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TREATMENT OF BRASS

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This invention relates to the treatment of brass and to the fabrication of articles from the treated brass by deep drawing, cold heading, or equivalent operation involving substantial plastic deformation of brass sheet, wire, or other primary shape. The method of the invention entails a particular preparatory treatment of the primary brass shape, involving subjecting it to sufficient cold working to effect a large reduction in area followed by a recrystallization annealing operation at an unusually low temperature. The annealed primary brass shape resulting from this preparatory treatment has the tensile strength and hardness of quarter-hard or even half-hard cold finished brass, yet it has been found to be remarkably amenable to fabrication into cups, shells, screws, rivets, and like articles, by operations such as deep drawing and cold heading which involve substantial plastic deformation of the primary metal shape from which they are made.

In the fabrication of brass articles by deep drawing, cold heading, and like operations involving substantial plastic deformation, it has been customary heretofore to use a primary brass shape which has been fully annealed and is either in the dead soft condition, or nearly so. For example, cartridge brass sheet for deep drawing is usually supplied as soft, fully annealed metal having a tensile strength considerably less than 55,000 pounds per square inch, a grain size of 0.025 to 0.050 mm. (or even larger), and a Rockwell "B" hardness of less than 40. Such material in the cold-finished quarter-hard or half-hard condition having, say, a tensile strength of 58,000 pounds per square inch or more and a Rockwell "B" hardness of 60 or more, is unsatisfactory for fabrication by deep drawing or cold heading methods because it is incapable of undergoing substantial plastic deformation without the danger of cracking.

When brass, say cartridge brass or yellow brass, is subjected to such severe cold working as to result in a reduction in cross-sectional area of say 70% or more and is then annealed at the unusually low temperature of about 375° C. for a sufficient length of time to achieve substantially complete recrystallization but without increasing the average grain size to above 0.008 mm., the annealed product is found to have a tensile strength of about 58,000 pounds per square inch, thus meeting A. S. T. M. (i. e., American Society for Testing Materials) specifications for both quarter-hard and half-hard metal. I have discovered, however, that brass prepared in this

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fashion is remarkably amenable to fabricating operations entailing very substantial plastic deformation, such for example as deep drawing operations, cold heading operations, etc. I have discovered, for example, that some forms of deep drawn cups of such design that they cannot be made in a single cut-and-draw operation from ordinary commercial deep drawing brass strip can, surprisingly enough, be made successfully with a single cut-and-draw from brass sheet prepared as just described.

Based on these discoveries, the present invention provides a method which comprises subjecting brass containing 5% to 40% by weight of zinc and the balance essentially all copper to cold working and then annealing the brass at a temperature in the range from 500° C. to 600° C. for a sufficient period of time to effect substantially complete recrystallization without increasing the average grain size to above about 0.045 mm., then subjecting the brass to a severe cold working operation sufficient to effect a reduction in cross-sectional area greater than 65%, then annealing the thus worked brass at a temperature of about 375° C. for a sufficient period of time to effect substantially complete recrystallization of the metal without increasing the average grain size to above 0.008 mm., whereby the tensile strength of the annealed brass is maintained at a value above 55,000 pounds per square inch, and then subjecting the thus-annealed brass substantially at room temperature to an operation involving substantial plastic deformation. (Throughout this specification and in the appended claims I have for convenience referred to the tensile strength of the annealed brass fabricated in accordance with the invention as being above 55,000 pounds per square inch. This numerical value is substantially the average tensile strength for quarter-hard brass strip composed of 70% or less of copper, balance zinc, according to A. S. T. M. specification B36-49-T, or for eighth-hard brass wire of the same composition according to A. S. T. M. specification B-134-49. It is my intention that this numerical value, as used herein, be regarded as substantially such average value, and that in the case of alloys of less than 30% zinc content it be regarded with sufficient flexibility to mean the average tensile strength, according to said A. S. T. M. specifications, of quarter-hard strip or eighth-hard wire of such lesser zinc content.)

The brass alloys that may be fabricated with advantage by the method of the present invention are alloys containing from 5% to 40% by

weight of zinc, and the balance essentially all copper. I do not exclude, however, the possibility that such brass alloys may include minor amounts of additional metals, either by way of impurities or as metals intentionally added to impart modified properties to the alloy. For example, the alloy may contain, in addition to copper and zinc, a small amount of lead, or tin, or manganese, or other metal commonly used to modify the properties of binary copper-zinc alloys or commonly present as an impurity in such alloys. It is to be understood that the composition of the alloy does not in itself form a part of the present invention; the invention rather lies in the method of treating well-known brasses and then subsequently fabricating the treated brass by a method involving plastic deformation.

Preparatory to carrying out the method of this invention, the brass is subjected to conventional rolling, drawing, or other primary working operations until it is brought to its ready-to-finish size and shape. The conventional working methods used for this purpose need not be described in detail. Generally they comprise melting the brass alloy, casting it into a wirebar, cake, or other suitable shape, and then reducing its cross-sectional area by rolling, wire drawing, or other conventional primary working operation. As the cross-sectional area of the metal is reduced by cold working, it becomes hardened and its capacity to be worked further is lessened. Accordingly, it is customary to anneal the metal from time to time during the course of the working operations, to restore it to a soft condition in which it can readily be further worked.

After the metal has been brought to its ready-to-finish size, it is given a somewhat lighter anneal than is customary by heating at a temperature in the range from 500° C. to 600° C. for a sufficient period of time to effect substantially complete recrystallization of the alloy without increasing the grain size above 0.045 mm. (A full recrystallizing anneal of cold worked brass at the ready-to-finish size commonly is at a temperature and for a time sufficient to effect grain growth to an average size of 0.070 to 0.090 mm.)

The term "average grain size" is used herein, in the manner customary in the art, to mean that the average diameter or equivalent dimension of a typical grain is of the size stated. The grains are of course very irregular in size and shape, but for the most part they are similar to one another in size and shape, and it is customary in referring to average grain size to have reference to the most typical size that is found upon microscopic examination of the metal structure. In general, the estimation of grain sizes is herein contemplated to be in accordance with the methods set forth in A. S. T. M. specification E78–49–T, entitled "Tentative Methods for Estimating the Average Grain Size of Wrought Copper and Copper Base Alloys."

The annealed metal at ready-to-finish size, with its average grain size less than 0.045 mm., is then subjected to severe cold working (that is, to working at a temperature below the recrystallization temperature and generally at or near room temperature) sufficient to reduce its cross-sectional area by at least 65% and preferably by 70% or more. The manner in which such cold working is effected is not in itself critical. It may be by rolling or by drawing through dies, or by any other cold working method; and it may be performed in whatever number of successive rolling, drawing, or like operations is most convenient. However it is done, its effect must be to reduce the cross-sectional area of the worked metal, without any intermediate anneals, by the amount stated.

At the conclusion of this cold working operation, the metal is at its finished size and shape. Thus, if the metal has been prepared in sheet or strip form by a rolling operation, it will be at its finished thickness when this cold working operation is completed; and if it has been prepared by drawing through dies, it will be in the form of rod or wire of the desired finished diameter (or other dimension if the finished shape is non-circular).

The cold worked metal, now at finished gauge, is subjected to a very unusually light anneal by heating it at a temperature of about 375° C. for a sufficient length of time to effect substantially complete recrystallization of the metal, but to do so without increasing the average grain size to above 0.008 mm., and preferably to do so without increasing the average grain size to above 0.005 mm. The time required for such annealing at the rather low temperature of 375° C. is the same as is usually employed at a substantially higher temperature (say 500° to 550° C.) for full recrystallization of brass for deep drawing to an average grain size of about 0.025 to 0.040 mm. Upon completion of this annealing operation, the brass is found to have the tensile strength and hardness that is characteristic of cold finished metal rather than of annealed fully recrystallized metal. Its tensile strength is upwards of 55,000 pounds per square inch, and advantageously (especially for the alloys containing near 30% of zinc) about 60,000 pounds per square inch or higher. Hardness of the alloy on the Rockwell 30T scale is above 48, and even 58 or higher in the case of metals showing a tensile strength of 60,000 pounds per square inch or higher. The metal meets all of the requirements of A. S. T. M. specifications B36–49–T for brass sheet and strip in the quarter-hard or even half-hard condition and B–134–49 for brass wire in the eighth-hard or even quarter-hard condition, even though it is fully recrystallized and has not been cold finished.

Because of its evident hardness and high tensile strength, the metal prepared as described above would seem to be a most unpromising material for making into articles such as cups and rivets by methods involving substantial plastic deformation, e. g. by deep drawing of strip or by cold heading of wire. Nonetheless, I have found that it does in fact possess a most remarkable ability to undergo such plastic deformation, so that parts can be fabricated from it more readily and with fewer operations than with the softer brass heretofore customarily supplied for deep drawing and cold heading operations.

The methods involving plastic deformation by which brass strip or brass wire produced as described above may be fabricated into desired articles are in themselves conventional. Cupping and deep drawing operations are performed on the metal in the usual manner, using conventional punches, dies and other tools. Likewise, cold heading of brass wire prepared as described above is carried out in the conventional manner, using conventional heading tools. The forces applied to the strip or wire in such drawing or heading operations may have to be a little greater than is necessary when working with the heretofore conventional soft annealed deep

drawing or cold heading brass, but otherwise the operations are essentially the same.

I have found that brass cups and shells made by deep drawing operations from brass sheet or strip can be formed in many instances more simply when using brass prepared as described above than is possible when using conventional deep drawing brass strip. For example, a deep drawn brass cup having a depth about equal to its diameter and formed with an outwardly offset and flared lip at its open end has been made successfully in a single cut-and-draw operation from brass strip prepared as herein described. When conventional relatively soft deep drawing brass was employed in efforts to make this same part in the same way, the metal invariably tore or cracked in the vicinity of the lip. In order to make the part successfully from such soft annealed brass, it was necessary to subject it to at least two successive drawing operations. Thus, in making the part according to the invention, the tooling necessary for the deep drawing operation was very much simplified and the part was produced more economically and more efficiently.

Wire prepared as described above may be fabricated successfully in all conventional types of cold heading operations. The wire heads without difficulty on standard cold-heading machines to form virtually every conventional type of wood or machine screw head, including such complex head forms requiring severe cold deformation of the metal as washer heads, clutch heads, and fillister heads. For a given tensile strength the ductility of the wire, as measured by elongation test, is substantially twice as great as conventional cold-finished wire, so that it is unnecessary to make it in special tempers for different types of heads; and in practice it has been found that the wire is much more uniform from coil to coil than conventional cold-finished wire.

Another advantage of the method of the invention is that even though the metal is subjected to very severe plastic deformation during the final operation of forming the desired article, the finished article itself is virtually free from any surface roughness of the character known as "orange peel." Even in the vicinity of sharp convex curves in deep drawn cups, and in cold headed parts where the direction and nature of metal flow has been such as to favor the formation of orange peel, parts made in accordance with the invention are found to have remarkably smooth bright surfaces which require little or no buffing, even when the character of the surface finish is important for decorative purposes.

In consequence of the advantages described above, articles fabricated in accordance with the invention can in general be made more simply in fewer operations and with less complex tooling than has been necessary heretofore in the fabrication of like articles from conventional soft annealed deep drawing or cold heading brass strip, wire or other primary shape.

Another advantage to the brass mill in preparing metal in the manner described above is that it can be supplied to the customer in hard cold finished tempers with substantially fewer cold finishing operations than are necessary when the metal is prepared by the procedures heretofore conventionally employed. For example, one common method of specifying commercial degrees of hardness is to call for the brass mill to furnish the metal rolled or drawn two B&S numbers, or four B&S numbers, or six B&S numbers, or some number of B&S numbers, hard. This

terminology means that the metal is to have the hardness and tensile strength which results from cold finishing fully annealed metal by working it either by cold rolling or by cold drawing by the amount necessary to reduce its gauge by the specified number of B&S gauge numbers. For example, if a customer asks for brass strip cold finished eight B&S numbers hard, the procedure heretofore followed for making it is to subject it, after the final anneal, to one or more cold rolling operations which reduce its thickness by eight B&S gauge numbers. Metal which has been severely cold worked to the extent of more than 65% reduction in area and then given the very light anneal at 375° C. as described above is already of the hardness and tensile strength corresponding to what is conventionally obtained by cold finishing at least two B&S gauge numbers hard. If the metal is required cold finished, say, six or eight B&S numbers hard, such hardness may be imparted by cold working the annealed metal by an amount corresponding to a reduction of considerably less than the specified number of B&S gauge numbers, say, by cold working it to the extent necessary to further reduce its cross-sectional area by only two or three B&S gauge numbers. In consequence, the manufacture of cold finished brass in the harder tempers can be achieved more readily by following the practices described above than is possible when using the methods heretofore conventionally employed.

I claim:

1. The method which comprises subjecting brass containing 5% to 40% zinc and the balance essentially all copper to cold working and then annealing it at a temperature in the range from 500° C. to 600° C. for a sufficient period of time to effect substantially complete recrystallization without increasing the average grain size to above about 0.045 mm., then subjecting the brass to severe cold working sufficient to effect a reduction in cross-sectional area greater than 65%, then annealing the thus-worked brass at a temperature of about 375° C. for a sufficient period of time to effect substantially complete recrystallization without increasing the average grain size to above 0.008 mm., whereby the tensile strength of the annealed brass is maintained at a value above 55,000 pounds per square inch, and then subjecting the thus-annealed brass substantially at room temperature to substantial plastic deformation.

2. The method which comprises subjecting brass containing 5% to 40% zinc and the balance essentially all copper to cold working and then annealing it at a temperature in the range from 500° C. to 600° C. for a sufficient period of time to effect substantially complete recrystallization without increasing the average grain size to above about 0.045 mm., then subjecting the brass to severe cold working to effect a reduction in cross-sectional area greater than 70%, then annealing the thus worked brass at a temperature of about 375° C. for a sufficient period of time to effect substantially complete recrystallization without increasing the average grain size to above 0.005 mm., whereby the tensile strength of the annealed brass is maintained at a value above 60,000 pounds per square inch, and then subjecting the thus annealed brass substantially at room temperature to substantial plastic deformation.

3. The method of making a drawn article of sheet brass containing 5% to 40% zinc and the balance essentially all copper which comprises

subjecting a bar of such brass to cold rolling and then annealing the bar at a temperature in the range from 500° C. to 600° C. for a sufficient period of time to effect substantially complete recrystallization without increasing the average grain size to above about 0.045 mm., then cold rolling the bar to a sheet of desired thickness, said cold rolling being sufficiently severe to effect a reduction in cross-sectional area of at least 65%, then annealing the sheet at a temperature of about 375° C. for a suffiicent period of time to effect substantially complete recrystallization without increasing the average grain size to above 0.008 mm., whereby the tensile strength of the annealed sheet is maintained at a value above 5,000 pounds per square inch, and then forming the desired drawn article by subjecting the thus-annealed sheet to a deep drawing operation at room temperature.

4. The method of making a drawn article of brass which comprises subjecting to a deep drawing operation at room temperature a sheet of brass containing 5% to 40% zinc and the balance essentially all copper, said brass sheet being the product resulting from subjecting a bar of said composition to cold rolling and then annealing the bar at a temperature in the range from 500° C. to 600° C. for a sufficient period of time to effect substantially complete recrystallization without increasing the average grain size to above about 0.045 mm., then rolling the bar to a sheet of desired final thickness by subjecting it to a series of rolling operations at room temperature, said rolling at room temperature being sufficiently severe to effect a total reduction in cross-sectional area of at least 70%, and then annealing the thus-rolled sheet at a temperature of about 375° C. for a sufficient period of time to effect substantially complete recrystallization without increasing the average grain size to above 0.005 mm., whereby the tensile strength of the annealed brass is maintained at a value above 60,000 pounds per square inch.

5. The method of making a headed article of a brass alloy containing 5% to 40% zinc and the balance essentially all copper which comprises cold drawing a wire of such brass and then annealing it at a temperature in the range from 500° C. to 600° C. for a sufficient period of time to effect substantially complete recrystallization without increasing the average grain size to above about 0.045 mm., then cold drawing the wire to finished size, such cold drawing being sufficiently severe to effect a reduction in cross-sectional area of at least 65%, then annealing the thus-drawn wire at a temperature of about 375° C. for a sufficient period of time to effect substantially complete recrystallization without increasing the average grain size to above 0.008 mm., whereby the tensile strength of the annealed brass is maintained at a value above 55,000 pounds per square inch, and then forming the desired headed article by subjecting the thus-annealed wire to a cold heading operation.

6. The method of making a headed article of brass which comprises subjecting to a cold heading operation a brass wire containing 5% to 40% zinc and the balance essentially all copper, said brass wire being the product resulting from cold drawing a wire of such brass and then annealing it at a temperature in the range from 500° C. to 600° C. for a sufficient period of time to effect substantially complete recrystallization without increasing the average grain size to above about 0.045 mm., then drawing the wire to finished size by subjecting it to a series of drawing operations at room temperature, said drawing at room temperature being sufficiently severe to effect a total reduction in cross-sectional area of at least 70%, and then annealing the thus-drawn wire at a temperature of about 375° C. for a sufficient period of time to effect substantially complete recrystallization without increasing the average grain size to above 0.005 mm., whereby the tensile strength of the annealed brass is maintained at a value above 60,000 pounds per square inch.

7. A deep drawn article of brass containing 5% to 50% zinc and the balance essentially all copper, said article being the product resulting from subjecting a brass bar of said composition to cold rolling and then annealing the bar at a temperature in the range from 500° C. to 600° C. for a sufficient period of time to effect substantially complete recrystallization without increasing the average grain size to above about 0.045 mm., then cold rolling the bar to a sheet of desired thickness, said cold rolling being sufficiently severe to effect a reduction in cross-sectional area of at least 65%, then annealing the sheet at a temperature of about 375° C. for a sufficient period of time to effect substantially complete recrystallization without increasing the average grain size to above 0.008 mm., whereby the tensile strength of the annealed sheet is maintained at a value above 55,000 pounds per square inch, and then forming the desired drawn article by subjecting the thus-annealed sheet to a deep drawing operation at room temperature.

8. A headed article of brass containing 5% to 40% zinc and the balance essentially all copper, said article being the product resulting from cold drawing a wire of such brass and then annealing it at a temperature in the range from 500° C. to 600° C. for a sufficient period of time to effect substantially complete recrystallization without increasing the average grain size to above about 0.045 mm., then cold drawing the wire to finished size, such cold drawing being sufficiently severe to effect a reduction in cross-sectional area of at least 65%, then annealing the thus drawn wire at a temperature of about 375° C. for a sufficient period of time to effect substantially complete recrystallization without increasing the average grain size to above 0.008 mm., whereby the tensile strength of the annealed brass is maintained at a value above 55,000 pounds per square inch, and then forming the desired headed article by subjecting the thus-annealed wire to a cold heading operation.

9. The method of making a plastically deformed article of brass which comprises subjecting to substantial plastic deformation at room temperature a brass shape which contains 5% to 40% zinc and the balance substantially all copper, said shape being the product resulting from subjecting brass of said composition to cold working and then annealing at a temperature in the range from 500° C. to 600° C. for a sufficient period of time to effect substantially complete recrystallization without increasing the average grain size to above about 0.045 mm., then subjecting the brass to severe cold working sufficient to effect a reduction in cross-sectional area greater than 65%, and then annealing the thus-worked brass at a temperature of about 375° C. for a sufficient period of time to effect substantially complete recrystallization without increasing the average grain size to above 0.008 mm., whereby the ten-

sile strength of the annealed brass is maintained at a value above 55,000 pounds per square inch.

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