Sept. 26, 1944. C. D. COXE 2,359,087

AMMUNITION

Original Filed June 12, 1940 2 Sheets-Sheet 1

Fig. 1

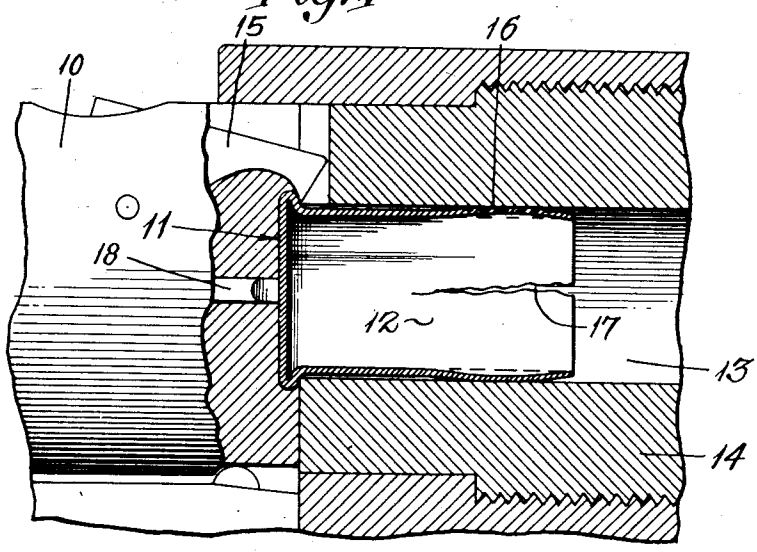


Fig. 4

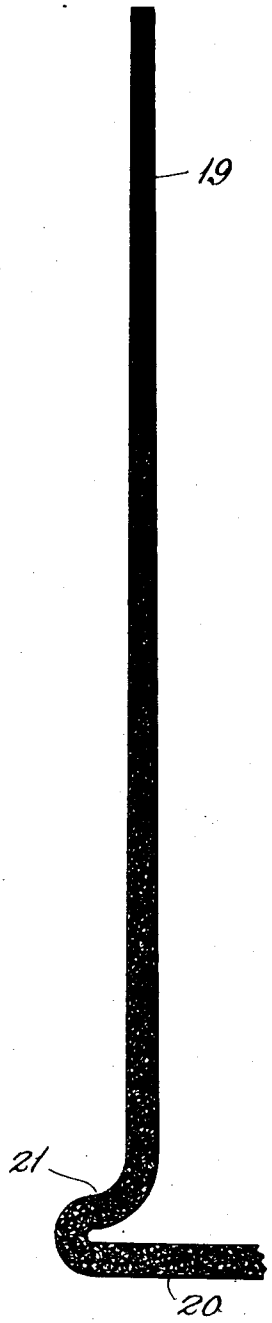


Fig. 2A



Fig. 3

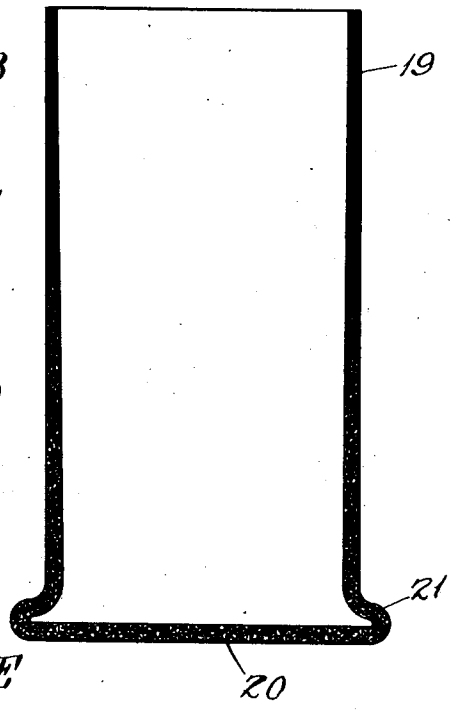


Fig. 2B



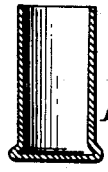
Fig. 2C



Fig. 2D



Fig. 2E



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Fig. 5

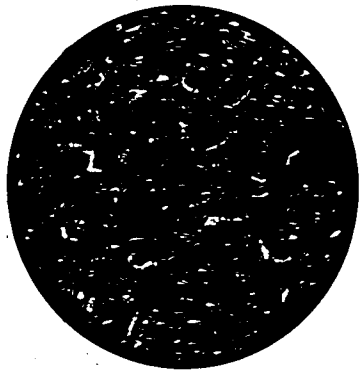


Fig. 6



Fig. 7

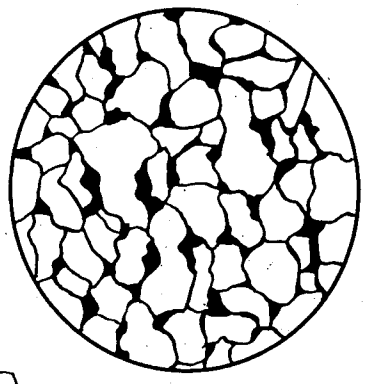


Fig. 10

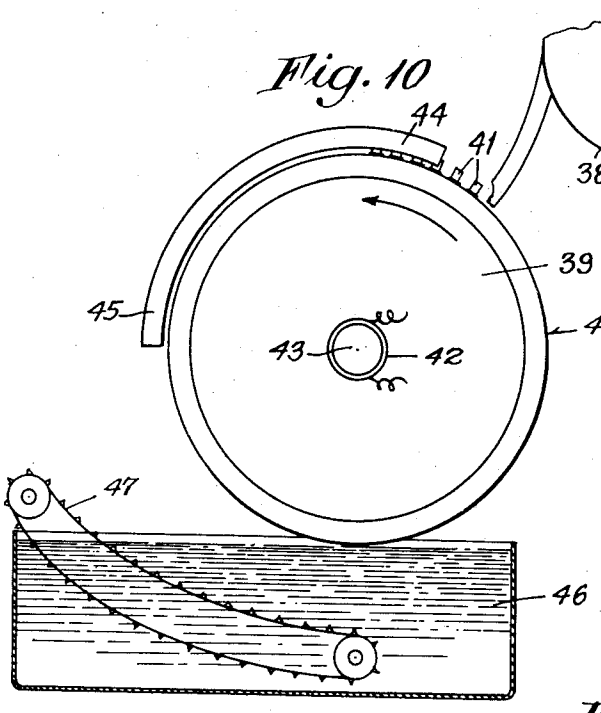


Fig. 11

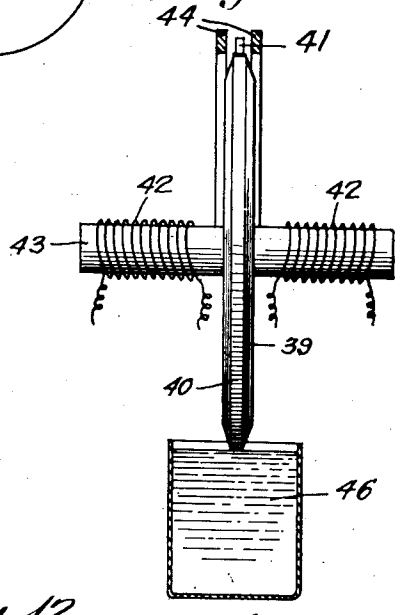


Fig. 9

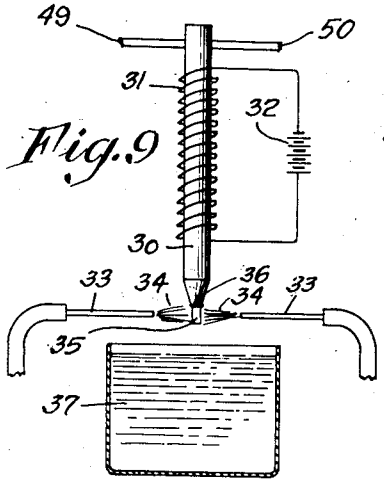


Fig. 12

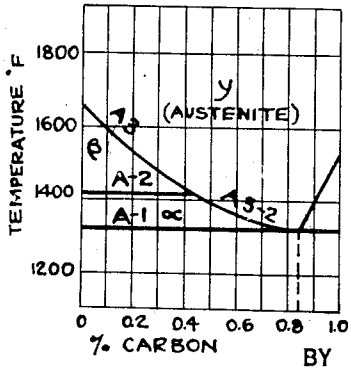
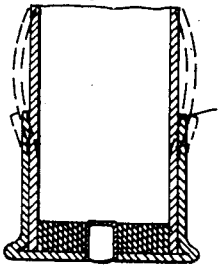


Fig. 8



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Original application June 12, 1940, Serial No. 340,005. Divided and this application July 8, 1942, Serial No. 450,163

3 Claims. (Cl. 148—10)

This invention relates to ammunition components of steel and the method of making the same, and particularly to a steel component that has been heat treated so as to obtain the proper grain structure and give satisfactory results.

The present application is a division of application Serial No. 340,005, filed June 12, 1940, which has matured into Patent No. 2,331,870.

In the embodiment disclosed herein, the use of steel is shown as applied to a cartridge case of the conventional rim-fire type, or to a shotshell head, but it is to be distinctly understood that the invention may be applied to any type of cartridge case and for other ammunition components, such as, for example, centerfire cartridge primer cups. Brass is in almost universal use as a cartridge case, because, as will be shown later, it is the only metal previous to the invention herein described that has satisfactorily met the requirements in such use in regard to cost, shaping, strength, corrosion resistance, and extractability from the gun. Brass, however, has many disadvantages, and much work and research have been expended in the search for a substitute which will meet the desired requirements. Brass is expensive and cannot be used in combination with certain desirable primers and/or powders, as it will season crack, corrode and cause reactions rendering the primers and/or powders unstable. The matter of cost is of particular importance in the manufacture of conventional rimfire cartridges. There have been many attempts to use steel or an alloy thereof, but such have never proven feasible. The other objects of the invention will appear from the following description and illustrations, which, as stated above, are not intended to limit the use of the invention to the form shown and described.

In the drawings:

Fig. 1 is a sectional view of a rimfire cartridge case with an exaggerated clearance between the case and the chamber of the gun. The bulging of the shell, due to firing pressures, is shown exaggerated, as is also a split in the body of the case.

Figs. 2A, 2B, 2C, 2D and 2E show diagrammatically, by way of example, sectional views of the five steps in the forming of a conventional rimfire shell from a flat blank, as in Fig. 2A, to the finished rimfire case, as in Fig. 2E.

Fig. 3 is an enlarged sectional view of a rimfire shell showing diagrammatically the grain structure after it has been heat treated in accordances with the present invention.

Fig. 4 is a fragmentary sectional view of one wall of the rimfire shell showing in detail the grain structure of Fig. 3.

Fig. 5 is an enlarged view representing a photomicrograph enlarged 800 diameters of the body portion of the shell of Figs. 3 and 4 showing the homogeneous grain structure of the body.

Fig. 6 is a similar view of the portion near or at the bend of the rim, showing the interspersed martensite-like structure and the ferrite.

Fig. 7 is similar to Fig. 5, except that it is taken from the base of the shell and shows the soft ferrite structure with the few scattered martensite-like areas dispersed in the ferrite.

Fig. 8 shows a section of a shotshell head, the dotted lines showing in exaggerated form the expansion of the case and head as the shell is fired.

Fig. 9 shows diagrammatically a simplified apparatus which may be employed for heat treating the rimfire shells in the manner disclosed in the present invention.

Fig. 10 is a side view of another apparatus suitable for production use that may be used to treat the shells in accordance with the present invention.

Fig. 11 is an end view of the apparatus disclosed in Fig. 10.

Fig. 12 is an iron carbide diagram.

The purpose of a cartridge case is to serve as a container or carrier for the powder and the priming mixture which initiates the combustion of the powder. The projectile is placed in the mouth of the cartridge case and is propelled from the barrel when the primer of the cartridge is struck by the firing pin, thereby igniting the propellant powder. When in position in the gun, the shell is located in the chamber thereof, which is closely matched with the size of the shell, the shell being properly sized in the course of manufacture so that it will fit into the chamber. It is obvious, however, that a certain clearance will aways be present between the outside of the case and the chamber. There is also a variation in the snugness of the fit of the case in the chamber and the relative roughness of the chambers in different guns, all of which affect the operation of the cartridge and extraction thereof.

In a shotshell, the conventional construction employs a paper or similar body and a metallic head thereon, said metallic head containing the primer cup.

Referring to Fig. 1, in which a conventional rimfire shell is shown, 10 represents the bolt of

the gun which has been closed against the head 11 of the case 12, the case 12 fitting within the chamber 13 of the barrel 14 (shown fragmentarily), for instance. An extractor 15 of the conventional type engages the rim of the shell as it is pushed into the chamber 13. A suitable striker or firing pin 18 is provided to strike the rim of the case 12 in which the priming mixture is placed. It is to be noted that Fig. 1 is a horizontal section and that the striker engages near the rim portion of a rimfire shell. It is necessary that the material of the case have sufficient strength and a sufficiently high yield point so that upon the combustion of the propellant charge and under the high pressure developed thereby, that it will not be forced a substantial amount beyond this yield point, because when such occurs the sides of the shell will be bulged outwardly and will remain permanently in that position, as is shown at 16 in exaggerated form (Fig. 1). It is desirable, however, that at the time of firing, the shell be resilient enough so that it will spring outwardly and seal the chamber and prevent the escape of the gases from the chamber of the barrel. In the event that the pressure is such as to cause the yield point of the metal in the body of the shell to be exceeded, allowing too great a deformation to take place, it is obvious that the bulging portion of the shell will tightly engage the side of the chamber 13. This bulging will require an unusually high extraction force, which in many instances causes the extractor 10 to pull through the rim or portion of the shell with which it engages as the bolt is moved backwardly, leaving the expended shell within the chamber and causing great inconvenience and/or difficult operation. Even if the extractor does engage the shell and withdraw the same, an excessive force is required to operate the gun, which is undesirable. It is seen, therefore, that the yield point of the metal bears an important relationship, to the extraction force necessary to withdraw the shell, and also to the sealing of the powder gases and the prevention of the escape thereof through the mechanism of the gun and into the face of the operator. Such leakage of gas backwardly also detracts power from the propelling of the projectile through the barrel of the gun and is undesirable. The ductility of the metal of the case must also be such that upon the firing thereof splits will not occur, such as has been indicated in exaggerated form at 17 of Fig. 1. The base of the shell should also be sufficiently soft so that the blow of the firing pin will be properly transmitted to the priming mixture within the case, and cause the same to be ignited.

Brass shells also have the disadvantage of developing season cracks, which are cracks which have a tendency to develop at the mouth of brass shells after a bullet has been put in place. In Figs. 2A, 2B, 2C, 2D, 2E, five of the stages in the forming of the usual rimfire shell are shown, it being understood, however, that any number of intermediate operations may be used or any type of shell or case may be formed similarly. 2A is a cross section of a circular disc of metal. It is usual to both form the disc 2A from a strip of metal, and, at the same time, pass it through a die by means of a punch and cup it, as shown in Fig. 2B. By successive drawing operations, the shell and rimfire case are shaped until they reach the final form shown in 2E.

In Fig. 3, is shown an enlarged sectional view of a finished rimfire shell, wherein the grain structures in the varying portions of the body and rim are shown diagrammatically. As has been stated, it is necessary that the body of the case have a sufficiently high yield point, and, therefore, strength, so that it will not become permanently deformed upon firing of the shell. It is also necessary that the shell not be so hard as to develop splits in the body. The rim portion of the shell should be sufficiently soft so that the blow of the firing pin will be properly transmitted to the primer mixture. By this invention it has been found that by proper differential heat treatment, as will be outlined, the body portion of the case is put into the form having the desired characteristics, as is also the rim or base.

In the iron carbon alloy system of less than .90% carbon content, when the metal is in the field above the A_3 and A_{3-2} line, shown in Fig. 12, the carbon is in a solid solution in the iron, known as the γ form or austenite. If the metal be cooled slowly from this state as it passes through the A_2 line or A_{3-2} line, the metal becomes magnetic, above this point it being non-magnetic. It is upon reaching the A_3 or A_{3-2} line that free ferrite begins to be rejected, and as the A_1 line is reached the remaining austenite completes its transition into pearlite so that the final structure is composed of pearlite and ferrite. These matters are well-known to those skilled in the art. Upon the heating of the steel from its cold condition, the pearlite first changes into austenite as the A_1 line is reached, and as the heating continues through the A_1 and A_2 lines, the austenite begins to absorb the free ferrite, the ferrite being in what is known as the α form. As the A_2 range is passed or A_{3-2} line, the α ferrite changes into either β ferrite or directly into the γ or austenitic form. The maximum refinement or the smallest grain size occurs at the temperatures where the changes take place, and, as the temperature is increased, the grains will grow larger in size. By control of the rate of cooling from the austenite field, this size and type of final grain structure are affected, and it is upon this principle that heat treating processes are generally founded. Upon the cooling from the austenitic field, various grain structures are obtained and are known in the art as martensite, troostite, sorbite, bainite, etc. The martensite, troostite, and sorbite forms are homogeneous in character, and the resultant grain has a featherly acicular appearance, and the iron carbide therein is sub-microscopic. In this form the metal is comparatively hard and has a relatively high strength, in contrast to the pearlite and ferrite form which is relatively soft and ductile. The grain structure of the pearlite and ferrite, resulting from slow cooling or from treatment such as to obtain this structure, is heterogeneous, as is also the structure resulting from the heat treatment in accordance with the present invention. The steel as drawn does not possess sufficient strength in the body of the case to resist the bulging, and the base is not in proper condition so as to be sensitive to the blow of the firing pin. By heat treating the case so that the body thereof is sufficiently hard and has sufficient strength, and the base is sufficiently soft, a satisfactory steel shell may be produced for all purposes. The body of the case should be heated above the A_3 or A_{3-2} line so that the metal thereof is transformed to the austenitic form. At the same time, it is desirable that the base have free ferrite remaining in its structure,

the body of the shell in the martensite-like structure being homogeneous in character, and the base of the shell being a heterogeneous structure. It is immaterial whether the body is in the martensite, troostite, or sorbite form, as long as the proper strength characteristics are present. The base contains free ferrite and has dispersed therein scattered areas of a martensite-like structure after heat treatment.

In Fig. 4 may be seen a diagrammatic illustration of the variances in the grain structure that occur between the body of the case and the base, when heat treated in accordance with the present invention, the body having a homogeneous or martensite-like structure which has sufficient strength, as at 19, and the base being soft and having a structure containing free ferrite, as at 20. There is no free ferrite present in the body, and the portion 21 between the body and the base is graduated from the homogeneous structure to the heterogeneous structure of the base. It is preferable that after the case has been hardened, a tempering heat treatment be given thereto, which will change the martensite-like structure slightly, the precise resultant structure not being exactly known.

Fig. 5 is taken from a photo-micrograph of 800 diameters magnification. In this figure is shown the homogeneous martensite-like structure having no free ferrite present, similar to that in the vicinity of 19 of Figs. 3 and 4. These structures may be developed by means of suitable metallographic analyses wherein the surface is etched and photo-micrographs made under varying conditions, as is well-known in the art. The dense homogeneous feathery acicular structure is one that has a high strength which will resist the pressures within the shell and perform satisfactorily.

Fig. 7 is taken from a photo-micrograph of 800 diameters magnification, and shows the free ferrite with the martensite-like areas scattered between the grains of the free ferrite, and is similar to that of 20 of Figs. 3 and 4. The light areas are of free ferrite crystals, and the dark areas are crystals that are similar to those of Fig. 5 and may have the same structure as these.

Fig. 6 is taken from a photo-micrograph of 800 diameters magnification of the area contained near the bend (21 of Figs. 3 and 4), the light areas being free ferrite, and the dark areas being a martensite-like structure as shown in Fig. 5.

This type of structure in the shell may be obtained by heating the body of the case above the A_{-3} or A_{-3-2} line so that it is in the austenite field, and keeping the base below this point so that it is not changed to austenite, and if it is changed at all, only a partial recrystallization will occur. Then as the shell is quenched or rapidly cooled, the austenite structure of the body will turn to the martensite-like or homogeneous structure of Fig. 5, which may be martensite, troostite or sorbite. The ferrite of the base will be as shown in Fig. 7 with the small martensite-like areas dispersed between the free ferrite. The area between the body and base will be similar to that shown in Fig. 6 and 21 (Figs. 3 and 4). The A_{-3}, A_{-3-2} and A_{-1} lines change slightly in accordance with the composition of the steel, and may be definitely located by those skilled in the art, and are only generally indicated in Fig. 12. It is to be understood that the martensite, troostite, sorbite and martensite-like structures when referred to include these structures in the tempered form. These may be termed "tempered martensite-like," etc.

As another example of the use of the invention, shotshell heads made of steel such as in Fig. 8 may be hardened so as to give them sufficient strength to withstand the high pressures existent upon the firing of the shot shell. However, when the shotshell head is hardened, the deformability of the edge will be lessened so that upon firing of the shell, the paper tube expanding outwardly will tend to result in cutting of the tube at the upper edge 48 of the shotshell head. It is necessary, therefore, that the upper edge or rim of the shotshell head be softened so as to give it sufficient deformability to prevent this undesirable cutting. The shotshell head therefore may have the upper edge of it placed in a heterogeneous form similar to that shown in Fig. 7, and the remainder of the head placed in a homogeneous or martensite-like form, as shown in Fig. 5.

As has been mentioned, it is preferable that after the hardening of the body as described has taken place, that the case be tempered by heating to some temperature between 200° and 1300° F. for a suitable period so that the body will not be too hard, yet will be sufficiently tough to satisfactorily function upon firing. The case may then be allowed to cool slowly in the air. It has been found, for example, that 450° F. for one hour will give satisfactory results. This time will vary inversely with the temperature as is well-known in the art. For the higher temperature, the period may be one minute or less, and for a lower temperature, such as 600° F., it may be ½ to one hour. As the temperature is lowered and the time is increased, such increase of time is greater than a direct proportion.

As one example of the methods in which shells or cases may be treated, reference is made to Fig. 9, wherein 30 may be a water-cooled armature for the magnet 31, which is energized by a suitable source of electricity 32. The water cooling entrance and exit pipes are diagrammatically shown at 49 and 50. The burners 33 have flames 34 directed to the case 35 of the shell, whose base or rim portion 36 has been placed against the armature 30 and held there by the magnetic flux. The body of the case is heated by this flame and will rise above the A_{-3} or A_{-3-2} line so that it will be in the austenite form. The base is kept cool because it is against the cooled armature. As the heat is transmitted by conduction to the base, the base will finally rise to the A_{-2} or A_{-3-2} line, at which point it loses its magnetism. As this occurs, the shell will drop by gravity into a cooling means such as a reservoir of water 37 and will be cooled rapidly therein so that the body of the shell, which is in the austenite form, will become homogeneous or have a martensite-like structure. The base, which has not reached the austenite field, will have free ferrite therein and will be in the desired condition. It is to be understood that varying cooling means or materials may be used. The shell may then be removed from the water and suitably tempered, such as by subjecting to a temperature between 200° and 1300° F. It is to be understood, however, that it is not essential that the armature 30 be water-cooled. It is also not essential that the base of the shell reach the non-magnetic stage, as it is obvious that a balance will be reached, governed by the weight of the shell, when it will drop as soon as a sufficient portion of the shell has become non-magnetic,

so as to cause the remaining magnetic portion to be overcome by the force of gravity.

In Fig. 10 is shown another modification of the device, which may be used for the heat treatment of the shells in accordance with the present invention. The shells may be fed from any suitable means such as 38 onto a rotating magnetic disc 39, said magnetic disc having a portion 40 against which the base of the shell 41 passes and is held in such position. The disc may be magnetized by means of the coils 42 located on the shaft 43 of the disc 39. The disc 39 rotates in the direction shown by the arrow, and, as the shells pass 44, the bodies thereof may be heated in some suitable manner such as by a gas flame or electrically. The length of travel in 44 may be so fixed that when the shells emerge from the end 45, the base of the shell at this point, or shortly thereafter, will reach the temperature at which the weight of the shell will cause it to drop from the magnetic wheel and into the quenching medium 46. A conveyor 47 may be placed in the quenching medium to receive the shells and to deliver them to the desired point. The magnetic and heating means may take other and equivalent forms.

The shotshell heads, for example, may be treated in a similar manner, the top edge 48 being supported against the magnetic holding means, and the heat applied to the remainder or base portion of the head. In this manner, the base portion of the head may be brought into the austenite field, and, when the heat is conducted to the rim or top edge portion, the weight of the shell will cause it to drop from the magnetic holding means before this portion reaches the austenite field. By this means, the edge portion will not be hardened in the same manner as will be the remainder of the shotshell head.

It has been found that as the tempering temperature is raised, the sensitivity of the shell will be improved.

If desired, the components may be plated with some metal such as copper to protect the steel.

It has been found that conventional .22 caliber rimfire shells made from a steel containing .20 per cent carbon, heat treated, for example, on the apparatus of Fig. 9 and quenched in water upon falling from the magnet, and subsequently tempered at 600° F. for one-half hour, will have an extraction force of seven pounds and no splits, which compares with approximately five pounds extraction force and no splits for similar brass rimfire shells.

It is evident, therefore, from the foregoing description that a new and novel satisfactory ammunition component may be made of steel by differentially heat treating the component so that one portion thereof has a homogeneous structure of sufficient strength and the desired characteristics, and another portion has a soft heterogeneous structure of the desired characteristics.

It is apparent that a method has been evolved and a novel ammunition component produced that is superior in many ways to those in present use. As the invention provides a novel and satisfactory steel ammunition component and method of producing the same, it is not limited to the details and composition herein shown, described and illustrated in the drawings, but is to be construed broadly and as covering all equivalent devices and processes falling within the scope of the appended claims.

What is claimed is:

1. In the manufacture of steel cartridge cases having bodies and bases, the steps of magnetically supporting the bases, heating the bodies to such a temperature as to cause the body to become substantially entirely austenite while magnetically supported, the cases being released from the magnetic support when the portion adjacent thereto reaches the non-magnetic temperature, and then rapidly cooling the cases.

2. In the manufacture of steel ammunition components, the method comprising the steps of magnetically supporting a portion of said component; heating another portion only of said component to such a temperature as to cause that portion to become substantially entirely austenite and until sufficient heat reaches the portion adjacent the magnetic support to render said magnetically supported portion non-magnetic, thereby releasing the component from the magnetic support; removing the component from the magnetic support and source of heat; and rapidly cooling the component, whereby the portion adjacent the support remains relatively soft and the other portion becomes hardened.

3. In the manufacture of a steel rimfire cartridge case having a body and a rim portion, the method comprising the steps of magnetically supporting said rim portion; heating said body to such a temperature as to cause the body to become substantially entirely austenite and until sufficient heat reaches the rim portion to render it non-magnetic, which will release the rim from the magnetic support; and rapidly cooling the case whereby the body becomes hardened, and the rim portion remains relatively soft.

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