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ORDNANCE

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The invention described herein may be manufactured and used by or for the Government for governmental purposes without the payment to me of any royalty thereon.

This invention relates to ordnance and more particularly it has reference to composite barrels in which the liner may be readily removed.

The development of liners for guns which are to be capable of ready removal in the field may be resolved into three general classifications.

The first type includes those designs wherein the liner is in intimate contact with the tube without any provision being made to prevent permanent deformation of the exterior of the liner and consequent adherence to the metal of the tube.

The second type embraces those guns in which a definite clearance exists between the liner and tube to provide a space for the reception either of a jacket of various kinds of non-metallic material or a fluid which may be under pressure.

In the third type which represents the latest thought on the subject a clearance exists between the liner and tube and the liner is of sufficiently high elastic limit so that it is capable of dilation under the stress of firing without becoming permanently deformed. In some cases the outer tube acts merely as a container to define or limit the dilation of the liner without itself partaking of the expansion. This principle of operation was evolved when in the reboring of guns of large caliber a loose liner of a smaller caliber was to be inserted. In compensating for the dimunition of the bore the liner was accordingly made thicker and possessed a pressure which in effect made it a one piece gun. The outer tube being constituted by a built-up gun, assembled by heating and shrinkage, and being of great strength was capable of restricting the dilation of the liner and where the liner was not of sufficient strength the over pressure tended to draw it out. Where its elongation was restricted the metal piled up at the point of restriction.

In the remaining cases a clearance exists between the liner and tube but its amount is inconsequential. So long as the liner does not exceed its elastic limit it may be taken out with precisely the same ease with which it was inserted. The liner in this instance is very thin and dilates with the outer tube which by confining the liner within its elastic limit and preventing deformation insures the re-establishing of the initial clearance. It is with this type of removable liner that the present invention deals due consideration being given to the requirements of gun design as relating to strength, weight, time and cost of production and availability of material.

It has been seen from the foregoing that in two-piece guns a certain definite relation may exist between the liner and the outer tube which is controlled by their strength or resistance to pressure as effected by their thickness and elastic limit.

Considering first the availability of material the fact may be accepted that in time of emergency the high quality alloy steels having an elastic limit in the vicinity of 150,000 pounds per square inch will be expensive and difficult of procurement. Steel of this character will be homogeneous and isotropic and will probably not contain defective portions which in the application of pressure can be permanently deformed and adhere to the outer tube with such tenacity as to prevent the ready removal of the liner.

It is, therefore, proposed to employ steel whose resistance to pressure is increased by an overstrain resulting in a permanent set or deformation being imparted to the inner layer of the cylinder while the outer layers which have not been stretched beyond their elastic limit because of the ratio of flow will possess an elastic deformation or enlargement and in tending to return to their original size place the inner layers under compression. This operation generally referred to as auto-frettage or self-hooping may be conducted either through hot or cold working and produces a container which is free of defects.

In making calculations on a three inch gun I have discovered that if a liner of high quality steel having an initial elastic

limit of 65,000 pounds per square inch be overstrained 5% of its inner diameter it will possess a resistance which will permit the employment of an outer tube which may be of a lesser quality steel. With a liner of the character mentioned the outer tube need possess an elastic limit of approximately only 48,000 pounds per square inch and the combination will form a gun having the usual factor of safety at both the breech and muzzle end. Because of the low requirement of the outer tube it may consist of a medium quality or plain carbon steel. In order to insure the absence of defects in the outer tube it may be made by centrifugal casting method, which method may also be adopted in forming the liner.

When desired to eliminate the necessity for inspection of the tube it is contemplated to increase the resistance by overstraining. In this event a metal, such as cast steel having an elastic limit of 40,000 pounds per square inch may be employed and if overstrained 2% of its inner diameter it will possess a theoretical elastic limit of 63,000 pounds per square inch which is well above the safety factor. Consequently, a cast steel tube with or without overstraining may be employed to reinforce a liner possessing the requisite elastic limit, whether such quality is initially present or obtained by overstraining.

From the foregoing it will be seen that there is no foundation for the requirement that the liner and tube must be of metal of the same composition or metal having the same characteristics. Disregarding the interests of economy the outer tube might consist of the higher quality of material.

When the clearance between the liner and the tube is so slight as to be comparable to a sliding fit the least amount of permanent deformation of any point will be sufficient to prevent the ready withdrawal of the liner. The liner and likewise the tube after being overstrained are therefore annealed to remove internal strains.

The liner and tube may be tapered on their adjacent surfaces to facilitate insertion and removal of the liner.

While the calculations pertain to a 3-inch gun it is to be understood that the principles of the invention are equally applicable to guns of all calibers, irrespective of the number of outer tubes or reinforcing jackets.

I claim:

1. A gun including an elastic outer tube having its inner layers permanently set by overstraining and an elastic liner of a higher quality material freely insertable in said tube, said liner having its inner layers permanently set by over-straining.

2. A gun including an elastic outer tube having its inner layers permanently set by overstraining and an elastic liner of higher quality material freely insertable in said tube.

3. A gun including an elastic outer tube, an elastic liner of a higher quality material freely insertable in said tube, said liner having its inner layers permanently set by overstraining.

4. A gun including a centrifugally cast elastic outer tube having its inner layers permanently set by overstraining and a centrifugally cast elastic liner freely insertable in said tube and having its inner layers permanently set by over-straining.

5. A gun including a centrifugally cast elastic outer tube having its inner layers permanently set by over straining and a centrifugally cast elastic liner freely insertable in said tube.

6. A gun including a centrifugally cast elastic outer tube and a centrifugally cast elastic liner freely insertable in said tube and having its inner layers permanently set by overstraining.

7. A gun including a centrifugally cast elastic outer tube having its inner layers permanently set by overstraining and a liner freely insertable in said tube.

8. A gun including an elastic outer tube and a centrifugally cast elastic liner freely insertable in said tube and having its inner layers permanently set by overstraining.

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