059** carrying the locks **1058** is connected by a link **1072** to the lower end of a lever **1074**, the upper end of which is arranged to engage the cam **1068** when the cam is in the full-line position shown in FIG. 61, thereby to hold the locking lever **1059** in the position shown in full lines in FIG. 60 against the force of the spring **1064** in which position it is ineffective to lock the doors.

After the release of the shell from the fuse-setting station, and at the beginning of downward movement of the transfer tray, the cam **1068** is swung to the broken-line position shown in FIG. 61 so that it is ineffective to hold the locking lever **1059** in its inoperative position. Accordingly, the spring **1064** swings the lever in a clockwise direction, as viewed in FIG. 60, to position the locks **1058** behind the projections **1062** of the doors **1050**. For thus moving the cam to permit operation of the clocks, the cam includes an upwardly extending arm **1076** (FIG. 61) connected by a link **1078** to a crank **1080** on the shaft **504** by which the shell grippers at the fuse-setting station are released. Before the transfer tray returns to its uppermost position the cam **1068** is moved back to the full-line position of FIG. 61, in which it is engageable by the upper end of the lever **1074** which thus renders the locks **1058** inoperative, thereby permitting opening of the doors to receive another shell.

The reduced forward portion of the shell is held by pivoted supports **1082** (FIGS. 60 and 63) mounted on pins **1084** extending between pairs of ears at the front of the transfer tray. These supports are held in the positions illustrated by torsion springs **1086** which permit the supports to move forwardly thereby accommodating the larger diameter of the shell case when the shell is rammed from the transfer tray into the firing chamber of the gun.

Provision is made for preventing lengthwise movement of the shell within the transfer tray during transport of the shell to ramming position. For this purpose a latch **1088** (FIG. 61) is provided at one side of the loading tray. The latch is pivoted on a pin **1090** and has an arm **1092** engageable with the shell immediately ahead of the flange at the rear of the shell case. The latch includes a downwardly extending arm **1094** between which and the arm **1092** is received one end of a latch-operating lever **1096** (FIGS. 61 and 64) pivoted at **1098** to the rear of the transfer tray. A spring **1100** holds the lever **1096** in the position shown in FIG. 64 to lock the shell against axial movement. The latch **1088** is moved in a clockwise direction as the tray reaches its lowermost position to retract the latch and permit ramming the shell. For this purpose the lever **1096** includes an upwardly extending arm **1102** carrying a roll **1104** engageable with a cam **1106** (FIG. 65) on the carriage G. This cam causes the lever **1096** to move in the direction of the arrow (FIG. 64), thereby acting on the arm **1094** of the latch **1088** to move it out of engagement with the rim at the rear of the shell. Upon return upward movement of the tray the spring acts on the lever **1096** to return the latch **1088** to its locking position to engage the rim

of the shell which has been moved into the fuse-setting position.

Rammer

After the shell has been moved into alinement with the bore of the gun it is forced into the firing chamber of the gun by the rammer P, shown in FIGS. 60 and 66. The rammer comprises a shell-engaging arm **1110** carried by a hollow shaft **1112** slidable in bearings **1114**, **1116** (FIG. 68) on the gun carriage. The hollow shaft **1112** is mounted above and to one side of the bore of the gun so that it does not interfere with the downward movement of the transfer tray as the shell is moved into ramming position. The shaft **1112** is moved forwardly and rearwardly of the gun upon rotation of the cam shaft **290** by the following mechanism. The cam shaft carries a cam **1118** having a cam groove **1120** which receives a cam roll **1122** carried by a gear segment **1124** pivoted on the carriage at **1126**. The gear segment **1124** acts through a train of gears **1128**, **1130**, **1132** and **1134** to move the shaft **1112** very rapidly forwardly and rearwardly of the gun during the rotation of the cam shaft. The gear **1134** engages worm teeth **1136** formed in the outer surface of the shaft **1112** to impart sliding movement to the shaft as the gear is rotated.

At the end of a firing cycle the rammer comes to rest in the position shown in FIG. 60, in which it is forwardly of the shell next to be fired. During the downward movement of the transfer tray the rammer shaft **1112** moves rearwardly until the arm **1110** has been carried rearwardly of the shell on the transfer tray. The shaft **1112** is now turned to carry the rammer arm into position to engage the rear of the shell when the shaft is again moved forwardly thereby to move the shell into the gun. For thus turning the shaft **1112**, a cam **1140** (FIG. 69) is carried by the cam shaft **290**. This cam includes a groove **1142** which receives a cam roll **1144** carried by a lever **1146** pivoted on a bracket **1148** mounted on the carriage. The upper end of the lever **1146** is connected by a rod **1160** (FIGS. 66 and 67) to a crank pin **1162** carried by a gear segment **1164** pivoted at **1166** on the carriage. The gear segment **1164** meshes with a gear **1168** splined to the shaft **1112**. The gear segment **1164** starts to turn the shaft **1112** as the rammer arm **1110** reaches its rearmost position. After the arm has moved into position to engage the rearward end of the shell, the shaft **1112** is moved forwardly by the cam **1118** to move the shell into the gun.

In order to absorb the initial shock when the rammer reaches the rearmost limit of its travel, the following mechanism is provided. Within the hollow shaft **1112** is provided a piston **1170** having a forwardly extending rod **1172** engaging one end of a compression spring **1174**, the other end of which engages a plug **1176** in the forward end of the shaft **1112**. A plunger **1178** is carried by the rearward portion of the carriage and extends forwardly in alinement with the shaft **1112**. As the shaft approaches the rearward end of its travel, the plunger **1178** enters the shaft **1112**, engaging the piston **1170**, and forces it forwardly against the spring **1174**. The energy stored up in the spring during this action assists in the forward movement of the rammer during the loading of the shell, thereby reducing the work which would be required of the cam shaft in ramming the shell rapidly into the gun were this spring not present.

As soon as the shell has been rammed into the gun the breech block is automatically closed by any suitable mechanism, not shown. During this closing of the breech block, the lower end of the arm **1110** of the rammer is engaged by the block, thereby turning the shaft **1112**. To permit turning of the shaft by the action of the breech block at this time, the groove **1142** of the cam **1140** is widened at **1180**, thereby to permit the roll **1144** to be moved inwardly toward the cam shaft by the action of the breech block. After the cam shaft **290** has turned sufficiently, the outer surface of the groove **1142** engages the cam roll, thereby holding the arm **1110** in its inoperative position. To permit the rammer arm to be swung by the breech block without interference with the gun while providing sufficient area of the arm in contact with the shell during the ramming operation, the rammer arm **1110** is provided with a sliding portion **1182** normally held in extended position by a spring **1184**. When the breech block closes, the portion **1182** of the rammer arm is moved inwardly, compressing the spring **1184**, so that the rammer arm clears the end of the gun as it is swung by the breech block about the axis of the shaft **1112**. A spring **1186** (FIG. 67) acts between a pin **1188** on the carriage and a pin **1190** carried by an arm **1192** fast with the lever **1146** normally to maintain the cam roll **1144** in engagement with the outer surface of the cam groove **1142**.

Firing mechanism

The firing of the shell, after it has been rammed into the firing chamber of the gun and the breech block closed, is controlled by the cam **514** on the cam shaft **290**. A cam follower **1196** (FIG. 70) carried by a lever **1198** pivoted at **1200** on the carriage cooperates with the outer surface of the plate **516** carried by the cam **514**. The lower end of the lever **1198** engages a spring-pressed plunger **1202** carried by the upper end of a lever **1204** pivoted at **1206** on the gun, the lower end of this lever acting through a sliding rod **1208**, a link **1210** and a lever **1214** to operate the firing-pin-release mechanism, not shown. As is customary, the firing pin is cocked in response to the closing of the breech. During the loading of the magazine, when the gun is not in operation, it will be understood that the breech block remains open so that the firing pin is not cocked. The spring-pressed plunger **1202** permits movement of the lever **1198** by the cam **514** during rotation of the cam shaft **290** when the magazine is being loaded without actuating the firing pin release mechanism.

Carried by a bracket **1220** (FIG. 70) mounted on the gun is a pair of switches **1222**, **1224** which are arranged to be opened during the firing of the gun and closed upon counter-recoil of the gun. As hereinafter explained, the switch **1222** when opened prevents energization of the solenoid **384** (FIG. 16) which trips the camshaft clutch, thereby preventing operation of the cam shaft during firing of the gun. This switch prevents jamming of the mechanism should the firing switch remain closed and the shell in the gun fail to fire. The switch **1224** when opened prevents operation of the solenoid **960**, thereby preventing operation of the fuse setter during firing of the gun.

The switches **1222**, **1224** are operated from the cam **714** (FIGS. 72 and 72*a*) as follows. To the lever **706** operated by the cam **714** is pivoted an arm **1226** the forward end of which is recessed and held by a spring **1228** in engagement with a pin **1230** carried by the upper end of a lever **1232** fulcrumed on a pin **1234** in a bracket secured to the gun carriage. The lower end of the lever **1232** is connected by a rod **1236** to an arm **1238** on a shaft **1239** on which are journaled for unitary rotary movement ratchets **1240**, **1242** and a cam **1244**. As the cam shaft **290** rotates to operate the firing mechanism, a pawl **1241** on the arm **1238** in engagement with the ratchet **1242** operates to turn the ratchets and cam **1244** in a counterclockwise direction (FIG. 72) until a pawl **1246** engages the next succeeding tooth of the ratchet **1240**. During this movement the cam **1244** operates a switch arm **1248** pivoted at **1250** on the carriage and having a cam follower **1251** engageable with the periphery of the cam, to permit the arm to be swung by a spring **1252** to open the switches **1222** and **1224**. During the final portion of the counter-recoil of the gun after the shell has been fired a rod **1254** is engaged by the gun. This rod is carried by an arm **1256** carrying a pawl **1258** engageable with the teeth of the ratchet **1242**. Accordingly, as the gun returns to

battery position the ratchet **1242** is turned in a counterclockwise direction, thereby moving the cam **1244** in the same direction causing movement of the switch arm **1248** to close the switches **1222** and **1224** so that the next cycle of operation of the gun may be initiated. A spring **1259** moves the arm **1256** back to its original position during counterrecoil movement of the gun, during which time retrograde movement of the ratchets and cam is prevented by engagement of pawl **1246** with the ratchet **1240**.

It is not desirable to operate the switches **1222** and **1224** during the loading of the magazine, inasmuch as there is no movement of the gun to close the switches after they have been opened by the cam **714**. Accordingly, the arm **1226** operated by the cam **714** is rendered ineffective to move the lever **1232** during rotation of the cam. For this purpose the arm **1226** has a rearwardly extending portion **1260** engageable by a pin **1262** at one end of a lever **1264** pivoted at **1266** in the carriage. The other end of the lever **1264** engages a cam surface **1268** on an arm **1270** movable with the lever **996** (FIG. 43) which is turned by the movement of the rod **630** to render the latch **1002** (FIG. 44) inoperative. This movement of the lever **996** causes the arm **1270** to move in a clockwise direction, whereupon the rearward end of the arm **1226** is depressed by movement of the lever **1264** and the forward portion is moved against the action of the spring **1228** out of engagement with the pin **1230** so that as the arm **1226** is moved by the cam **714** no motion is transmitted to the lever **1232** and the switches **1222**, **1224** are not opened. The lever **1232** is acted upon by a spring **1272** normally to maintain the pin **1230** in operative engagement with the arm **1226**.

A switch **1274** (FIGS. 43 and 74) is arranged to be operated by the cam shaft **290** to render the fuse setter inoperative while a shell is being carried to ramming position and another shell is indexed into the fuse-setting station. The cam shaft **290** carries a cam **1276** which acts through a lever **1278** to control the position of an arm **1280** (FIG. 74) of the switch **1274**. With the cam shaft at rest, as shown in FIG. 43, the switch arm **1280** is held in engagement with a contact **1282** of the switch **1274** but during the operation of the cam shaft the switch arm **1280** moves out of engagement with a contact **1282** and into engagement with a second contact **1284**, the purpose of which will become apparent as the description proceeds.

Operation

The first step in the operation of the gun is the loading of the magazine M. The shells are loaded in the magazine at the loading station, indicated in FIG. 3, by moving the arm **476** in a counterclockwise direction, thereby breaking the toggle links **456** (FIGS. 22 and 23) which opens the grippers **450** permitting the shell to be inserted therebetween. After a shell has been properly inserted in the magazine at the loading station, the arm **476** is released, whereupon the toggle links **456** are moved into alinement, causing the grippers to move into engagement with the shell. The shell is now indexed out of the loading station by operation of the rod **584** (FIGS. 2, 34 and 38). Before this rod can be operated, however, it is necessary to move the slide **600** of the switch **598** out of locking engagement with the arm **588** operated by the rod **584**. This movement of the slide **600** opens a circuit through the switch **598**, thereby rendering the solenoids **960**, **982** (FIG. 74) inoperative by deenergizing a relay **1300** which controls the circuits through these solenoids, as will be described. Deenergization of this relay by the switch **598** also opens the circuit through the fuse-setting motor **784**.

With the switch **598** open, the rod **584** may now be pulled by the operator to operate the clutch **296** (FIGS. 15 and 16) through link **620** (FIG. 38), arm **622**, shaft **624**, arm **628**, link **630**, lever **634** and shaft **364**. The movement of the rod **584** to trip this clutch also operates through the arm **588** (FIG. 34) and arm **614** to hold the plate **554** carrying the locking pins **544** in the position shown in FIG. 35, whereby the pins are maintained out of locking engagement with the shell holders **420**. This movement of the rod **584** also operates through the lever **1018** (FIGS. 43 and 44) to hold the latch **1002** in inoperative position so that the clutch **810** will not be shifted through the operation of the cam **714**, as such shifting of the clutch by this mechanism would upset the proper sequence of operation of the clutch during the fuse-setting operation, inasmuch as the solenoids **960**, **982** do not operate during the loading operation. The cam **1270** (FIG. 72) is also operated at this time to render the arm **1226** inoperative so that the switches **1222** and **1224** are not opened during the operation of the cam shaft **290**. These switches should be kept closed during the loading operation inasmuch as there is no counterrecoil of the gun during this operation to close these switches to permit the gun to be subsequently fired. The shell grippers at the fuse-setting station are prevented from opening during the loading of the magazine, thereby permitting loading the magazine to its full capacity. This is effected by operation of the lever **634** (FIG. 38) which moves the rod **524** axially, thereby moving the arm **522** to carry the cam roll **520** out of operative engagement with the cam **514**. Accordingly, the mechanism for opening the grippers in the fuse-setting station is rendered inoperative.

The clutch **296** now being tripped by movement of the rod **584**, the cam shaft **290** is turned through one complete revolution which, through the aforedescribed mechanism, indexes the shell holders in the magazine one space, whereupon a second shell may be inserted at the loading station. This operation is preferably repeated until the magazine has been filled to capacity with shells. It will be understood that until several shells have been inserted in the magazine there will be no shell at the fuse-setting station. Accordingly, the spring **748** (FIG. 42) operates to withdraw the block **722** thereby to prevent the fuse-cutter head **662** from being snapped by the spring **698** into fuse-setting position. However, after a sufficient number of shells have been inserted in the magazine so that a shell is located at the fuse-setting station, the block **722** is moved into operative position, whereupon the fuse-cutter head **662** snaps with sufficient force onto the shell so that the knives **674** cut into the fuse ring. Consequently, after the magazine is filled to capacity the fuse-cutter head is in fuse-setting position in readiness for the gun to be fired. The snapping of the fuse-cutter head onto the first round that moves into the fuse-setting position in no way affects subsequent loading of the magazine as the head will be retracted before the next indexing operation commences, as shown on the timing chart (FIG. 73).

The switch **598** is now closed, thus locking the rod **584** against outward movement. The closing of this switch (FIG. 74) energizes the relay **1300** as follows: from line wire Y through wires A1, A2, switch **598**, wire A3, the coil of relay **1300** and wires A4 and A5 to line wire Z. Energization of the relay through the closure of switch **598** closes the circuit through the fuse-setting motor **784** as follows: from line wire Y through wire A1, relay contacts B1, wires B2, B3, manually operated switch B4 (which is maintained closed during operation of the gun), wires B5, B6, B7 through the motor **784**, wires B8, B9, B10, B11 and A5 to the line wire Z. After the proper fuse-setting time has been determined, the arm **888** of the fuse-setter transmitter **880** is positioned in accordance with the desired fuse-setting time, which causes the arm **884** of the repeater **882** to be moved to a corresponding position. As soon as this has been done, assuming the gun has been properly aimed, a firing switch **1302** (FIGS. 1 and 74) is closed, thereby initiating the firing cycle of the gun.

The closure of the firing switch **1302** closes a circuit through a coil of relay **1304** as follows: from line wire Y through wires A1, contacts B1 of relay **1300**, wires B2, C1, switch **1302**, wire C2, coil of relay **1304** and wires C3 and A5 to the line wire Z. The energization of the

relay 1304 closes a circuit through the solenoid 960 which operates the clutch 810 (FIG. 47) to start the fuse-setting operation, this circuit being as follows: from line wire Y through wires A1, contacts B1 of relay 1300, wires B2, D1, D2, D3, arm 1280 of switch 1274, contact 1282 with which the arm is in engagement when the cam shaft 290 is at rest, wires D4, D5, D6 through switch 916 located at the upper end of the segment 862 (FIGS. 55 to 57) which is closed when the timing arm 860 of the fuse setter is in initial position, wires D7, D8, D9, D10, contacts D11 of relay 1304, wires D12, D13, switch 1224 (FIG. 71) which is closed at this time, wires D14, D15, D16, through the solenoid 960 and wires D17, D18, B9, B10, B11, A5 back to the line wire Z.

The energization of the solenoid 960 shifts the clutch 810 (FIGS. 44 and 47), whereupon the motor 784 which is now operating drives the fuse-cutter head in a direction to set the fuse of the shell. The fuse-timing arm 860 (FIG. 58) moves with the fuse-cutter head and the first portion of this movement opens the circuit through the switch 916 thereby interrupting the circuit through the solenoid 960. The brake pad 892 on the lever 890 (FIG. 59) is moved at this time into engagement with the disk 893 carried by the repeater shaft to hold the repeater shaft in the position to which it was moved prior to the beginning of the fuse-setting operation. The fuse-cutter head continues turning until the timing arm has carried the contact 902 into engagement with the contact 906 on the arm 884 connected to the repeater shaft. As soon as these contacts are engaged, the arm 872 (FIG. 58) is moved relatively to the arm 860 whereupon the pawls 864 are moved into engagement with the segment 862 to lock the arm 860 thereto, which interrupts the turning movement of the fuse-cutter head. At the same time, the clutch 810 is shifted to neutral position to interrupt the drive from the fuse-setter motor to the fuse-cutter head, as explained below.

The engagement of the contacts 902 and 906 energizes a relay 1306 (FIG. 74) of an electronic control device 1308 by completing a circuit between wires E1 and E2 leading to the electronic control device as follows: from wire E1 through wires E3, E4, E5 and E6, contacts 902, 906, wires E7, E8 and E9 to the wire E2. The coil of the relay 1306 is now energized, thereby establishing a circuit through a relay 1310 as follows: from the line wire Y through wires F1, F2, F3, F4, F5, F6, F7, F8, contacts F9 of the relay 1306, wires F10, F11, the coil of relay 1310 and wires F12 and A5 to the line wire Z. The energization of this relay closes a circuit through the solenoid 982 as follows: from line wire Y through wire A1, contacts B1 of relay 1300, wires B2, G1, the contacts of relay 1310, wires G2, G3, G4, G5 through the arm of the switch 918, which is now in the position opposite to that shown in FIG. 74 inasmuch as the timing arm of the fuse setter has moved out of its zero position, wire G6 through the coil of solenoid 982, and wires G7, D18, B9, B10, B11 and A5 to the line wire Z. The energization of the solenoid D shifts the clutch 810 back to neutral position, thereby interrupting the drive from the fuse-setter motor 784 to the fuse-cutter head. The fuse is now set and the parts are in the positions indicated by the timing chart of FIG. 73 in which the fuse-cutter head is at rest, the main cam shaft is at rest, the grippers at the fuse-setter station are closed, the transfer tray is at rest in engagement with the shell at the fuse-setting station and the rammer is at rest in its forward position.

The relay 1310 which is energized at the completion of the fuse-setting operation also closes a circuit through the solenoid 384 which operates the main drive clutch 296 to start the operation of the main cam shaft. The circuit through this solenoid is as follows. From the line wire Y through wire A1, contacts B1 of relay 1300, wires B2, G1 through the relay 1310, wires G2, G3, H1, H2, safety switch 1222, which is now in closed position, wire H3, solenoid 384 and wires H4, H5, B10, B11 and A5 to the line wire Z. Thus, as soon as the fuse has been set the desired amount, the rotation of the fuse-cutter head stops and the solenoid 384 is energized to start the rotation of the main cam shaft 290. At the beginning of the rotation of the cam shaft the cam 714 (FIG. 42) operates to move the fuse-cutter head forwardly out of engagement with the nose of the shell. After the came shaft has turned a slight amount and the fuse-cutter head is out of engagement with the nose of the shell, the cam 714 operates the mechanism shown in FIGS. 43 and 44 to operate the latch 1002, thereby shifting the clutch 810 to reverse the direction of movement of the fuse-cutter head, causing it to move back toward its initial or zero position. After it has been moved into initial position, the arm of switch 918 is moved back to the position shown in FIG. 74 again to energize the solenoid 982 through the following circuit: from line wire Y through wire A1, relay 1300, wires B2, D1, D2, D3, contact 1284 of switch J the arm of which has been moved out of the position shown in FIG. 74 by the cam 1276 (FIG. 43), the circuit then continuing through wires J1, J2, J3, switch 918, wire G6 solenoid 982 and wires G7, D18, B9, B10, B11 and A5 back to the line wire Z. The energization of the solenoid 982, which occurs by the operation of the switch 918 when the timing arm of the fuse setter has returned to its initial position, shifts the clutch 810 back to neutral position, whereupon the fuse-cutter head comes to rest.

Meanwhile the cam 514, driven by the main cam shaft (FIGS. 2 and 38) operates through the link 530, lever 532, link 538, crank 540 and shaft 504 to release the grippers at the fuse-setter station so that the shell, the fuse of which is now set, may be carried by the transfer tray into ramming position. Shortly after the shell is released, as indicated by the timing chart, the transfer tray starts to move down to carry the shell into ramming position. At approximately the same time the variable speed transmission 448 starts to operate to index the shells in the magazine and to carry another shell into the fuse-setting station. During the downward movement of the transfer tray the cam 1118 (FIG. 68) starts to move the shaft 1112 carrying the rammer rearwardly, and during this rearward movement of the rammer the cam 1140 (FIG. 69) starts turning the shaft 1102 to swing the arm 1110 of the rammer into position to engage the end of the shell. To save time, these movements of the rammer occur during the downward movement of the transfer tray so that when the tray reaches its lowermost position the rammer is positioned rearwardly of the shell in readiness to ram the shell into the firing chamber of the gun.

The rammer now starts to move forwardly, thereby moving the shell with it into the gun and during this ramming movement the transfer tray starts its return or upward movement into engagement with the shell which has been indexed into the fuse-setting station. As soon as a shell has been rammed into the firing chamber, the breech block closes, tipping the rammer arm upwardly to move it out of the way, after which the cam 1140 acts to hold the rammer arm in this position until the rammer has again been moved rearwardly during the subsequent firing cycle.

After the breech block is closed, the cam plate 516 on the cam 514 (FIGS. 70 and 71) operates through levers 1198, 1204, slide 1208 and link 1210 to operate the lever 1214 which releases the firing pin, whereupon the shell in the gun is fired. During this time the switches 1222 and 1224 are opened by the cam 714 (FIG. 72), thereby preventing closure of the circuit through the solenoid 384 controlling the main cam shaft clutch and the solenoid 960 which, when energized, initiates the fuse-setting operation. Upon counterrecoil of the gun, these switches are again closed by engagement between the gun and the pin 1254 (FIG. 72).

Prior to the firing of the shell the fuse-cutter head is moved into engagement with the round which has been indexed into the fuse-setting station of the magazine. If now the firing button 1302 has been held closed during

the cycle of operation, as soon as the switches **1222** and **1224** are closed by the counterrecoil of the gun the cycle will start again by the operation of the fuse-setting mechanism, setting the fuse to correspond to the last setting of the transmitter **888**, and the above cycle of operations will be repeated as indicated by the timing chart. Consequently, by maintaining the firing button depressed, automatic firing of the gun is made possible and the gun will continue firing until all the rounds in the magazine are spent. If automatic fire of the gun is not desired, the firing button is depressed only momentarily at the beginning of the firing cycle, whereupon the parts will come to rest in readiness for the next cycle of operation when initiated by subsequent depression of the firing button. Inasmuch as the different shell-handling mechanisms are operating simultaneously, so far as possible, without causing interference between the parts, it is possible to obtain a very high rate of fire of the gun with the apparatus herein disclosed. This is particularly desirable when using the gun against a fast-moving target, such as an airplane.

The fuse setter is not claimed herein but forms the subject matter of a divisional application Serial No. 754,856, filed June 16, 1947, in my name.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent of the United States is:

1. In combination, a gun assembly and a kidney-shaped shell magazine having upper and lower arcuate runs concentrically disposed relatively to the barrel of the gun assembly.

2. In combination, a gun assembly and a kidney-shaped shell magazine having upper and lower arcuate runs, said magazine being mounted rearwardly of and above said gun with said runs concentric with the barrel of the gun assembly.

3. In combination, a gun assembly, a kidney-shaped shell magazine having upper and lower arcuate runs, said magazine being mounted rearwardly of and above said gun with said runs concentric with the barrel of the gun assembly, means for indexing shells around said magazine, and means for transferring shells from the lower central portion of said magazine into alinement with the bore of the gun.

4. In combination, a gun assembly, a kidney-shaped shell magazine having upper and lower arcuate runs, said magazine being mounted rearwardly of and above said gun with said runs concentric with the barrel of the gun assembly, means for indexing shells around said magazine, and automatic means for transferring shells one by one from the magazine into alinement with the bore of the gun and for ramming each shell into the gun.

5. In combination, a gun assembly, a shell magazine comprising spaced kidney-shaped tracks having upper and lower arcuate runs, shell holders carried by said tracks, means for indexing said shell holders in arcuate paths along said tracks, and means mounting said magazine rearwardly of and above said gun with said runs concentric with the barrel of the gun assembly.

6. In combination, a gun assembly, a shell magazine comprising spaced kidney-shaped tracks having upper and lower arcuate runs, shell holders carried by said tracks, means for indexing said shell holders in arcuate paths along said tracks, means mounting said magazine rearwardly of and above said gun with said runs concentric with the barrel of the gun assembly, and means for transferring shells from the lower central portion of the magazine into alinement with the bore of the gun.

7. A shell magazine comprising a pair of spaced parallel endless tracks, a plurality of individual U-shaped shell holders carried by said tracks and arranged in pairs to support the forward and rearward portions of a plurality of shells, grippers associated with each shell holder for locking a shell therein, and means for moving said grippers out of engagement with each shell when the shell is in a predetermined position in the magazine.

8. A shell magazine comprising a pair of spaced, parallel endless tracks, a plurality of individual U-shaped shell holders carried by said tracks and arranged in pairs to support the forward and rearward portions of a plurality of shells, means for indexing the shell holders intermittently around said tracks, grippers associated with the shell holders for locking the shells therein, and means for automatically moving the grippers of each pair of shell holders out of engagement with a shell after the shell has been moved to a predetermined position in the magazine.

9. A non-circular shell magazine comprising a plurality of U-shaped shell holders arranged to support a plurality of shells in substantially horizontal positions, means guiding said holders for movement in a closed path having upper and lower runs, grippers carried by each of said shell holders for locking a shell therein, and means operative to retract each of said grippers after its associated shell holder has reached a predetermined position in the lower run of the path to permit removal of the shell therefrom.

10. A shell magazine comprising a plurality of U-shaped shell holders arranged to support a plurality of shells in substantially horizontal positions, means guiding said holders for movement in a closed path having upper and lower runs, grippers carried by each of said shell holders for locking a shell therein, and manually operable means to retract each of the grippers when its associated shell holder is in a predetermined position in the upper run of the path to permit loading the magazine.

11. A shell magazine comprising a plurality of U-shaped shell holders arranged to support a plurality of shells in substantially horizontal positions, means guiding said holders for movement in a closed path having upper and lower runs, grippers carried by each of said shell holders for locking a shell therein, automatic means operative to retract each of said grippers after its associated shell holder has reached a predetermined position in the lower run of the path to permit removal of the shell therefrom, and means for rendering said automatic means inoperative during loading of the magazine.

12. A shell magazine comprising a plurality of U-shaped shell holders arranged to support a plurality of shells in substantially horizontal positions, means guiding said holders for movement in a closed path having upper and lower runs, grippers carried by each of said shell holders for locking a shell therein, manually operable means to retract each of the grippers when its associated shell holder is in a predetermined position in the upper run of the path to permit loading the magazine, automatic means for retracting each of the grippers after the associated shell holder has reached a predetermined position in the lower run of the path to permit removal of the shell therefrom, and means rendering said last-named means inoperative during the loading of the magazine.

13. A shell magazine comprising a pair of endless parallel tracks, a plurality of U-shaped shell holders carried by said tracks and arranged to support a plurality of shells to be fed to a gun, a pair of shell grippers pivoted to each of said shell holders and arranged to lock a shell in the holder, toggles connecting said grippers and arranged when straightened to maintain the grippers in locking positions, plates associated with each of said tracks and arranged to be engaged by said toggles during feeding of the shells around the tracks to maintain said toggles straightened, said plates being provided with notches at predetermined points to permit breaking the toggles when the shell holders reach predetermined positions in the magazine, and means for breaking the toggle associated with each shell holder after movement of said shell holder into either one of said positions.

14. A shell magazine comprising a pair of parallel endless tracks around which a plurality of shells are disposed in substantially horizontal parallel relation, a plurality of U-shaped shell holders movable in said tracks

for carrying the shells therearound, a pair of grippers pivoted to each of said holders and arranged to engage a shell therein to prevent its removal from the holders, toggles connecting said grippers and arranged when straightened to maintain the grippers in locking engagement with the shell, plates associated with said tracks are arranged to engage said toggles to maintain them straightened, said plates each being provided in its lower portion with a recess to permit breaking of the toggles and release of a shell from the magazine after the shell has been moved into a predetermined position, and means for breaking the toggles after the shell has been moved into said position.

15. A shell magazine comprising a pair of parallel endless tracks around which a plurality of shells are disposed in substantially horizontal parallel relation, a plurality of U-shaped shell holders movable in said tracks for carrying the shells therearound, a pair of grippers pivoted to each of said holders and arranged to engage a shell therein to prevent its removal from the holders, toggles connecting said grippers and arranged when straightened to maintain the grippers in locking engagement with the shell, plates associated with said tracks and arranged to engage said toggles to maintain them straightened, said plates being formed in their upper portions with recesses to permit breaking of the toggles and retraction of the grippers to facilitate loading of the magazine, manual means for breaking said toggles after the shell holders have moved into said position, recesses in the lower portions of said plates arranged to permit breaking of the toggles after the shells have been moved into a predetermined position, automatic means for retracting said toggles after the shells have moved into said last-named position to permit removal of the shell from the magazine, and means for rendering said automatic means inoperative during loading of the magazine.

16. In combination, a gun, a shell magazine, means for indexing shells step by step in said magazine to a release station, means for transferring shells from the release station into a position in alinement with the bore of the gun, means for locking each shell against movement in any direction relatively to the transferring means during its transfer, and means for releasing the locking means at the end of the movement of the shell into alinement with the bore of the gun to permit ramming the shell into the gun.

17. In combination, a gun, a shell magazine, means for indexing shells step by step in said magazine to a release station, means for transferring shells from the release station into a position in alinement with the bore of the gun, means for locking each shell against movement in any direction relatively to the transferring means during its transfer, means for releasing the locking means at the end of the movement of the shell into alinement with the bore of the gun to permit ramming the shell into the gun, and means for ramming each shell from the transferring means into the firing chamber of the gun.

18. In combination, a gun, a shell magazine, means for indexing shells step by step in said magazine to a release station, means for locking each shell in the release station, a transfer tray, means for moving the transfer tray into position to receive a shell at the release station, means for releasing said locking means, means carried by the tray for locking the shell therein, and means for moving the tray to carry the shell into alinement with the bore of the gun.

19. In combination, a gun, a shell magazine, means for indexing shells step by step in said magazine to a release station, means for locking each shell in the release station, a transfer tray, means for moving the transfer tray into position to receive the shell at the release station, means for releasing said locking means, means carried by the tray for locking the shell therein, means for moving the tray to carry the shell into alinement with the bore of the gun, and means for releasing the locking means carried by the tray upon movement of the shell by the tray into alinement with the bore of the gun thereby to permit ramming the shell into the gun.

20. In combination, a gun, a shell magazine, a U-shaped transfer tray for carrying shells from the magazine into ramming position in alinement with the bore of the gun, a pair of doors pivoted to opposite sides of the transfer tray and arranged to hold the shell therein during transport of the shell to ramming position, means for locking said doors in shell-retaining positions, and means operative in response to movement of the tray into position to receive a shell in the magazine for releasing said locking means, said doors being arranged to be opened by the engagement of a shell with cam surfaces formed on the doors as the tray is moved into shell-receiving position.

21. In combination, a gun, a shell magazine, means for indexing shells step by step in the magazine into a release station, a transfer tray for carrying shells from the release station in the magazine into alinement with the bore of the gun, doors pivoted to opposite sides of the tray and arranged to hold the shell therein during its transport by the tray, and means for unlocking the shell at the release station in the magazine and simultaneously locking the doors of the transfer tray in shell-retaining positions.

22. In combination, a gun, a rammer for loading shells into the gun, a drive shaft for moving said rammer forwardly and rearwardly of the gun, and a spring acting on said rammer and arranged to be compressed during rearward movement of the rammer to assist the drive shaft during forward movement of the rammer to load the shell into the gun.

23. In combination, a gun, a rammer for loading shells into the gun, a drive shaft for moving said rammer forwardly and rearwardly of the gun, a spring acting on said rammer and arranged to be compressed during rearward movement of the rammer to assist the drive shaft during forward movement of the rammer to load the shell into the gun, and means operative during rearward movement of the rammer for moving a shell into ramming position in alinement with the bore of the gun.

24. In combination, a gun, a rammer for loading shells into the gun, a drive shaft for moving said rammer forwardly and rearwardly of the gun, a spring carried by said rammer, and means cooperating with said rammer during rearward movement thereof for compressing said spring whereby the spring acts during forward movement of the rammer to assist the drive shaft.

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