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2,847,784

PRE-STRESSED OPEN-CHAMBER GUN WITH ROTATABLE CYLINDER

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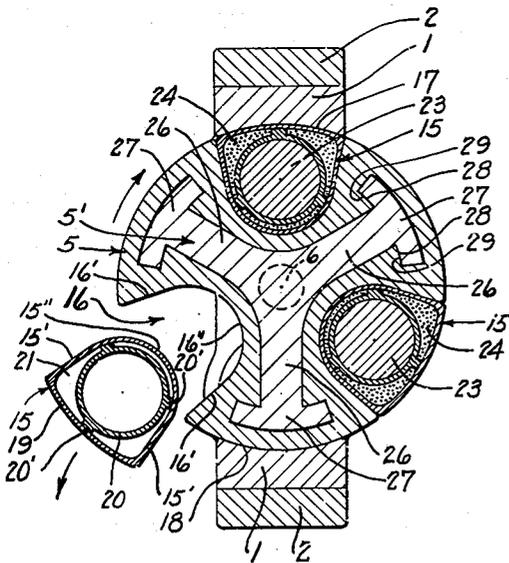
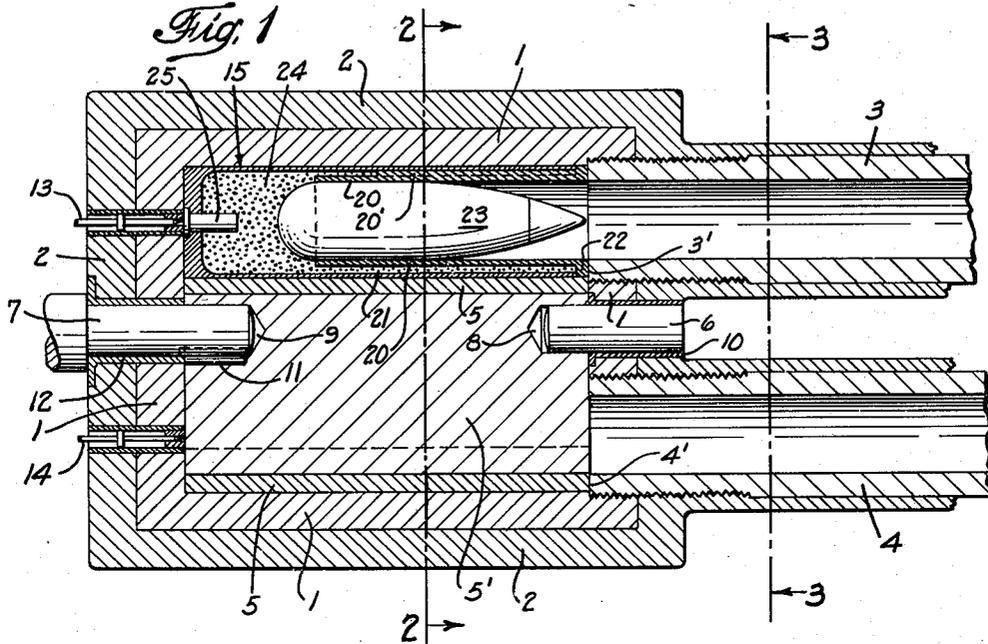


Fig. 2

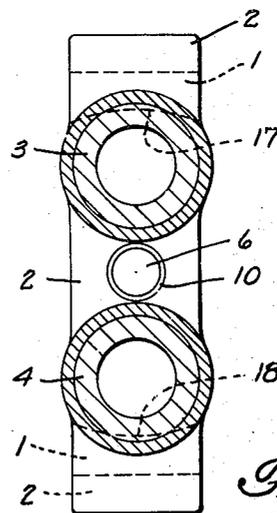


Fig. 3

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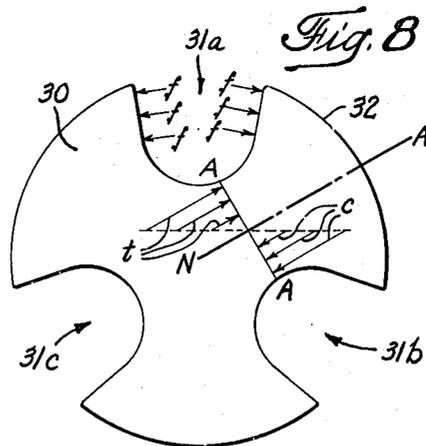
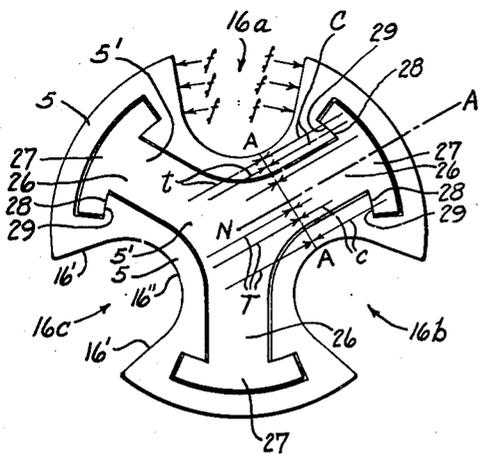
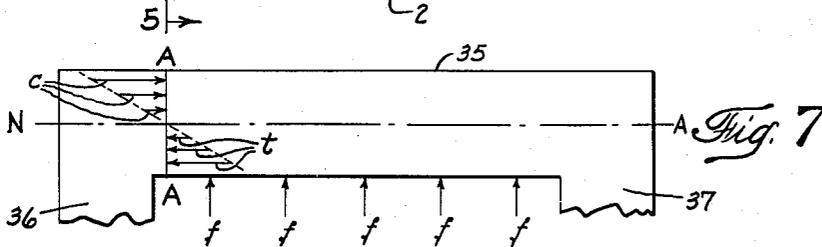
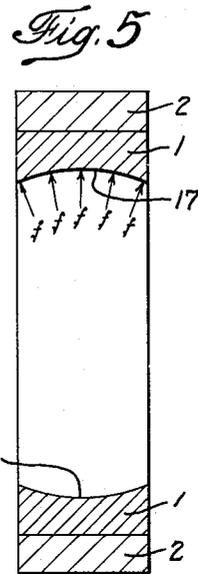
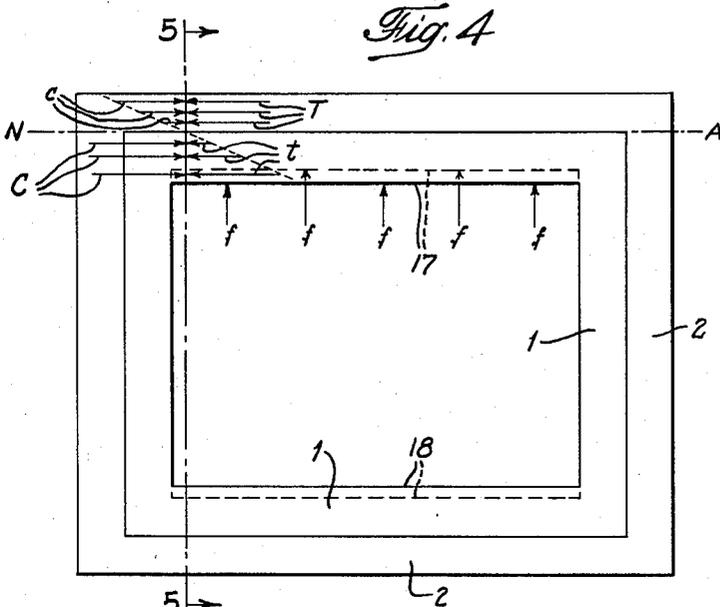


Fig. 6

Fig. 8

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PRE-STRESSED OPEN-CHAMBER GUN WITH ROTATABLE CYLINDER

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4 Claims. (Cl. 42—39.5)

This invention relates to open-chamber guns and relates more particularly to open-chamber guns of utility especially for the firing of high pressure shells or cartridges.

One of the major obstacles to the development of successful open-chamber gun applications, particularly with high pressure weapons, is the fact that because of the high firing stresses very high beam moments are encountered resulting in relatively high deflections of chamber-forming members, of the gun.

This condition permits cartridge cases, when fired, to expand beyond their elastic limit, thereby making them swell permanently and making their ejection from the gun extremely difficult. This is particularly true as respects open-chamber guns having, as chamber-forming members, a rotary cylinder structure and a breech structure which encloses or frames the cylinder structure in the plane of the cylinder axis and serves as a relatively stationary journal-mounting therefor. In such guns, the difficulty of ejection can become extreme both as regards sliding of the case past the stationary breech structure, and ejection of the case out of the cylinder structure.

It is therefore an object of this invention to overcome such obstacles and to prevent such undue expansion and attendant defects, by minimizing such beam deflections and, as a corollary thereto, to minimize such stresses so as to enable the use of lighter structures for equivalent stresses, through the provision in an open-chamber gun of pre-stressed chamber-forming members having permanent stresses therein which are opposite in sign to temporary stresses induced by the firing loads and, by serving to oppose said temporary firing stresses, will minimize or prevent deflections which would permit expansion or swelling of cartridge or shell cases beyond their elastic limit.

It is another object of this invention to provide an improved open-chamber gun of utility especially for the firing of high pressure ammunition.

It is another object of this invention to provide an improved open-chamber gun with which cartridge or shell cases of material having a relatively lower elastic limit than has heretofore been practically permissible, may be used.

Other and further objects of this invention will appear from the accompanying drawings, the following description and the appended claims.

In accordance with this invention, stresses of opposite sign are produced in a given chamber-forming member by making the member of an inner and outer part, the relative dimensions of which are such that, for assembly, one or the other must be expanded by heat so that on cooling permanent stresses will be created therein opposite in sign to the temporary stresses induced in the member by the firing loads.

Speaking generally, the open-chamber may be considered as formed by a breech portion and a cylinder portion each having a surface concavity and movable relative

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to each other into and out of a position wherein the two concavities co-act to form the chamber.

In analyzing deflection occurring in the breech portion of the open-chamber, one may consider the breech portion as a beam, fixed at both ends, and subjected to a uniformly distributed unit load, upon firing.

As in any beam structure of this type, the greatest stresses, due to flexure, are produced at the supports, while the greatest deflection occurs at the center of the span. Considering the area of the breech portion adjacent to the supports, the firing load produces tensile stresses in the section of this area which is at the inner or chamber side of the neutral axis of the beam formed by the breech portion, and produces compressive stresses in the section of this area which is at the opposite side of the neutral axis. The stress in the plane containing the neutral axis is zero.

In accordance with this invention deflection at the center of the breech portion is minimized or prevented by creating permanent equalizing stresses in the breech portion which are opposite in sign to the temporary stresses induced therein by the firing loads. To this end, the breech structure is constructed as a built-up structure comprising an inner member and a mating outer member, with the junction occurring at the plane of the neutral axis of the resultant structure, considered as a unitary structure. This may be accomplished by making the outer member so that its interior dimensions are smaller than the exterior dimensions of the inner member at normal temperatures. The outer member may then be expanded, by heat, and shrunk over the inner member while in this condition. The inner member may also be refrigerated to reduce its size prior to assembly.

Depending upon the temperature differential, it is possible to pre-stress the members by as much as 100,000 lbs./sq. in., in steel structures. Since the stresses due to the firing loads would be of opposite sign, in each member, the ordinary pre-stressing would tend to equalize these firing stresses thereby producing minimum beam deflections, or permitting the use of lighter structures for equivalent stresses, all as above mentioned.

The cylinder portion of the open-chamber may be considered as two integrally connected sections of the cylinder structure. These lie at opposite sides of the plane containing the cylinder axis of the structure and are of a surface configuration to provide a trough or recess therebetween which is symmetrical with said plane and serving to receive, and then transport, a round of ammunition into the chamber-forming position.

In analyzing deflection occurring in the cylinder portion of the open-chamber, one may consider each such section as a cantilever beam, fixed at one end, and subjected to a uniformly distributed unit load, upon firing. As in any beam structure of this type, it is obvious that the greatest flexure of each such section would occur at the tip of the section and the greatest stress, due to flexure, would occur close to the base of the section, that is, close to the bottom of the recess. Considering the area of the cylinder portion of the open-chamber adjacent the base of each such section, the firing load produces tensile stresses in the portion of this area which is at the inner or chamber side of the neutral axis of the beam formed by the section, and produces compressive stresses in the portion of this area which is at the opposite side of the neutral axis. The stress in the plane of the neutral axis, is zero.

In accordance with this invention, this flexure of the cantilever sections, and hence the tensile stress at the base, is minimized or reduced by creating permanent equalizing stresses in the cylinder, which are opposite in sign to the temporary stresses induced therein by the firing loads. To this end, the cylinder structure also is

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constructed as a built-up structure comprised of an inner member, or core, and an outer member, or jacket, containing or forming the cylinder portion of the open chamber. Speaking generally, the core is normally smaller than the bore of the jacket but is of a configuration such that it must be expanded for assembly with the jacket. Upon heating, the core expands, permitting the assembly. As thermal equilibrium is established and the core shrinks, a permanent tensile stress is produced in the core, and a compressive stress in the jacket and hence in the cantilever sections of the cylinder portion of the open chamber. These are, again, opposite to the stresses produced during firing, thus minimizing or preventing deflections and tending to equalize the firing stresses.

In the accompanying drawings which form part of the instant specification and in which like numbers refer to like parts throughout the several views:

Fig. 1 is a fragmentary view in section of an open-chamber gun embodying this invention;

Fig. 2 is a view in section taken along the line 2—2 of Fig. 1, the view showing one loaded chamber of the three chamber cylinder depicted, in firing position, the second in loading position, and the third in ejecting position with an empty cartridge case being discharged;

Fig. 3 is a view in section taken along the line 3—3 of Fig. 1;

Fig. 4 is a semi-diagrammatic view in side elevation of a pre-stressed stationary breech structure in accordance with this invention, the view serving to illustrate, diagrammatically, stress in the breech structure under firing loads;

Fig. 5 is a view in section taken along the line 5—5 of Fig. 4;

Fig. 6 is a semi-diagrammatic view in end elevation of a pre-stressed cylinder structure in accordance with this invention, the view serving to illustrate, diagrammatically, stress in the cylinder structure under firing loads;

Fig. 7 is a fragmentary diagrammatic view in side elevation of an unstressed breech structure serving to illustrate diagrammatically stress therein due to the firing loads; and

Fig. 8 is a semi-diagrammatic view in end elevation of an unstressed cylinder structure serving to illustrate diagrammatically stress therein due to the firing loads.

Referring now more particularly to the open chamber gun depicted in Figs. 1 to 3 inclusive, inner and outer rectangular breech members 1 and 2, respectively, together form a stationary breech structure which serves to support, at one end, upper and lower gun barrels 3 and 4, respectively, the barrels paralleling each other and being threadedly received within the breech members so as to permit their removal at will.

The outer breech member 2 has internal dimensions which are smaller than the external dimensions of the inner breech member 1 at normal temperatures. Assembly is effected by expanding the outer member, by heat, and sprinkling it over the inner member while in this condition. In consequence, the inner member 1 is subjected to a permanent compressive stress while the outer member 2 is subjected to a permanent tensile stress. Assembly may also be facilitated, if desired, by refrigerating the inner member to reduce its size prior to assembly. The respective junctures between the top rails and the bottom rails of the members 1 and 2, as viewed in Fig. 1, are each in or substantially in the plane of the neutral axis of each pair of abutting rails, considered as a solid member, as will be more fully discussed hereinafter.

A cylinder structure comprised of jacket 5 and core 5' is mounted for rotation on its cylinder axis in the stationary breech structure with the cylinder axis paralleling, and in the plane of the longitudinal axis of the gun barrels. The core 5', considered as a unit, is smaller in its external dimensions at normal temperatures than the bore of the jacket 5 in which it is assembled. It is also of a configuration such that in order for assembly to be

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effected, it must be expanded, by heat, and then inserted in the bore. As thermal equilibrium is established and the core shrinks, a permanent tensile stress is produced in the core 5' and a permanent compressive stress is produced in the jacket 5 as will be more fully discussed hereinafter.

The breech structure is provided with coaxially aligned shafts 6 and 7 extending into recesses 8 and 9, respectively, in and concentric with the cylinder structure. The shaft 6 is preferably keyed to the core 5' and journalled for rotation therewith in a sleeve bearing 10 carried by the breech structure. Likewise, the shaft 7 is keyed to the core 5' as by a key 11 and is journalled for rotation with the cylinder structure in a sleeve bearing 12 carried by the breech structure. Suitable drive means (not shown) may be connected to the shaft 7 for rotating the cylinder structure relative to the breech structure and preferably in a clockwise direction as indicated in Fig. 2.

Firing means, such, for example, as the firing pins 13 and 14 carried by the breech structure and disposed in coaxial alignment with the gun barrels 3 and 4, respectively, and adapted to be energized by means (not shown) for firing cartridges or shells 15 carried by the cylinder structure in identical troughs or recesses 16 formed in the jacket 5, for movement into firing position in alignment with the respective upper and lower gun barrels.

The cylinder jacket 5 as here preferably embodied, is provided with three such troughs 16 each preferably having straight side walls 16' converging from top to bottom and terminating at the bottom of the trough in a circular bottom wall 16". The cartridges 15 have side walls 15' and a bottom wall 15" of a corresponding configuration so as to be received within and fit snugly against the side and bottom walls of the trough and be supported thereby, during the firing.

The open top of each trough is adapted to be closed by the stationary breech structure when the trough is brought into firing position in alignment with one or the other of the gun barrels. To this end, the inner member 1 of the stationary breech structure has upper and lower arcuate breech surfaces 17 and 18 (as viewed in Fig. 2) which are coextensive in length with the troughs and are surfaces of a common cylinder whose diameter is substantially the same as that of the cylinder jacket 5 so as to permit relative rotation. The cartridges 15 have an arcuate wall 19 of radius of curvature the same as that of the cylinder jacket 5 so that with a cartridge in the trough, the top or mouth of the trough is spanned by the wall 19 of the cartridge and may be capped by the arcuate breech surface 17 when a trough is aligned with the upper gun barrel as depicted in Fig. 2, and capped by the arcuate surface 18 when a trough is aligned with the lower gun barrel. Thus, the top and bottom portions of the built-up breech structure over the length of the arcuate breech surfaces 17 and 18, respectively, may be considered as the breech portion of the open chamber.

Each of the troughs 16 is open at its opposite ends so that the cartridge case 15 in a given trough in firing position, as in Fig. 1, will be opposed at one end by the breech end of the gun barrel with which it is aligned, for example, the breech end 3' of gun barrel 2 as in Fig. 1, and will be opposed at its opposite end by the inner member 1 of the stationary breech structure.

The cartridge case 15 as shown is of non-circular configuration as is each trough of the cylinder structure 5. However, by reason of the pre-stressing of the breech structure and the cylinder structure in accordance with this invention, a circular case is within the contemplation of this invention since expansion of the case beyond the elastic limit of its material will be prevented by the pre-stressing. The case 15, as here preferably embodied, is closed at one end and open at the other and is provided with an internal obturating sleeve 20 which is co-equal in internal diameter with the bore of the gun barrels 3 and 4 and is of cylindrical shape throughout its length. The

sleeve 20 is annularly spaced from the case by spiders 20' to provide a generally annular chamber 21 between case and sleeve in which the propellant gases may expand and press an annular obturating flange 22 connecting sleeve 20 and case 15 at the open end of the case, into firm sealing engagement with the breech end of the aligned gun barrel. The obturating sleeve 20 is adapted to contain and yieldably sealingly hold a projectile 23 to be propelled through the gun barrel by burning of the propellant 24 when fired. The primer 25 in the closed end of the case is energized electrically or mechanically by the firing means 13 or 14 as the case may be. It will be observed that the cartridge case 15 with its internally contained projectile 23 and propellant 24 constitutes a telescoped round of ammunition.

The core 5' as here preferably embodied, is provided with three identical symmetrically positioned lobes 26 each extending radially outwardly from the hub of the core and disposed between a pair of the three symmetrically positioned recesses 16. Preferably, each lobe is symmetrical about its radial plane and terminates in a traction head 27 having at opposite sides of the lobe plane of symmetry, a pair of traction surfaces 28 for engaging complementary pressure surfaces 29 of the cylinder jacket 5. Advantageously, the traction heads 27 are segments of a common cylinder co-axial with the jacket 5, the traction surfaces 29 being portions of the inner surface of the cylinder. The core 5', though of similar configuration to the bore of the jacket 5, is slightly smaller in cross section normal to the cylinder axis than the corresponding cross section of the bore. Thus, at thermal equilibrium there will be a slight clearance between the core and jacket over the opposing surface areas except over the contacting traction and pressure surfaces 28 and 29, respectively.

This condition is illustrated in exaggerated form in Fig. 6 wherein the traction surfaces 28 abut and are in powerful pressure contact with the pressure surfaces 29 while the remaining opposing surfaces of core and jacket are spaced apart. It will be understood that the spacing need be sufficient only to ensure that when, prior to axial assembly of the core and jacket, the core 5' is expanded, by heat, to effect lengthening of the lobes 26 sufficient to permit traction head surfaces 28 to slide axially past pressure surfaces 29, there will be sufficient clearance between the other opposing surfaces of core and jacket to permit the assembly. As a practical matter, the clearance need be only sufficient for the purpose.

As a result of the pressure exerted by the traction surfaces at thermal equilibrium, the section of the jacket 5 adjacent the bottom of each recess, that is, in the cylinder portion of the open chamber, is in a permanent state of compression while each of the lobes 26 is in a permanent state of tension. This permanent compressive stress in the area of the cylinder portion of the open chamber adjacent the bottom of the recess, is opposite in sign to the temporary tensile stresses induced in the same area by the firing loads.

For the purposes of a comparative study of this relationship, reference may first be had to Fig. 8 which indicates diagrammatically a probable temporary stress pattern due to firing loads in the cylinder structure 30 of a known type of open-chamber gun having recesses 31a, 31b and 31c for the cartridge or shell case (not shown). In this case, the distributed unit load on the walls of the recess 31a, for example, under firing conditions, is denoted as f , and the plane of the neutral axis of the cantilever beam structure 32 between recess 31a and the adjacent recess 31b, is denoted by the dash dot line N—A. In such case, the temporary stress pattern of the beam 32 in the area at the base of the beam represented by the solid line A—A, will be one of tensile stress t on the side of the neutral axis occupied by the recess 31a, and one of compressive stress c at the opposite side. This temporary tensile stress decreases in known manner, as indicated in Fig. 8, from a maximum at the bottom of the recess 31a,

to zero at the neutral axis, with a corresponding variation in the compressive stress c at the opposite side.

Referring now to Fig. 6, it will be seen that if the neutral axis of the cantilever beam represented by the segment of the built-up cylinder structure between the adjacent recesses 16a and 16b, for example, be considered as represented by the dash-dot line N—A, the pattern of temporary tensile stress t and compressive stress c in the area at the base of the beam represented by the line A—A, due to the uniformly distributed firing loads f in the recess 16a, will correspond generally to the pattern of Fig. 8. However, because of the permanent compressive stress C created by the shrunk core 5' in the portion of this area occupied by the jacket 5, the temporary tensile stress t will be opposed and equalized by the permanent compressive stress C , as indicated. At the same time, the permanent tensile stress T in the portion of the area represented by the line A—A which is occupied by the core lobe 26 located between the recesses 16a and 16b, is opposed by the temporary compressive stress c in this same portion, thus serving to reduce the tensile stress in the lobe under firing conditions. As a result, deflection of the beam segments between the recess 16a and its flanking recesses 16b and 16c, is substantially minimized. Thus, since the span of the walls 16' (Fig. 2) of the cylinder portion of the open chamber may be maintained at a constant, or substantially constant, value, it follows that expansion of the cartridge or shell case in the cylinder portion of the chamber may be held within desired limits. More particularly, expansion of the case beyond its elastic limit may thus be prevented in this portion of the open chamber.

A similar result is obtained in the breech portion of the open chamber by reason of the pre-stressed breech structure. In this connection, Figs. 4, 5 and 7 provide a diagrammatic illustration of stress patterns under firing loads as between a pre-stressed built-up breech structure in accordance with this invention, typified by Figs. 4 and 5, and an unstressed solid breech structure, typified by Fig. 7. It will be understood however that the structure of Figs. 4 and 5, though diagrammatic, is intended to be illustrative of the conditions which would obtain in the breech structure of the embodiment of open-chamber gun depicted in Figs. 1, 2 and 3.

Referring to Fig. 7, the top rail 35 of the structure 35, viewed as a beam supported at its ends, is depicted as subjected to a uniformly distributed unit load f , due to firing. Considering the area adjacent the rear support 36 the temporary stress pattern about the neutral axis N—A of the beam 35 varies over the plane of the area designated by line A—A, from zero at the neutral axis to a maximum of temporary compressive stress c outwardly of the neutral axis and to a maximum of temporary tensile stress t inwardly of the neutral axis. In accordance with this invention, however, and with particular reference to the built-up pre-stressed breech structure of Figs. 1, 2 and 3 as diagrammatically depicted in Figs. 4 and 5, the stress pattern adjacent the end supports due to deflection caused by the unit firing loads f applied to the inner breech member 1 is one of tension t in the inner member 1 and compression c in the outer member 2, as indicated. These forces vary from zero at the neutral axis N—A of the structure, considered as a solid structure, to a maximum at the opposite sides of the neutral axis. However, because of the shrunk fit of the outer member 2 on the inner member 1, a permanent compressive stress C exists in the inner member 1 which, being opposite in sign to the temporary tensile firing stress t , minimizes or substantially prevents deflection of the inner member under the firing loads. At the same time, the permanent tensile stress T existing in the outer member 2 is opposed and minimized by the temporary compressive stress c in the outer member due to the firing loads.

In the construction shown in Figs. 1 to 3 inclusive

and in Figs. 4 and 5, the top, bottom and side rails of the pre-stressed rectangular breech structure are each built-up elements each comprised of elements of the inner and outer members 1 and 2, respectively. The top rail and the bottom rail are each adapted to serve as the breech portion of the open chamber depending on whether a given recess in the cylinder structure is in alignment with the upper gun barrel 3, as in Figs. 1 to 3, or in alignment with the lower gun barrel 4. In the embodiment of Figs. 1 to 3 inclusive, the arrangement of the recesses 16 in the cylinder structure in relation to the upper and lower gun barrels 3 and 4, respectively is such that the barrel may be fired alternately with one barrel being fired every 60° of rotation of the cylinder structure.

It will be clear from Fig. 4 that the neutral axis N—A of the breech portion of the open chamber is in the plane of the juncture between the inner and outer members 1 and 2, respectively, considered as a solid structure. Moreover, it will be apparent that because of the pre-stressing, the built-up breech structure may be lighter than an equivalent solid structure such as that of Fig. 7, the same being true of the pre-stressed cylinder structure.

It will be understood that certain features and sub-combinations are of utility and may be employed without reference to other features and sub-combinations. This is contemplated by and is within the scope of my claims. It is further obvious that various changes may be made in details within the scope of my claims without departing from the spirit of my invention. It is therefore, to be understood that my invention is not to be limited to the specific details shown and described.

What is claimed is:

1. In an open-chamber gun having, as chamber-forming members, a pre-stressed rotatable cylinder structure and a stationary breech structure, said structures having arcuate surface portions which are concentric and are substantially co-equal in radius of curvature, said cylinder structure comprising a cylindrical jacket having uniformly circumferentially spaced open cartridge chambers in its outer surface and radially extending sockets in its inner surface between said chambers, said sockets each having shoulder portions at opposite sides thereof; and, assembled in said jacket in nested relation thereto, a core having radially extending lobes mated with said sockets, said lobes, respectively, being smaller than said sockets at normal temperatures and prior to assembly and having shoulder portions complementary to and in shrunk fit engagement with those of the socket, whereby a permanent tensile stress is produced in the core and a permanent compressive stress in the jacket.

2. An open-chamber gun comprising a breech structure providing a breech portion for an open chamber of the gun and a cylinder structure providing a cylinder portion for the open chamber, each such portion having a surface concavity and being movable relative to the other into and out of a position wherein the concavities co-act to form an open chamber of the gun, the surface

concavity of said breech portion being arcuate and being concentric with said cylinder structure and substantially co-equal in radius of curvature therewith, said breech portion constituting a beam fixed at both ends and subjected to a substantially uniformly distributed unit load, upon firing, said cylinder portion comprising two integrally connected sections of the cylinder structure, lying at opposite sides of the plane containing the cylinder axis of the cylinder structure and of a configuration to provide therebetween, as the concavity aforesaid, a recess which is symmetrical with said plane and serves to receive and transport a round of ammunition into and out of the said chamber-forming position, each said section constituting a cantilever beam, fixed at one end, and subjected to a substantially uniformly distributed load, upon firing, and said fixed beam and said cantilever beams each having permanent equalizing stresses therein which are opposite in sign to the temporary stresses induced therein by the firing loads.

3. An open-chamber gun in accordance with claim 2 in which the surface concavity in said breech portion is of arcuate configuration and in which the surface concavity in said cylinder portion is of a configuration other than arcuate.

4. An open-chamber gun in accordance with claim 2 in which said breech structure provides at least a pair of such breech portions disposed in opposing parallel relation to each other and in which said cylinder structure is disposed between said breech portions and provides at least three such cylinder portions arcuately spaced from each other by 120°, each such cylinder portion being movable relative to said breech portions into and out of successive chamber-forming positions fixed by the respective breech portions, in each of which positions the surface concavity of the cylinder portion stationed therein co-acts with the surface concavity of the breech portion to form an open chamber whereby an open chamber is formed alternately with said breech portions and said gun may be fired at every 60° of arcuate movement of said cylinder structure.

References Cited in the file of this patent

UNITED STATES PATENTS

Re. 1,839	Slocum	Dec. 20, 1864
35,996	Doolittle	July 29, 1862
40,687	Graham	Nov. 24, 1863
378,091	Greth	Feb. 21, 1888
467,089	Forbes	Jan. 12, 1892
1,003,790	Pordon et al.	Sept. 19, 1911
1,242,719	Ostrander	Oct. 9, 1917
1,772,507	Barnes	Aug. 12, 1930
2,362,075	Keahey	Nov. 7, 1944

FOREIGN PATENTS

20,275	Great Britain	1914
--------	---------------	------