United States Patent

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[73] Assignee **The United States of America as represented by the Secretary of the Army**

[54] **AUTOMATIC REPLENISHER FOR THE HYDROPNEUMATIC RECOIL SYSTEMS OF LARGE CALIBER GUNS**
4 Claims, 3 Drawing Figs.

[52] **U.S. Cl.** ..... **89/43 R**
[51] **Int. Cl.** **F41f 19/02**
[50] **Field of Search** ..... 89/42 R, 42 A, 42 B, 43 R, 43 A, 44

[56] **References Cited**
UNITED STATES PATENTS
3,410,174 11/1968 Hahn 89/43

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ABSTRACT: In order to maintain a uniform starting point for the reciprocable piston in a hydropneumatic recuperator of the type utilized in the recoil systems of large caliber guns, a reservoir is jointly connected to each of the gas and oil chambers in the recuperator and is provided with a floating piston arranged to separate the oil and the gas into individual areas and maintain an equilibrium position therebetween arranged to return the recuperator piston against a fixed stop at the end of each firing cycle regardless of any change in the volume of the oil.

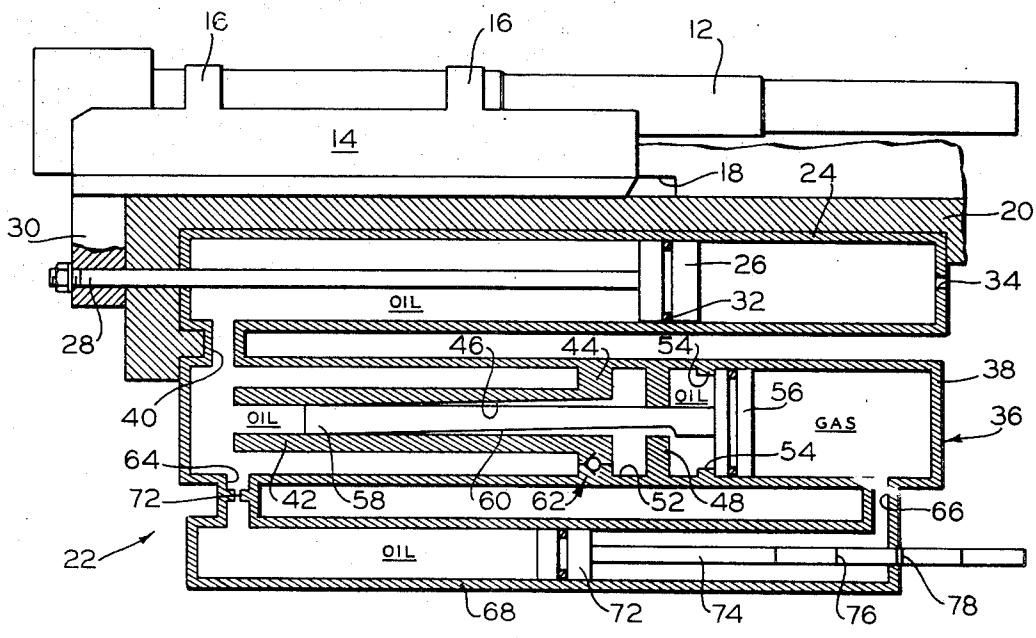

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Fig. 1

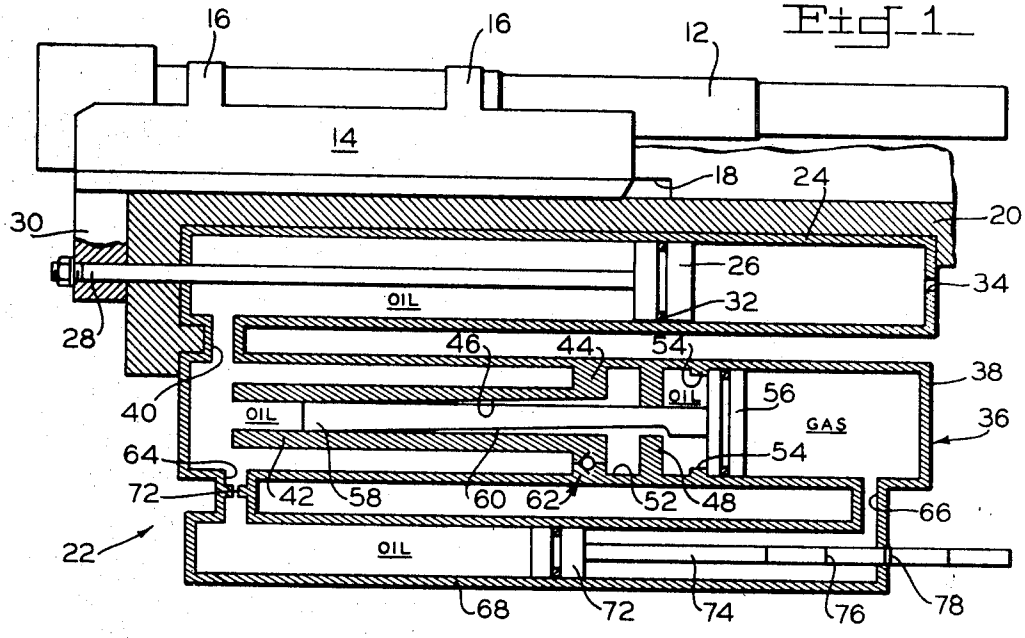
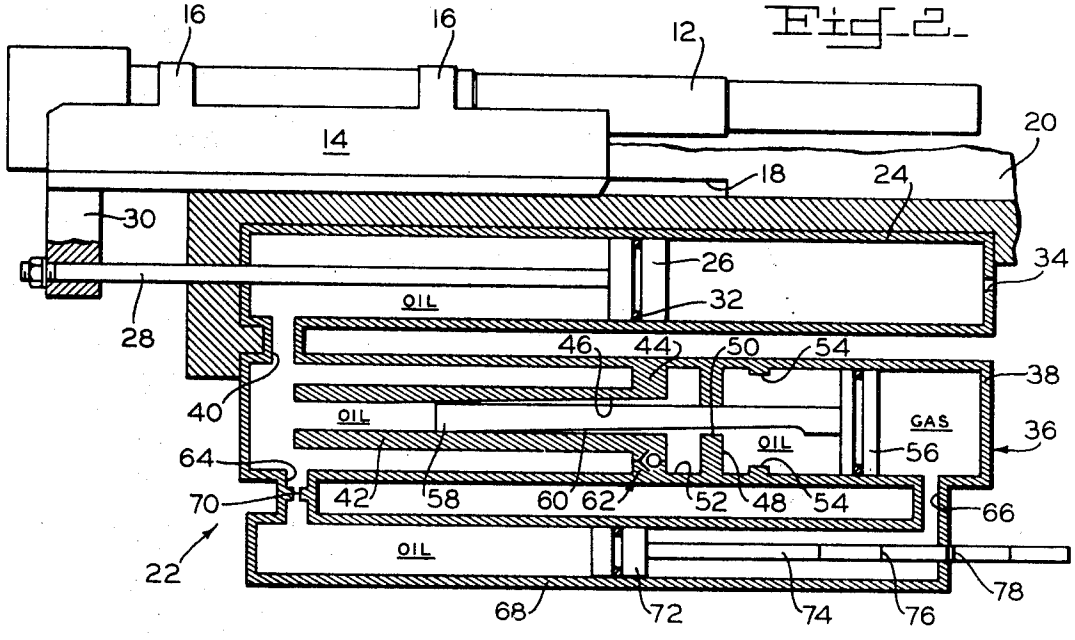


Fig. 2



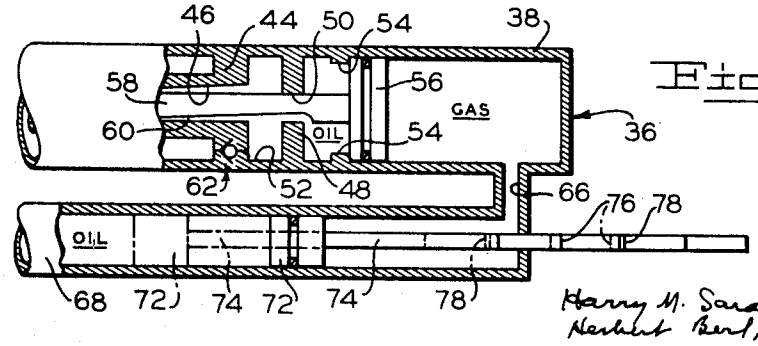


Fig. 3

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AUTOMATIC REPLENISHER FOR THE HYDROPNEUMATIC RECOIL SYSTEMS OF LARGE CALIBER GUNS

BACKGROUND OF THE INVENTION

The present invention relates to hydropneumatic recoil systems for artillery weapons and is more particularly directed to means for insuring relative uniformity to each return of the recoiling parts to battery position despite any change in the volume of the hydraulic oil in the recoil system.

In current recoil systems for artillery weapons of relatively large caliber, the flow of the hydraulic oil from the recoil cylinder to the recuperator during the recoil phase of the firing cycle is customarily utilized to actuate a floating piston in the recuperator for compressing a quantity of nitrogen gas therein to furnish the motive power for the subsequent return of the recoiling parts to battery position. The required oil flow is, in turn, achieved by the displacement of a piston head slidably seated in the recoil cylinder with a stem extending exteriorly thereof into fixed engagement with the recoiling parts. In order to ensure substantially equal trunnion forces from one firing cycle to the next, the floating piston in the recuperator must be returned to essentially the same starting point at the conclusion of each firing cycle. Such requirement can be simply achieved by the provision of a fixed stop within the interior of the recuperator in the counterrecoil path of the floating piston. However, since the heat generated in the recoil system during the relatively sustained firing frequently required in modern warfare generally produces an unpredictable increase in the volume of the hydraulic oil therein, considerable difficulty has been encountered in maintaining the desired uniformity in the starting point of the floating piston.

It has been suggested, therefore, that a spring-operated member be slidably interposed between the head of the floating piston and the nitrogen gas to accommodate the expanded volume of the hydraulic oil without disturbing the required abutment between the piston head and the fixed stop in the recuperator. However, this expedient has not proven satisfactory inasmuch as the expansion of the oil frequently reaches such proportions that the slidable member carries the spring entirely out of contact with the piston head thereby eliminating the restraint necessary to maintain the latter against the fixed stop. While the bias of the spring could be increased sufficiently to cope with the anticipated change in the volume of the oil, the resulting increase in the size and weight thereof would be prohibitive.

Accordingly, it is an object of this invention to provide a hydropneumatic recoil mechanism in which the hydraulic oil is automatically maintained at a relatively constant pressure despite any leakage or heat expansion thereof.

A further object of this invention is to provide a replenisher unit for the aforesaid recoil mechanism which will operate to return the floating piston in the recuperator to the same starting position at the end of each firing cycle regardless of changes in the volume of the oil therein.

Still another object of the present invention lies in the provision of a replenisher unit as aforesaid which will automatically compensate for any loss or gain in the volume of the oil without the need for a mechanical spring.

SUMMARY OF THE INVENTION

It has been found that these objects can best be attained by adding a replenisher unit to the recuperator in the form of a cylindrical reservoir in respective communication with both the oil and gas portions thereof and providing a slidable piston in the reservoir to separate the oil from the gas. The gas side of the reservoir piston is formed with a rod extending outwardly through the corresponding end of the cylinder to serve as an indicator for any change in the volume of the oil in the entire recoil mechanism. The resulting reduction in the reservoir piston area exposed for contact by the nitrogen gas results in a differential pressure which, under static conditions, will permit the reservoir piston to compensate for changes in the volume of the oil while the initial higher pressure of the gas continues to maintain the recuperator piston against the fixed stop. Thus, in the event of an increase in the volume of the oil, the corresponding increase in the pressure thereof will actuate the reservoir piston to a new equilibrium position without changing the position of the recuperator piston. Such is also the case in the event of any decrease in oil inasmuch as the compressed nitrogen gas will displace the reservoir piston until equilibrium is again attained. The oil passage between the recuperator and the reservoir is restricted to such extent that oil will not flow therethrough during the actuation of the recoiling parts.

BRIEF DESCRIPTION OF THE DRAWINGS

The exact nature of the invention as well as other objects and advantages thereof will be readily apparent from consideration of the following specification relating to the annexed drawings wherein:

FIG. 1 is a schematic sectional representation of a hydropneumatic recoil unit for a gun of large caliber, such unit being secured to the underside of the stationary cradle in which the carrier for the gun tube is slidably mounted and shown in the battery position thereof;

FIG. 2 is a view similar to that of FIG. 1 but showing the relationship of the parts during the initial portion of the recoil cycle; and

FIG. 3 is a fragmentary schematic sectional representation showing the recuperator piston at the conclusion of a firing cycle and the different positions of the reservoir piston at such point, the latter being shown in full in the position required to compensate for an increase in the volume of the oil and shown in phantom in the position required to compensate for a decrease in the volume of oil.

DESCRIPTION OF A PREFERRED EMBODIMENT

Referring more particularly to the drawings wherein similar reference characters have been employed to designate corresponding parts throughout, there is shown a large caliber gun tube **12** to which a suitable carrier **14** is fixedly secured as by rings or loops **16**. Carrier **14** is, in turn, slidably mounted in a longitudinal track **18** within the interior of a stationary cradle **20**. Fixedly mounted to cradle **20** is a recoil unit **22** which, for simplicity of explanation, is here schematically illustrated and consequently does not show the actual size and relative position of the various components thereof. However, it should be understood that the forward and rearward ends of recoil unit **22** are oriented in the same respective directions as the muzzle and breech ends of gun tube **12**.

Recoil unit **22** includes a recoil cylinder **24** suitably fastened to cradle **20** and a piston **26** slidably disposed in cylinder **24**. Piston **26** is provided with a rod **28** which extends through the rearward end wall of cylinder **24** into fixed engagement with a depending portion **30** of carrier **14**. The portion of cylinder **24** through which rod **28** passes is utilized to house a quantity of hydraulic fluid, such as recoil oil, ad piston **26** is therefore provided with a suitable seal **32** arranged for slidable contact with the interior wall surface of cylinder **24**. The forward end wall of cylinder **24** is provided with an opening or outlet **34** therethrough to permit exhaustion of the air therefrom during the counterrecoil stroke of piston **26**.

A recuperator **36** preferably formed with a cylindrical housing **38** is connected to recoil cylinder **24** to form an oil passage **40** therebetween in the vicinity of the rear end wall thereof. Within housing **38** and in spaced relation to the interior wall surface thereof is a concentric tubular member **42** terminating in an enlarged flange portion **44** at the forward end thereof extending into integral connection with housing **38**. The interior of tubular member **42** is provided with a plurality of circumferentially spaced longitudinal throttling grooves **46** originating at a point slightly more than halfway therealong and extending forwardly out to flange portion **44** with a progressively

increasing depth. The rear end of tubular member **42** is spaced forwardly of the corresponding end wall of housing **38** to open into the vicinity of oil passage **40**. A barrier wall **48** with a central hole **50** therethrough is formed within housing **38** in spaced relation to the front end of flange portion **44** to form an accumulation chamber **52** for the oil flowing through tubular member **42**. Forwardly of wall **48**, the interior wall surface of housing **38** is provided with oppositely disposed lugs or stops **54** which serve to establish the starting point for the reciprocating travel of a piston **56** provided with a longitudinally extending control rod **58** slidably engageable in tubular member **42**.

A plurality of throttling slots **60** of progressively increasing depth are circumferentially spaced about the exterior periphery of control rod **58** and extend from the rear end thereof to a length which will terminate slightly forwardly of barrier wall **48** when the rear end of piston **56** is in abutment with stops **54**. Forwardly of the head of piston **56**, housing **38** is filled with nitrogen gas which is arranged to be compressed by piston **56** during the forward stroke thereof in order to provide the motive power required to return the recoiling parts of the gun to the battery position thereof. A check valve **62** is contained in flange portion **44** to permit oil to flow into accumulation chamber **52** during the forward movement of piston **56** and yet operate to block any flow therethrough during the return movement of piston **56**.

Suitable ducts **64** and **66** extending from opposite end portion of recuperator **36** provide for the coextensive connection thereto of a generally cylindrical replenisher **68**. Duct **64** is formed with a restricted opening **70** therein which effectively prevents any surging of the oil therethrough during the movement of control rod **58** and yet, once such rod comes to a halt, permits oil to flow between recuperator **36** and replenisher **68** in the event of any change in the volume of the oil. Duct **66**, on the other hand, is of sufficient diameter to permit ready passage of the nitrogen gas therethrough in either direction responsive to the movement of piston **72** slidably seated in replenisher **68** in sealing engagement with the interior wall surfaces thereof. Piston **72** is also provided with a forwardly extending rod **74** projecting out through the front end wall of replenisher **68** and provided with spaced indicia **76** arranged to indicate the quantity of oil within the entire system. One of the indicia is specifically located and marked, as at **78**, so as to be positioned slightly beyond the forward end wall of replenisher **68** in the absence of any increase or decrease in the volume of the oil. The differential area formed by the opposite faces of replenisher piston **72** is such that the pressure of the gas thereon is at all times slightly greater than the pressure of the oil.

During the recoil movement of gun tube carrier **14** in cradle **20**, piston **26** is pulled along therewith to force oil from recoil cylinder **24** into recuperator **36**. The force thus applied against the rear end of control rod **58** displaces piston **56** out of contact with stops **54**. As control rod **58** moves forwardly, throttling slots **60** therein and throttling grooves **46** in the tubular member **42** are both exposed for the passage of oil therethrough. At the same time, the flow of oil into recuperator **36** opens check valve **62** to increase the quantity which will pass through accumulation chamber **52** and act against the rear face of the head on piston **56** to continue the forward movement thereof. Piston **56** continues forwardly until the recoil forces produced by the firing of the gun are absorbed by the combination of the frictional forces opposing such travel, the pressure drop in throttling grooves **46**, and the increasing compression of the nitrogen gas. As the gas is thus compressed, piston **72** in replenisher **68** remains virtually stationary since it is isolated from transient conditions in the pressure of the oil by restricted opening **70** in duct **64**.

During the counterrecoil or return travel of control rod **58**, the compressed nitrogen gas in recuperator **36** actuates piston **56** to force oil back into recoil cylinder **24** and thereby operate piston **26** to return carrier **14** to the battery position in cradle **20**. As oil begins to flow rearwardly through accumulation chamber **52**, check valve **62** is closed to limit the flow of oil to the space between control rod **58** and tubular member **42**. Since throttling grooves **46** and slots **60** decrease in depth in a rearward direction, the resulting resistance to the rearward travel of control rod **58** prevents excessive impact of carrier **14** against the mating portion of cradle **20**. In the event the oil in the system expands due to the heat engendered therein by any relatively sustained firing operation of the gun and thereby prevents control rod piston **56** from reaching stops **54** once the recoiling parts have attained battery position, the resulting imbalance of the forces on replenisher piston **72** will automatically adjust the latter to permit the excess oil in the recuperator **36** to flow therefrom into replenisher **68** through restricted opening **70**. Thus, recuperator piston **56** will return to its starting position in contact with stops **54**. In the event any leakage of the oil or any substantial drop in the temperature thereof produces a decrease in volume which will permit control rod piston **56** to reach stops **54** before the recoiling parts attain battery position, the imbalance of the forces on replenisher piston **72** will automatically move the latter rearwardly, as best indicated in FIG. **3**, to force additional oil through restricted opening **70** into recuperator **36** to restore the volume originally contained therein and in recoil cylinder **24**.

Thus, there is here provided improved means for compensating for any loss or gain in the volume of the oil in a combined recoil and recuperator system in order to ensure the return of the recuperator piston to the same starting position for each firing cycle. The use of a floating piston in an added replenisher separately connected to each of the oil and gas portions of the recuperator is a simple yet positive expedient for maintaining the required equilibrium between the oil and gas pressures at the beginning of each firing cycle.

We wish it to be understood that we do not desire to be limited to the exact details of construction shown and described, for obvious modifications will occur to a person skilled in the art.

We claim:

1. In a large caliber gun having a hydropneumatic recoil mechanism including a recuperator unit with a reciprocating piston responsive to the recoil flow of oil thereagainst for compressing a quantity of nitrogen gas to provide the motive power for returning the recoiling parts of the gun to battery position, means for returning the recuperator piston to the same starting position at the end of each firing cycle comprising,

a replenisher connected to each end of the recuperator, and

a piston slidably seated in said replenisher between the oil and

the gas therein to maintain an equilibrium position responsive

to changes in the quantity of oil within the entire recoil mechanism.

2. The invention defined in claim **1** wherein said replenisher piston is contoured to produce a differential pressure thereon responsive to changes in the volume of the oil in the recoil mechanism.

3. The invention defined in claim **1** wherein said replenisher piston comprises a head and a rod extending from one side of said head through the nitrogen gas to project outwardly of said replenisher whereby the area exposed to the oil is larger than the area exposed to the gas to provide a differential pressure thereagainst for normally urging said piston to compensate for changes in the volume of oil.

4. The invention defined in claim **1** wherein the connection between the recuperator and said replenisher includes a restricted passage for preventing the flow of oil therebetween during the reciprocation of the recoiling parts without affecting the required equalization of the pressure between the oil in the recuperator and the oil in said replenisher following the termination of the counterrecoil movement of the recoiling parts.