Dec. 6, 1955 G. A. LYON 2,726,181

METHOD OF HEAT TREATING CARTRIDGE CASES

Filed Oct. 26, 1951 2 Sheets-Sheet 1

Fig. 1

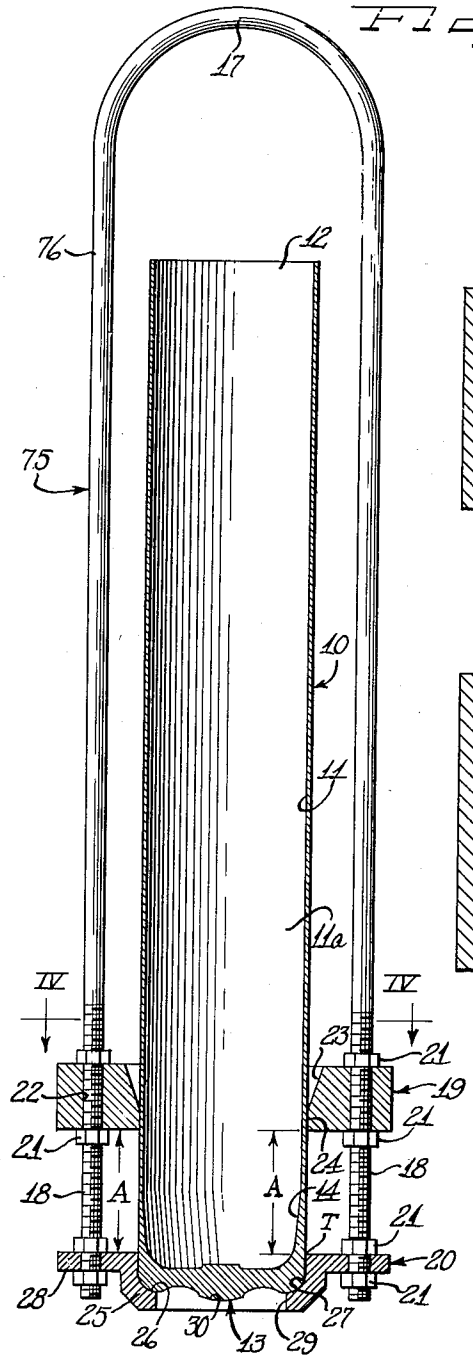


Fig. 2

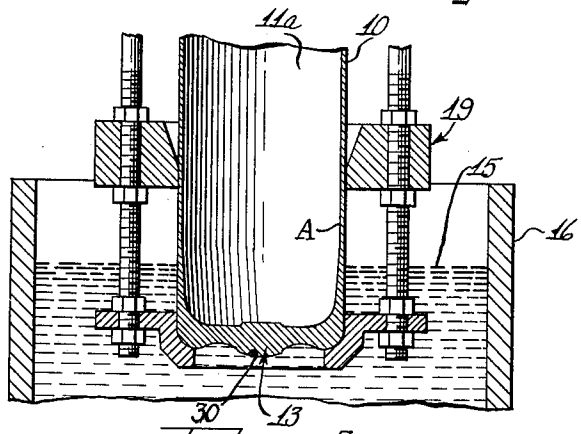


Fig. 3

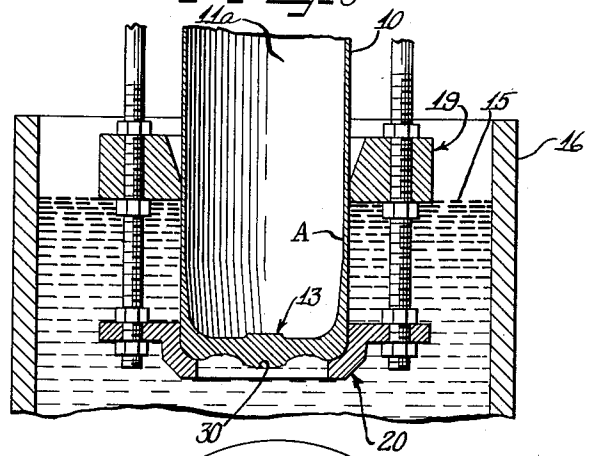
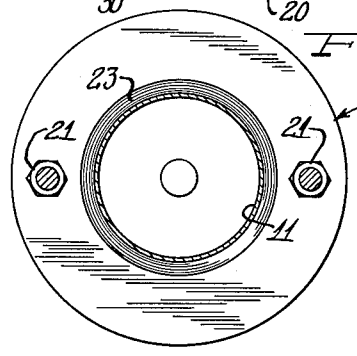


Fig. 4



Inventor

George Albert Lyon

by Kill, Sherman, Morris, Gross & Simpson Attys

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METHOD OF HEAT TREATING CARTRIDGE CASES

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Fig-5

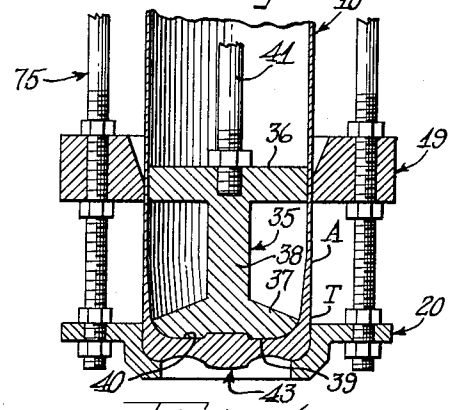


Fig-6

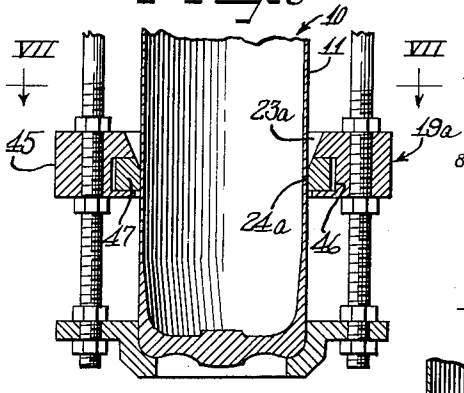


Fig-7

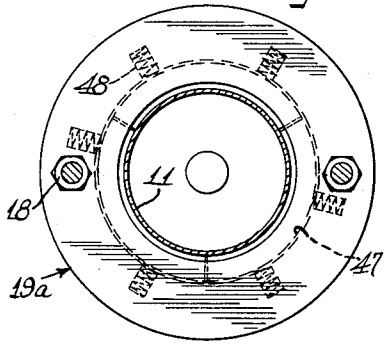


Fig-8

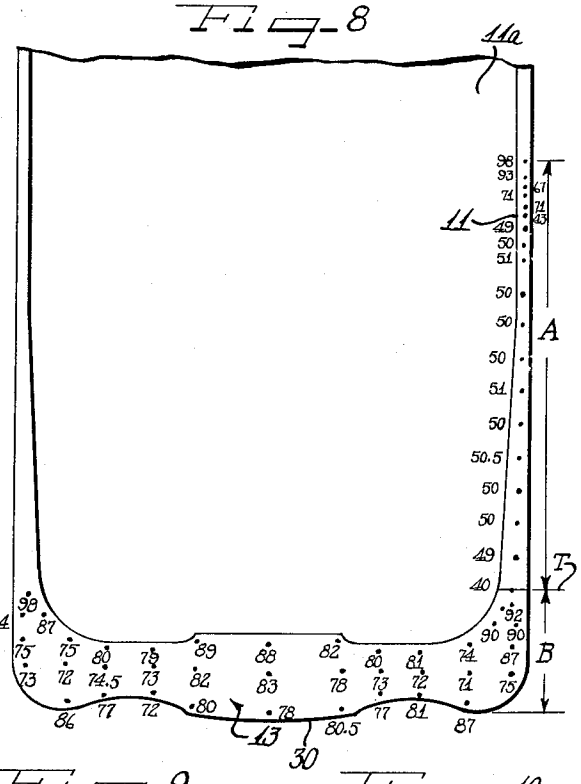


Fig-9

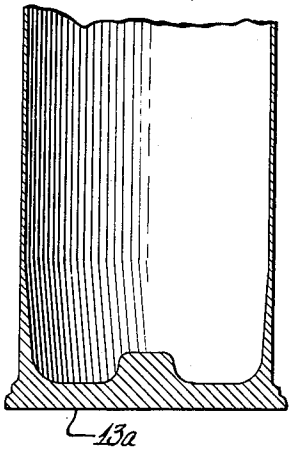
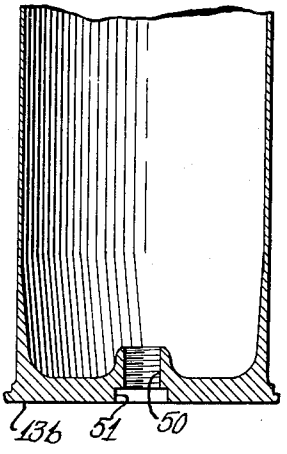


Fig-10



Inventor

George Albert Lyon

by Hill, Sherman, Meroni, Gross & Simpson Attys

United States Patent Office 2,726,181 Patented Dec. 6, 1955

2,726,181

METHOD OF HEAT TREATING CARTRIDGE CASES

George Albert Lyon, Detroit, Mich.

Application October 26, 1951, Serial No. 253,279

9 Claims. (Cl. 148—21.55)

This invention relates to a method of heat treating cartridge cases, and more particularly to a method of heat treating cartridge cases formed of medium soft steel by a series of cold working steps.

It has heretofore been the practice in making steel cartridge cases to start with circular blanks of hot rolled, fully annealed, spheroidized steel of around 0.30% carbon content, and then by a series of drawing and intermediate annealing steps, to form first a cup and in succession, more elongated cases. Additional steps necessary to making the finished cartridge case include trimming, stress relieving, mouth annealing, cold heading, tapering and necking, final mouth annealing and machining the base. At some stage between the cold heading and the final machining operations it has been found necessary to harden the portion of the side wall contiguous to the roughly formed head, or base, usually for a distance of about three to four inches from the head end face in the case of a three-inch/50 mm. case. A relatively high degree of hardness is required for this particular area of the side wall of the case in order to withstand the expansive effect to which it is subjected when the shell is exploded in the gun.

The hardening of this portion of the side wall of the casing is, however, complicated by the fact that it is not desirable also to harden the steel of the head end of the case, since that must subsequently be machined, and the machining operation is made more difficult the harder the steel on which the machining is carried out. In addition, where attempts have been made to restrict the hardening effect to the particular portion of the side wall required to be hardened, it has been found that such side wall portion is liable to become warped and so badly out-of-round as to make the case unusable.

Where induction heating is employed in connection with the hardening of the side wall area immediately adjacent the head end, a great deal of difficulty has also been encountered in maintaining the proper temperature in the localized area to be hardened in relation to the carbon content of the steel. Proper hardening by the induction heating method requires a very close correlation between the time and temperature of heating and the particular carbon content of the steel. Furthermore, the induction heating type of hardening requires a certain amount of time, which I have found to be longer than that necessary in carrying out a comparable step in the method of my invention.

In accordance with my present invention, the preliminary operations of forming a cartridge case are carried out as described in my copending application Serial No. 179,971, filed August 17, 1950, now Patent 2,698,268. These steps include the shearing and coining of a polygonal blank of medium soft steel to form therefrom a circular disc provided with a central thickened portion and an annular marginal inclined portion which tapers from the center toward the periphery of the disc. Subsequent to the coining operation, the coined disc is subjected to a series of cold working operations that include

an initial cupping and subsequent drawing steps, followed by a cold heading step to impart to the closed end of the case roughly the shape of the head of the finished case.

It is after these preliminary cold working steps, and preferably after the fourth drawing step and the completion of the rough heading step that the case is subjected to the heat treatment of my present invention. This heat treatment comprises a heating step in which both the steel of the head end and of the contiguous side wall portion for a distance of a few inches from the head end are subjected to treatment in the same heating zone but for different lengths of time and under such conditions that the steel of the head end is not raised above the lower portion of its critical range while the steel of the side wall portion is raised through its critical range or at least to its upper critical temperature.

The heat treatment is carried out by advancing the head end into the heating zone first and then advancing the side wall portion into the heated zone until the length of the side wall to be hardened has been exposed to the desired temperature, and controlling the total times to which the head end and the side wall portion are subjected to the temperature of the heating zone so that upon quenching a differential result is obtained as between the head end and the adjacent side wall portion.

In order to obtain the desired differential result between the hardness of the head end and the contiguous side wall portion, it is generally necessary to augment the heat absorptive mass of the head end so that the temperature thereof during immersion in the heating zone, which is preferably a salt bath, is prevented from rising to the Ac_3 point of the metal of the head. At the same time, it may be desirable to augment the heat absorptive mass of the metal of the side wall beyond the portion thereof that is contiguous to the head end, so as to prevent the transmission of heat from the contiguous side wall portion, which is immersed in the heating zone, to the side wall portion therebeyond. In this way, it is only the contiguous portion of the side wall that is raised to a temperature above its Ac_3 point, and, therefore, only the metal of the contiguous side wall portion that is substantially hardened as a result of its immersion in the heating zone and subsequent drastic quenching. The metal of the head end, in accordance with my method of heat treatment, does not reach its Ac_3 point, and, therefore, is annealed without substantial hardening, although subjected to immersion in the same heating zone.

Under optimum conditions, the steel of the head end is reduced in hardness and the steel of the side wall portion is increased in hardness relative to their respective degrees of hardness following the last cold working operative just prior to the start of the heat treatment. This is accomplished without substantial coarsening of the grain structure and without warpage to an extent greater than can be easily corrected by the final tapering step that is customarily performed in the making of cartridge cases.

Furthermore, by the use of the heat treatment of my invention it is possible to obtain the desired results without starting with a spheroidized steel, although my method of heat treatment will work equally as well if the steel is initially in a spheroidized condition. Any medium soft steel, by which is meant a steel having a carbon content of between 0.25 and 0.40%, with a maximum manganese content of 0.90% and impurities within the usual maximum values specified for phosphorus, sulphur and silicon, may be used. In particular, steels meeting the specifications of SAE 1030 and 1035, and the military specifications designated as MIL-S-3289 have been

found suitable for processing in accordance with the method of my invention.

It is therefore an important object of this invention to provide a method for the heat treatment of a cartridge case while in an intermediate stage following cold working and rough heading steps, in accordance with which the head end and a contiguous side wall portion of a case are subjected to a heat treatment step in the same heating zone but under such conditions as to impart a differential effect resulting in a relative hardening of the treated side wall portion and either no substantial hardening or even a relative softening of the head end, without, however, substantial coarsening of the grain in either of the regions subjected to the heat treating step.

It is a further important object of this invention to provide a method of heat treating a cold drawn, roughly headed cartridge case shape of between 0.25 and 0.40% carbon content under such controlled and localized conditions of temperature and total time of heat treatment as to obtain the desired degrees of hardness in the metal of the wall portion contiguous to the head end and in the head end, respectively, to facilitate the subsequent machining thereof, without excessive warping of the metal of the case and without substantial coarsening of the grain of the steel undergoing heat treatment.

Other and further important objects of this invention will become apparent from the following description and appended claims.

The method of my invention is illustrated in the accompanying drawings, in which:

Figure 1 is a longitudinal sectional view of a cartridge case shape in an intermediate stage of processing following a series of cold drawing steps and a rough heading step, illustrating in association therewith a clamping device for aiding in obtaining the differential effect of the heat treatment, as referred to above, the clamping device being partly in section and partly in elevation.

Figure 2 is a fragmentary, sectional view of the lower end of the cartridge case shape, shown with the head end immersed in a fused salt bath to illustrate the first step of the heat treatment.

Figure 3 is a similar fragmentary, sectional view showing the head end of the cartridge case shape immersed more deeply into the fused salt bath.

Figure 4 is a sectional view taken substantially along the line IV—IV of Figure 1.

Figure 5 is a fragmentary, sectional view of the head end of the cartridge case shape illustrating a clamping device similar to that shown in Figures 1 to 4, inclusive, but with an internal plug associated therewith.

Figure 6 is a similar fragmentary, sectional view of the lower end of the cartridge case shape showing a modified form of external clamping device.

Figure 7 is a sectional view taken substantially along the line VII—VII of Figure 6.

Figure 8 is an enlarged, fragmentary, sectional view showing hardness measurements on the Rockwell hardness tester, B and C scale, at different points throughout the head end and contiguous side wall portion of the cartridge case shape, prior to the final cold heading operation but subsequent to the heat treatment of my invention.

Figure 9 is a fragmentary, sectional view of the head end of the cartridge case shape after a final cold heading operation has been performed thereon;

Figure 10 is a similar fragmentary, sectional view of the head end of the cartridge case shape after the machining, tapping and finishing steps have been performed on the head.

The heat treatment method of my invention is applied to a cartridge case at a point in its manufacture represented by the shape indicated by the reference numeral **10**. The shape **10** has been reached by a series of cold working steps such as those described in my copending application Serial No. 179,971, filed August 17, 1950. Preferably, the shape **10** represents the form of the cartridge case after the fourth cold draw and immediately following the rough heading step. At this point, the shape **10** comprises a relatively thin wall **11** of generally circular cross section open at its mouth end, as at **12**, and closed at its other end by a roughly formed head **13**, with which the thin wall **11** is integrally joined by a tapered portion **14**. The entire shape **10** is, of course, integrally formed.

For purposes of illustration, the shape **10** of Figure 1 may be considered as representing the size and dimensions obtained at the intermediate stage indicated in the production of a three-inch/50 mm. cartridge case. The shape has been formed in the manner already referred to from a medium soft steel within the limits for carbon content of 0.25 to 0.40%, and preferably with a carbon content of around 0.35%. The steel may, but need not be, in a spheroidized state at the start of the cold drawing, or other cold working operations.

By way of typical example, the head end **13**, prior to the heat treatment steps about to be described, may have a Rockwell hardness of 90 to 92, B scale, while the side wall **11** has a Rockwell hardness of 100 to 102, B scale. The head end **13** is relatively thicker than the side wall **11** and thus represents a greater concentration of mass than the side wall. This difference in mass as between the head end and the contiguous side wall portions is taken advantage of, and may be augmented in the manner about to be described, in heat treating the shape **10** to obtain a differential effect between the two regions of the case.

In the heat treatment of shape **10**, I prefer to use a salt bath, indicated generally by the reference numeral **15**. The salt bath **15** is maintained in a fused state within a suitable container **16** and at a temperature depending upon the particular analysis of the steel undergoing heat treatment and the particular results desired. In general, the temperature of the salt bath **15** will be between 1250° and 1650° F., and for a steel meeting the specifications of SAE 1035, will preferably be between 1450° and 1650° F.

While a salt bath is illustrated as constituting the heat treating zone, other specific types of heating zones may be employed. Some of the advantages of a fused salt bath for heat treating purposes are the ease with which its temperature can be controlled within the desired narrow limits, the high specific heat of the fused salt and the relatively rapid rate of heat transfer from the salt bath to the article undergoing heat treatment, with consequent shortening of the total time required for the heat treatment of the article. In addition, a salt bath can be chosen that will be relatively non-corrosive toward the metal of the article and that will protect the article from corrosion during subsequent processing steps, while at the same time being readily removable by the application of water.

As illustrated in Figures 1 to 4, inclusive, the cartridge case shape **10**, prior to immersion in the salt bath **15**, is mounted in a combination hanger and clamping device, indicated generally by the reference numeral **75**. Said device **75** comprises a bale **76** in the form of an inverted U, the bight **17** serving for the suspension of the device from a conveyor. The lower free ends of the bale **76** are threaded for a portion of their length, as at **18**, and a wall-engaging member **19** and a head-engaging member **20** are mounted on said lower threaded ends **18**, **18** by means of suitable nuts **21**.

The wall-engaging member **19** is in the form of a ring, or annulus, having aligned bores **22** freely receiving the threaded leg portions **18**, and having an inner tapered wall portion **23** merging downwardly into a lower substantially cylindrical inner peripheral surface **24**. The inside diameter of the peripheral surface **24** is substantially the same, or slightly less than the outside diameter of the generally cylindrical side wall of the cartridge case shape

10, so as to effect close contact therewith. The tapered surface 23 facilitates centering of the cartridge case shape in the mounting of the clamping device thereon. The member 19 is held in adjusted position, by means of the nuts 21, so as to contact the side wall 11 just above the level to which the cartridge case shape is to be finally immersed in the salt bath 15.

The head-clamping member 20 is also annular in form and comprises a ring-like body portion 25 having an inner surface 26 contoured to fit the outer annular periphery 27 of the head end 13, and having a radially extending annular flange 28 that is apertured to freely receive the lower end portions 18 of the bale 76. The head-clamping member 20 is positioned and held in place on the lower threaded ends 18 by means of nuts 21 threaded on said ends above and below the flange 28. The body portion 25 is provided with an opening 29 which leaves the central bottom face of the head 13 exposed directly to the fused salt bath 15, when the cartridge case shape is immersed therein, as shown in Figures 2 and 3.

The distance, represented by the letter A, between the lower surface of the clamping member 19 and the upper surface of the clamping member 20 is the height to which the side wall portion contiguous to the head 13 is to be hardened by the heat treatment method about to be described. That portion of the head 13 that lies below the level of the upper surface of the clamping member 20 represents the head end portion of the cartridge case shape that is not to be hardened substantially, and preferably is to be softened, during the heat treatment operation. This means that at the level of the upper surface of the clamping member 20, there is a transition point, which is represented by the letter T.

In carrying out the method of heat treatment embodying my invention, a cartridge case shape 10 carried in a hanger and clamping device 75 as shown in Figure 1, is lowered, head end first, into the salt bath 15. In the first immersing step, the head end 13 is lowered to the level indicated in Figure 2. By way of example, assuming that the cartridge case shape 10 is of the dimensions represented by a three-inch/50 mm. case, when finished, the head end of the shape 10 is immersed in the salt bath 15 to the extent of about 2 1/16 inches upwardly of the outer face 30 of said head end. Upon reaching this depth of immersion, the shape 10 is held immersed at that depth for a period of about 1½ minutes. It is then lowered approximately an additional inch and three-quarters into the salt bath 15, to the level indicated in Figure 3, and held immersed at that depth for an additional one-half minute. At the expiration of said one-half minute, the shape is quickly withdrawn from the salt bath 15 and immediately drastically quenched, preferably in water or in an aqueous salt solution, to effect rapid cooling to the temperature of the circumambient air, or at least to a temperature below 200° F. During the quenching operation, the shape 10 is not removed from the combined supporting and clamping device 75, but is carried therein from the salt bath to the quench bath. After reaching the temperature indicated, the shape is removed from the quenching bath and, after further cooling if necessary, is subjected to the remaining processing steps, which may be the customary ones in the making of cartridge cases, or variations of such steps. If the immersion steps above described are followed, it will be apparent that the head end of the shape for 2 1/16 inches upwardly from the end face 30 is heated for a total of two minutes, while the contiguous wall portion for a height of one and three-quarter inches is heated for only one-half minute. Under these conditions for a cartridge case shape of the size and type of steel indicated, the head end 13 will be heated to a maximum temperature not above the lower critical range of the particular steel used, and preferably below such lower critical range, while the side wall portion contiguous to the head end and within a band of about one and three-quarters inches in length, starting two and one-sixteenth inches up from the end face 30, will be heated through the critical range, or at least up to and including the upper critical point, Ac_3, of the steel used. The difference in temperature reached by the head end 13 and the contiguous side wall portion is made possible by the greater concentration of mass of metal in the head end 13 than in the side wall 11, and by augmenting this difference by means of the clamping members 20 and 19.

As shown in Figure 3, the immersion of the head end of the shape 10 is carried only to the level at which the clamping member 19 makes contact on its lower face with the surface of the fused salt bath 15. The substantial mass of metal in the clamping ring 19, being for the most part exposed to the atmosphere above the fused salt bath, tends to extract heat that would otherwise be conducted along the wall 11 of the shape upwardly beyond the clamping member 19. Thus the portion of the side wall of the shape above the clamping ring 19 and indicated by the reference numeral 11*a*, remains relatively cool and unaffected by the heat treatment to which the head end of the shape is subjected.

In the quenching operation, the cooling of the head 13 proceeds at a slower rate than the cooling of the contiguous portion A of the side wall, both because of the greater mass of the head and also because of the contact between the periphery of the head and the clamping member 20. Thus, while the wall portion A is being rapidly cooled from its Ac_3 point to a temperature of around 200° F., or lower, the metal of the head 13 is being cooled more slowly from a temperature well below its Ac_3 point. Consequently, the metal of the head 13 is not hardened, and may even become somewhat softer as a result of the heat treatment if carried out under optimum conditions, while the metal of the contiguous wall portion A develops its maximum hardness even though subjected to the same fused salt bath and the same quenching step.

After the quenching operation, if the heat treatment has been carried out in the manner just described, the head end 13 will have an average Rockwell, B scale, hardness of about 80, with a maximum value up to about 98 near the transition line T, between the head and side wall, while the contiguous portion A of the side wall will have imparted to it an average Rockwell hardness, C scale, of about 49, with a minimum value of about 43 adjacent the same transition line T. Actual values for the Rockwell hardness determinations are shown in Fig. 8. The dots shown on the section of the head end of the heat treated cartridge case shape in Figure 8 represent points where actual hardness measurements were taken. These hardness values have been averaged for the head 13 below the transition line T and for the contiguous wall portion A above the transition line T. The average hardness values, before and after the heat treatment, may be summarized as follows:

	Before Heat Treatment	After Heat Treatment
Head End 13	90–92 B scale	80 B scale.
Contiguous Wall Portion "A"	100–102 B scale	49 C scale.

In order to achieve the desired differential hardness as between the head and the contiguous wall portion, it may be necessary to further augment the mass of metal in contact with the head 13 and in contact with the upper side wall portion 11*a*. A modification of the clamping members for this purpose is illustrated in Figure 5, wherein, in addition to the clamping assembly 75, there is used an inner plug, represented generally by the reference numeral 35. Said inner plug 35 comprises upper and lower heads 36 and 37, joined by a stem 38. The plug 35 may suitably be formed as a casting, preferably of a metal or alloy having good heat transfer characteristics, such as copper. The upper head 36 is of cylin-

drical shape with an outside diameter substantially the same as the inside diameter of the cartridge case shape **10** so as to be in sliding contact therewith. The lower head **37** is contoured on its lower face **39** to conform with the upper face **40** of the head **13**. Consequently, when the plug **35** is in place, the lower surface of the head **37** is in full surface contact with the inner face **40** of the head to a point adjacent the transition line T. A rod **41** is threaded into the upper head **36** of the plug **35** to facilitate its insertion and removal into and out of the cartridge case shape **10**. The plug **35** thus serves to augment the mass of metal at the head end and above the contiguous wall portion A and thereby prevent the head end and the upper wall portion **11***a* from reaching the temperature of the fused salt bath during the immersion steps, while permitting the contiguous side wall portion A to reach the fused salt bath temperature.

The temperature of the fused salt bath will vary in accordance with the carbon content of the shape to be heat treated so that for any given specification of steel, the temperature of the fused salt bath will be at least equal to the Ac_3 point of that steel, and preferably slightly higher. Thus, as previously stated the temperature of the salt bath **15** will be between 1250° and 1650° F., and preferably between 1450° and 1650° F. This preferred higher range includes the Ac_3 point of any of the medium soft steels for which the heat treatment method of my invention is particularly suited.

By way of illustration, if the cartridge case shape is formed of a steel meeting the specifications of SAE 1035, and if the salt bath **15** is maintained at a temperature of about 1600° F., then under the conditions of immersion specified above and using the form of clamping device and inner plug shown in Figure 5, the maximum temperature to which the metal of the head **13** will be raised during immersion is about 1250° to 1275° F., while the contiguous wall portion A will, of course, reach the temperature of the fused salt bath, namely, about 1600° F. Since the upper critical point, Ac_3, for SAE 1035 steel is about 1430° F., this means that the contiguous wall portion A will be heated through its Ac_3 point, while the metal of the head portion **13** will never reach its Ac_3 point. Consequently, the metal of the head **13** will be little affected by the heat treatment, but will tend to be softened rather than hardened, while the metal of the contiguous wall portion A will be hardened to the maximum extent possible as a result of the heat treatment.

A further modification of a clamping device is illustrated in Figures 6 and 7, wherein the upper clamping member **19***a* is formed in a plurality of parts, including a main ring **45** having an inner peripheral groove **46**, in which are positioned arcuate segments **47** that are urged by means of springs **48** into pressure contact with the outer surface of the side wall **11** of the cartridge case shape **10**. The inner surface of the main ring **45** is tapered, as at **23***a*, while the inner surface of each of the segments **47** is cylindrical, as at **24***a* to effect close surface contact with the outer surface of the side wall **11**. The clamping device **19***a* shown in Figures 6 and 7 may, of course, be used in conjunction with the inner plug **35**, or may be used separately in the heat treatment step.

The differential effect in hardness as between the head **13** and the contiguous wall portion A is obtained without any significant coarsening of the grain of the steel and without any detrimental warping of the portion of the shape that has been subjected to heat treatment. The advantages of the differential hardening effect are realized in the subsequent cold heading and finishing operations, the results of which are illustrated in Figures 9 and 10, respectively.

In Figure 9, the head end of the shape is shown after a suitable cold heading or coining step has been performed to provide a head end **13***a* more nearly approaching the shape of the head after the machining and other finishing operations have been performed. As a result of the heading operation that results in the formation of the head **13***a*, the average hardness of the steel in the head increases, but only to about 90, B scale, whereas if it were not for the previous heat treatment step, the heading operation would bring the hardness up to about 102, B scale. This lower hardness that results from the heat treatment step facilitates the machining of the head **13***a* to give the head **13***b* (Fig. 10). In addition to being machined, the head **13***b* is provided with a coaxial tapped bore **50**, which is countersunk, as at **51**.

The further processing of the cartridge case includes a stress-relief anneal, which involves heating to about 700° F. for about one-half hour. This brings the hardness of the metal of the final contiguous side wall A of the case down to an average hardness of around 41 to 42, C scale. A subsequent full length tapering operation gives the desired taper to the case and also serves to bring the side wall of the case to a substantially true circular cross section. For instance, if the side wall gets out of round as much as 0.013 inch in the heat treatment, the tapering step restores the side wall to truly circular cross section, plus or minus 0.003 inch. This is within the permissible tolerance.

There may optionally be a stress relief heat treatment after tapering.

As a result of the successive cold drawing steps, the grain of the steel after, say, the fourth draw, which is represented by the shape **10** of Figure 1, is greatly elongated, as might be expected. During the stress relieving, after heading and before tapering, the grain structure is considerably refined, although still elongated, and this makes for a better drawing during the full length tapering operation. The stress relief treatment also, as stated, brings the hardness of the metal of the side wall down to an average hardness of about 41 to 42, C scale, which is within the specifications required.

It will be understood that the heat treatment operations referred to may be carried out in a more or less automatically controlled system. For instance, in carrying out the heat treating process, a conveyor will be used which will operate in properly timed cycles for progressively lowering the case by proper increments into the fused salt bath, lifting the case out of the bath and immersing it in the quenching bath.

In summary, the heat treatment step of my invention includes heating the head end of the partially processed cartridge case, or shape, up to or within the lower part of the critical range of the particular steel used, say up to 1250° F., but preferably not in excess of 1275° F., while at the same time bringing the thinner contiguous wall portion of the shape to its upper critical point, or Ac_3, point, generally in the neighborhood of 1650° F. This heating step in combination with the quenching, results in a softening of the steel of the head end, say from an average of between 90 and 92 down to around 80, and in a hardening of the metal of the side wall, say from an average of between 100 and 102, B scale, up to about 49, C scale, all measured on the Rockwell hardness tester.

After the heading operation to produce the shape **10***a* illustrated in Figure 4, the average hardness of the head end **13***a* increases to about 90, B scale, but is still not so hard as it normally would be without the special heat treatment step. This facilitates machining the head end.

In the treatment for stress relief prior to full length tapering of the side wall, the hardness of the side wall is reduced to between 41 and 42, C scale, which is within the specified requirements.

It will thus be appreciated that the heat treatment method of my invention makes possible the use of medium soft steels having a carbon content of between 0.25 and 0.40, whether spheroidized or not, to produce, by a series of cold drawing, heading, annealing and tapering steps, a cartridge case that meets specifications. At the same time, my method eliminates the use of the more expensive and less easily controlled step of hardening the

side wall contiguous to the head end of the case by induction heating, and eliminates any excessive warpage that might otherwise occur if the induction heating step were employed. In addition, the combination of processing steps, including the anneal before tapering, results in a fine grain structure that makes for better drawing during the tapering of the full length of the case side wall.

It will be understood that modifications and variations may be effected without departing from the scope of the novel concepts of the present invention.

I claim as my invention:

1. In a method of heat treating a case having a relatively thick head end and a relatively thin side wall, both the head end and wall having been integrally formed from a cold worked blank of steel of 0.25 to 0.40% carbon content, the steps which comprise immersing said case head end first into a heat treating atmosphere having a temperature between 1250° and 1650° F., augmenting the effective mass of the head end and controlling the time and conditions of immersion of said head end and portions of said side wall contiguous thereto to bring the head end to a temperature within the lower portion only of the critical range of said steel while bringing the thin side wall portions to a temperature of around the upper critical point of said steel, and quenching the heated head end and wall portions, whereby a partial annealing of the steel of said head end and a hardening of the steel of said side wall portions are effected.

2. In a method of heat treating a case having a relatively thick head end and a relatively thin side wall, both the head end and wall having been integrally formed from a cold worked blank of steel of 0.25 to 0.40% carbon content, the steps which comprise immersing said case head end first into a heat treating atmosphere having a temperature between 1250° and 1650° F., augmenting the effective mass of the head end and controlling the time and conditions of immersion of said head end and portions of said side wall contiguous thereto to bring the head end to a temperature within the lower portion only of the critical range of said steel while bringing the thin side wall portions to a temperature of around the upper critical point of said steel, and quenching the heated head end and wall portions, whereby a partial annealing of the steel of said head end and a hardening of the steel of said side wall portions are effected, the head end having a Rockwell hardness of about 90 to 92, B scale, before and of about 80, B scale, after said heat treating steps, and said wall portions having a Rockwell hardness of about 100 to 102, B scale, before and of about 49, C scale, after said heat treating steps.

3. In a method of heat treating a cold work-hardened cartridge case of 0.25 to 0.40% carbon steel to provide a thickened head end of less hardness than the contiguous thin side wall portions, the steps which comprise incrementally advancing said case with its head end first into a heated zone having a temperature between 1250° and 1650° F., augmenting the effective mass of the head end and controlling the time of such incremental advances and the total time of dwell within said zone to bring said head end and contiguous wall portions to such temperatures, respectively, that said head end will have after quenching a lower and said contiguous wall portions will have a higher degree of hardness than their respective initial hardnesses, and quenching the same.

4. In a method of heat treating a cold work-hardened cartridge case of 0.25 to 0.40% carbon steel to provide a thickened head end of less hardness than the contiguous thin side wall portions, the steps which comprise augmenting the effective mass of the head end of said case, incrementally advancing said case with its head end first into a heated salt bath having a temperature between 1250° and 1650° F. until said head end and a few inches of said contiguous side wall portions are immersed in said salt bath, controlling the time of such incremental advances and the total time of dwell within said salt bath to bring said head end and contiguous wall portions to such temperatures, respectively, that said head end will have after quenching a lower and said contiguous wall portions will have a higher degree of hardness than their respective initial hardnesses, and quenching the same.

5. In a method of heat treating an intermediate shape of cartridge case of a steel containing about 0.30% of carbon that has been cold worked to form a thickened head end and an integral generally circular side wall, the steps which comprise immersing first said head end and then a portion of said side wall contiguous to said head end in a salt bath maintained at a temperature of between 1450° and 1650° F., augmenting the effective mass of the head end and controlling the total time and effect of such immersion of said head end and of said side wall portions so as to raise said head end to a maximum temperature of only about 1250° F. while raising said contiguous side wall portions to substantially the temperature of said bath, the total time of immersion being not over about two minutes for the equivalent of a 3 inch/50 mm. cartridge case, and immediately thereafter quenching said case from said salt bath, whereby a slight softening of the steel of said head end and a hardening of said contiguous side wall portions are obtained as compared with the respective hardness values of the head end and wall portions prior to such heat treating steps without substantially enlarging the grain structure from that of said cold worked steel.

6. In a method of heat treating an intermediate shape formed of 0.25 to 0.40% carbon steel that has been cold worked to form a closed thickened head and an integral thinner side wall of generally circular section open at its other end, the steps which comprise immersing first said head end and then a contiguous portion of said side wall up from said head end into a fused salt bath maintained at a temperature between 1450° and 1650° F., augmenting the effective mass of the head end and controlling the depth of each immersion, the effective rate of heat transfer from said bath to said head end and to that part of said side wall lying above the point of final immersion, and the total time of immersion of said head end and of said contiguous side wall portions so that said head end will be raised to a maximum temperature of not over 1275° F., while said side wall portions will be raised to a temperature at least equal to the upper critical point of the steel, removing said shape from said fused salt bath within about two minutes after its initial contact therewith, and immediately thereafter drastically quenching the heat treated portion of said shape to a temperature below about 200° F., whereby a reduction in the hardness of the steel in said head end and an increase in the hardness of the heat treated portion of said side wall are obtained as compared with the hardness values for those respective parts of the shape prior to such heat treatment.

7. In a method of heat treating an intermediate shape formed of 0.25 to 0.40% carbon steel that has been cold worked to form a closed thickened head end and an integral thinner side wall of generally circular section open at its other end, the steps which comprise immersing first said head end and then a contiguous portion of said side wall up from said head end into a fused salt bath maintained at a temperature between 1450° to 1650° F., controlling the depth of the immersion, controlling the effective metal mass of said head end and of that portion of said side wall lying above the point of final immersion by supplementing the same with additional metal in heat conducting contact therewith, and controlling the total time of immersion of said head end and of said side wall portion so that said head end will be raised to a maximum temperature of not over 1275° F., while said side wall portion will be raised to a temperature at

least equal to the upper critical point of the steel, removing said shape from said fused salt bath within about two minutes after its initial contact therewith, and immediately thereafter drastically quenching the heat treated portion of said shape to a temperature below about 200° F., whereby a reduction in the hardness of the steel in said head end and an increase in the hardness of the heat treated portion are effected of said side wall as compared with the hardness values for those respective parts of the shape prior to such heat treatment.

8. In a method of heat treating a steel shape susceptible of being hardened by heating through the Ac_3 point and quenching, the steps of immersing said shape in a fused salt bath having a temperature at least equal to the Ac_3 point, prior to such immersion augmenting the mass of a first portion of said shape by placing said portion in heat conducting relation with an additional mass of metal while leaving a contiguous portion of said shape unaugmented in mass, and controlling the amount of said additional mass and the time of immersion of said first portion and said contiguous portion in said salt bath to prevent the temperature of said first portion from reaching its Ac_3 point while bringing said contiguous portion to its Ac_3 point, and quenching said shape, whereby a relative softening of said first portion while at the same time effecting a hardening of said contiguous portion is effected.

9. In a method of heat treating a cold work-hardened cartridge case of 0.25 to 0.40% carbon steel to provide a thickened head end of lower degree of hardness than the contiguous thin side wall portion, the steps of immersing said case, head end first, in a fused salt bath maintained at a temperature of from 1450° to 1650° F., prior to such immersion augmenting the mass of said head end while leaving the contiguous side wall portion unaugmented in mass, incrementally advancing said case into said salt bath, holding said head end in said bath for a longer total time than said contiguous side wall portion but selecting the amount by which the mass of said head end is augmented so that said head end never reaches a temperature of over 1275° F. while said contiguous side wall portion reaches the temperature of said bath, removing said case from said bath at the end of said holding period, and quenching said case, whereby a relative softening of said head portion and a relative hardening of said side wall portion are simultaneously effected.

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