June 11, 1946. N. A. MEADOR 2,402,068

AMMUNITION

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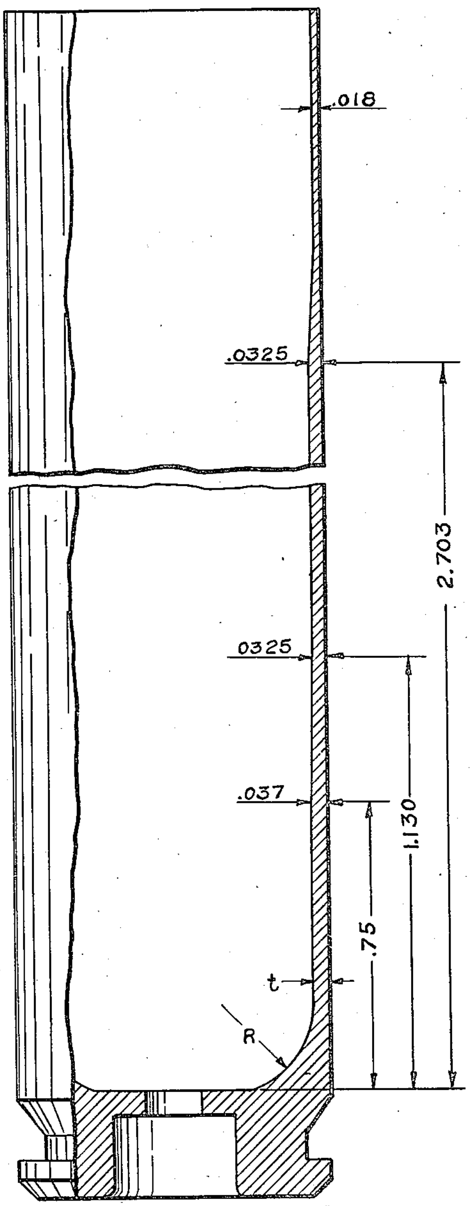

Fig. 2

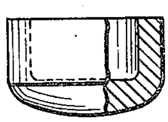

Fig. 1

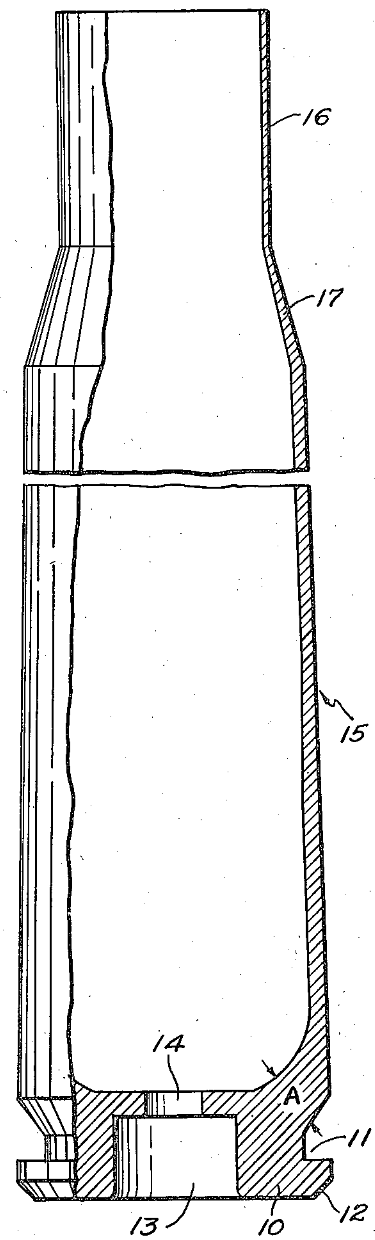

Fig. 3

INVENTOR.
NORWARD A. MEADOR

BY D. Verner Smythe

ATTORNEYS

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Norward A. Meador, Andover, Mass., assignor to Remington Arms Company, Inc., Bridgeport, Conn., a corporation of Delaware

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5 Claims. (Cl. 148—12)

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This invention relates to ammunition, and particularly to the production of a satisfactory bottleneck cartridge case from steel.

It is a well-known fact that the powder-containing cases for certain cartridges, particularly cartridges of .30 and .50 caliber extensively used in military operations, are of substantially greater diameter than the bullets with which they are fitted, the reduced diameter bullet receiving section at the mouth of the case being joined to the much larger diameter propellent powder containing body by a suitably tapered shoulder, which shoulder ordinarily forms an endwise support for the cartridge when chambered in a firearm. The cases are thus enlarged to accommodate the larger volume of propellent necessary to give the bullet or projectile the desired velocity, and the interior pressures generated in such cartridge cases are of substantially greater magnitude than the pressures generated in cases having a diameter which differs only slightly, if any at all, from the projectile diameter.

Even in manually operated firearms the cartridge case must fit somewhat loosely in the chamber, to enable its ready insertion therein and removal therefrom. No cartridge case is self-sustaining but, instead, under the pressure incident to firing, is laterally expanded until it is firmly supported by the chamber wall; in fact, pressure transmitted through the case causes some expansion of the chamber. As the powder pressure decreases, the case must contract or "spring back" to an extent such that it can be extracted from the chamber without the application of too great a force. The requisites of a successful cartridge case metal are thus a high elongation below the elastic limit and a low modulus of elasticity. The standard material for cartridge cases, particularly those of the necked-down type, which are subject to the greatest stresses, is brass of a relatively high copper content. In the absence of brass, and for reasons of economy, steel has had a limited use but chiefly, if not exclusively, in straight body cases subjected to relatively low firing stresses, as distinguished from necked-down cases which are subjected to very high firing stresses.

In machine guns, loaded cartridges are chambered and fired and empty cases withdrawn with such extreme rapidity that pressures within the fired case probably do not become normal before the extraction of the case from the chamber begins; hence, the stresses on cases thus fired are somewhat greater than those on cases fired in manually operated guns, and the requirements for such cases are more drastic.

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The present invention comprises the design of a steel cartridge case of the necked-down type capable of sustaining the pressures to which such cases are subjected.

In the drawing:

Fig. 1 is a sectional elevation of a cup from which a cartridge case is to be formed.

Fig. 2 is a fragmentary sectional elevation of a cylindrical case blank made in accordance with the present invention, complete except for tapering and necking.

Fig. 3 is a similar fragmentary sectional elevation of the final case.

The stresses to which a necked-down cartridge case is subjected during firing, especially in machine guns, are not fully understood and are probably incapable of exact determination. However, it may be stated with certainty that the load applied to a cartridge shell is an impact load, as distinguished from a static load, the load rising from 0 at the instant of powder ignition to a maximum of the order of 50,000 lbs. per square inch in a very few milli-seconds. The resistance of a member to an impact load depends largely, though not entirely, upon the energy absorbed, or work done, in deforming the resisting member. Let an impact tension of maximum force P be applied to bar or cartridge case of cross-sectional area a, length l and made from a material having a tensional modulus M, produce a total elongation E. Since work equals force times distance and the applied force increases at a constant rate from 0 to the maximum P, the total work done upon, or energy U absorbed by, the resisting member is

$$U=\tfrac{1}{2}PE \qquad (1)$$

and the unit stress s in the resisting member is

$$s=\frac{P}{a} \text{ and } P=sa$$

If the unit elongation is e

$$M=\frac{s}{e} \text{ and } E=el=\frac{sl}{M}$$

Substituting these values for P and E in Equation 1,

$$U=\frac{\tfrac{1}{2}sa.sl}{M}=\frac{s^2al}{2M} \qquad (2)$$

It can be similarly shown that

$$U=\frac{Mae^2}{2l} \qquad (3)$$

Now assume that the resisting member has one length l of cross-sectional area a and a second length l of cross-sectional area $2a$. Doubling the cross-sectional area reduces the unit stress s to $s/2$ and Equation 2 becomes

$$U_2=\frac{(s/_2)^2 2al}{2M}=\frac{s^2al}{4M} \qquad (4)$$

Doubling the area has halved the total energy absorbed, and the application of a given load to such a member accordingly induces a greater unit stress in the smaller section thereof than is induced if the member is of the same area throughout its length. In other words, a member of minimum area a has the greatest resistance to impact load if no part thereof has an area materially greater than a.

While the foregoing principles of impact loads have been utilized in the design of certain machinery, such as connecting bolts, the crossheads of reciprocating engines, head bolts for certain cylinders, and the like, the present invention is believed to comprise their first application to the design of cartridge cases. The cartridge case blank illustrated in Fig. 2 comprises a head **10** provided with an extractor groove **11**, extractor cam **12**, primer pocket **13**, flash hole **14**, and wall identified generally by the numeral **15**. The neck portion **16** of the case is joined to the body portion **15** by a taper or shoulder **17**. When such a case is in firing position in a gun chamber, the shoulder **17** is pressed against a corresponding shoulder of the gun chamber by the pressure of the breech bolt against the flat face of the head **10**. Associated with the breech bolt is an extractor which, before or as the cartridge is seated in the chamber, is cammed outwardly by the cam **12** and snaps into the extractor groove **11**. Due to the necessity for providing clearance for the extractor, the lateral margin of the head portion of the shell is substantially unsupported and all parts thereof must be of sufficient thickness to sustain the maximum interior pressure without external support. This fact establishes the minimum radius R of the curve joining the flat interior of the head **10** with the interior of the side wall **15**. Such radius must be sufficiently great to provide a thickness of metal A between the extractor groove and the interior adequate to sustain the maximum internal pressure. Moreover, the case interior must be free from angles or cusps which would create a concentration of stress, which means that the interior of the side wall **15** must join the radius R at a tangent thereto. These considerations substantially determine the minimum thickness t of that portion of the case wall closely adjacent to the base.

The present invention contemplates that the thickness of the wall **15** from the shoulder **17** to the head **10** shall be as near uniform as possible, subject to the limitation above described. The drawings show the proportionate dimensions for a .50 caliber cartridge case. The wall thickness of .0325'' adjacent the shoulder is empirically determined for a particular steel. Such wall thickness of .0325'' is maintained throughout as much of the length of the case as possible, the wall of this thickness being joined by an appropriate taper without sharp angles to the wall of thickness of .037'' adjacent the base; such thickness of .037'' having been determined by considerations of head strength heretofore outlined.

Cartridge cases drawn or otherwise produced from cups of the type illustrated in Fig. 1 in the manner above set forth and without heat treatment were found to be definitely superior to cartridge cases formed with the usual tapered (varying thickness) wall. However, while they

were free from body defects, they were found to be subject to occasional "rim shears," that is, the extractor claw engaging in the extractor groove **11**, instead of withdrawing the case from the chamber as desired, sheared through the rim, leaving the case in place. This effect may be due either to softness of the rim or softness of the body, or more probably to a combination of soft rim and soft body. Soft bodies do not contract as far or as rapidly from their expanded supporting engagement with the chamber wall, hence induce greater extraction force. Likewise, a soft head has less resistance to shearing and is less able to sustain the high stresses necessary to transmit a high extraction force to the body. It was found, however, that by appropriate heat treatment, body and head can both be given the combination of properties necessary for successful extraction.

The procedure is as follows: The cup, as shown in Fig. 1, is drawn and otherwise processed to the condition shown in Fig. 2, without any heat treatment. The body has been extensively worked and, if this work is done with the metal cold, a certain amount of work hardening takes place, such work hardening, however, being small by comparison with the work hardening of brass. The metal of the head has been worked only in being exteriorly flattened and outwardly displaced in the formation of the primer pocket **13**, hence it is quite soft. As shown in Fig. 2, the primer pocket **13** and flash hole **14** have been fully formed by plastic deformation and piercing, and the extractor groove **11** and cam **12** have been fully formed by turning, so that the mechanical operations on the head are complete. Preferably at this point, the case blank is heated to a temperature of the order of 1700° F. and is brine quenched from this temperature. This serves to substantially harden the entire case, both body and head. The head has substantially the hardness and toughness finally required, the body is somewhat too hard and brittle. The succeeding mechanical operations consist in slightly tapering the entire body and in forming the shoulder **17** and bullet receiving neck **16**. This is ordinarily done in a two-stage die machine but prior thereto the body, but not the head, is annealed. This is accomplished by standing the blanks head end down upon slowly rotating spindles and, while so rotating them, conveying them through an annealing flame. During this body anneal the rim portions of the heads are immersed in water. By a well-known regulation of the point of application and intensity of the annealing flame, the desired degree of anneal can be secured, the heads remaining substantially cold. Thereafter, the blanks are tapered to form the finished cases under progressive tapering dies, as above outlined.

By the use of the combination of substantially uniform thickness walls and heat treatment after completion of the head, as above described, what are believed to be the first entirely satisfactory necked-down steel cartridge cases capable of use in .30 and .50 caliber machine guns have been secured. Many million cartridges have been loaded in such cases, subjected to the severest of tests in a variety of places and under a variety of conditions, and have been finally accepted as machine gun ammunition suitable for aircraft use.

What is claimed is:

1. The method of making a shouldered steel cartridge case having an extractor groove which

comprises the steps of reforming a cup to a substantially cylindrical case blank having a thick head and an integral tubular body interiorly merged with said head in a radius providing a thickness of metal adjacent said exrtactor groove adequate to resist internal pressure substantially without external support, said reforming being performed to provide a body wall of substantially uniform thickness from a line closely adjacent said head substantially to said shoulder; hardening said case blank by heating and quenching; annealing only the body portion of said case; and tapering and necking said case to the desired final configuration.

2. The method of making a shouldered steel cartridge case having an extractor groove comprising the steps of providing a cup; drawing a substantially cylindrical headed integral body case blank and at least in the final draw maintaining the integral walls of the body of said blank of substantially uniform thickness from a line closely adjacent said head to said shoulder to make energy absorption when the case is fired substantially uniform throughout the length of said substantially uniformly thick wall and thus cause substantially the same unit stress to exist throughout the length of the uniform wall, said integral tubular body being drawn and shaped to interiorly merge with said head in a radius providing a thicknes of metal adjacent said extractor groove adequate to resist internal pressure substantially without external support; hardening said case blank by heating and quenching; annealing only the body portion of said case; and tapering and necking said case to the desired final configuration.

3. The method of making a shouldered steel cartridge case having an extractor groove comprising the steps of providing a cup; drawing a substantially cylindrical headed integral body case blank and at least in the final draw maintaining the integral walls of the body of said blank of substantially uniform thickness from a line closely adjacent said head to said shoulder to make energy absorption when the case is fired substantially uniform throughout the length of said substantially uniformly thick wall and thus cause substantially the same unit stress to exist throughout the length of the uniform wall, said integral tubular body being drawn and shaped to interiorly merge with said head in a radius providing a thickness of metal adjacent said extractor groove adequate to resist internal pressure substantially without external support; hardening said case blank by heating to about 1700° F. and brine quenching; annealing only the body portion of said case; and tapering and necking said case to the desired final configuration.

4. The method of making a shouldered steel cartridge case having an extractor groove comprising the steps of providing a cup; drawing a substantially cylindrical headed integral body case blank and at least in the final draw maintaining the integral walls of the body of said blank of substantially uniform thickness from a line closely adjacent said head to said shoulder, to make energy absorption when the case is fired substantially uniform throughout the length of said substantially uniformly thick wall and thus cause substantially the same unit stress to exist throughout the length of the uniform wall, said integral tubular body being drawn and shaped to interiorly merge with said head in a slight taper and radius providing a thickness of metal adjacent said extractor groove adequate to resist internal pressure substantially without external support; hardening said case blank by heating and quenching; annealing only the body portion of said case; and tapering and necking said case to the desired final configuration.

5. The method of making a shouldered steel cartridge case having an extractor groove comprising the steps of providing a cup; drawing a substantially cylindrical headed integral body case blank and at least in the final draw maintaining the integral walls of the body of said blank of substantially uniform thickness from a line closely adjacent said head to said shoulder to make energy absorption when the case is fired substantially uniform throughout the length of said substantially uniformly thick wall and thus cause substantially the same unit stress to exist throughout the length of the uniform wall, said integral tubular body being drawn and shaped to interiorly merge with said head in a radius providing a thickness of metal adjacent said extractor groove adequate to resist internal pressure substantially without external support, said radius being the minimum to give adequate strength and said merger being smooth so as to give a non-stress concentrating junction; hardening said case blank by heating and quenching; annealing only the body portion of said case; and tapering and necking said case to the desired final configuration.

NORWARD A. MEADOR.