Nov. 15, 1966 R. A. GRANGE ETAL 3,285,789

METHOD OF SOFTENING STEEL

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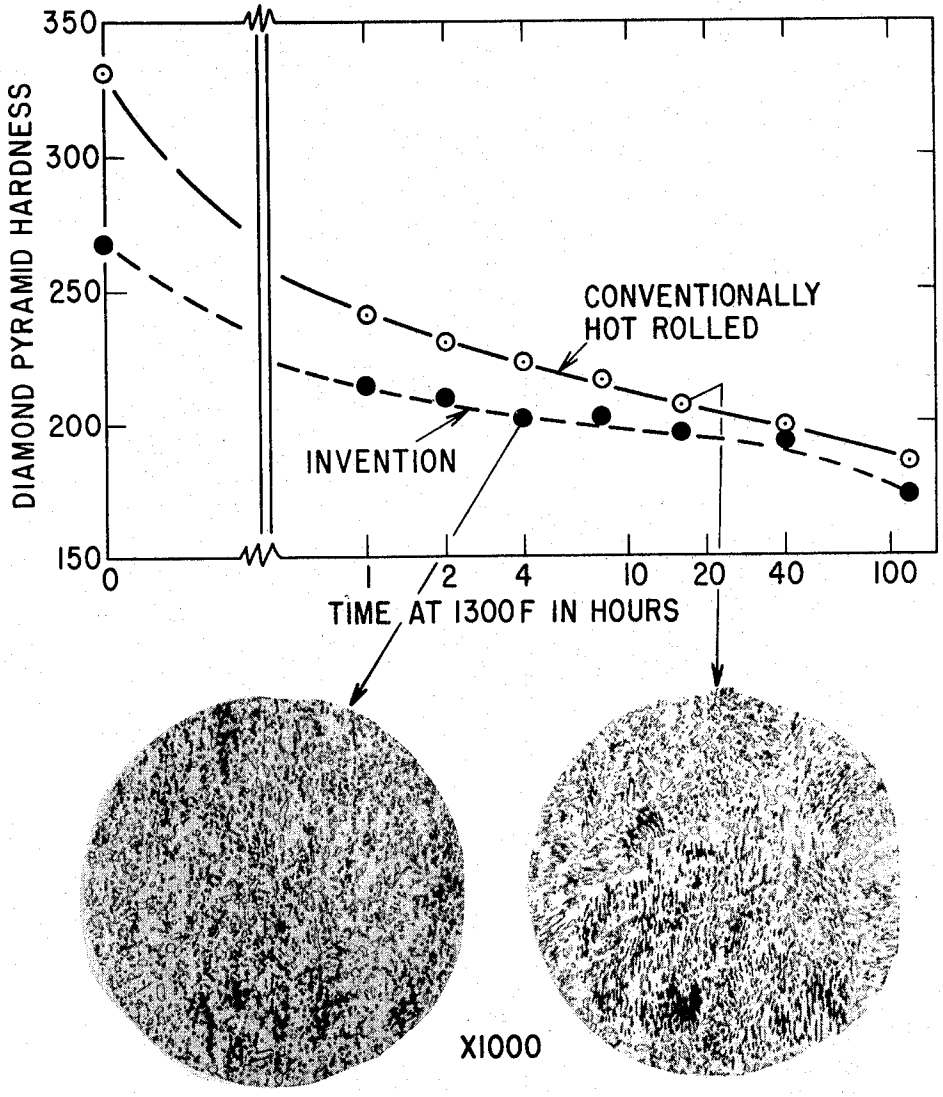
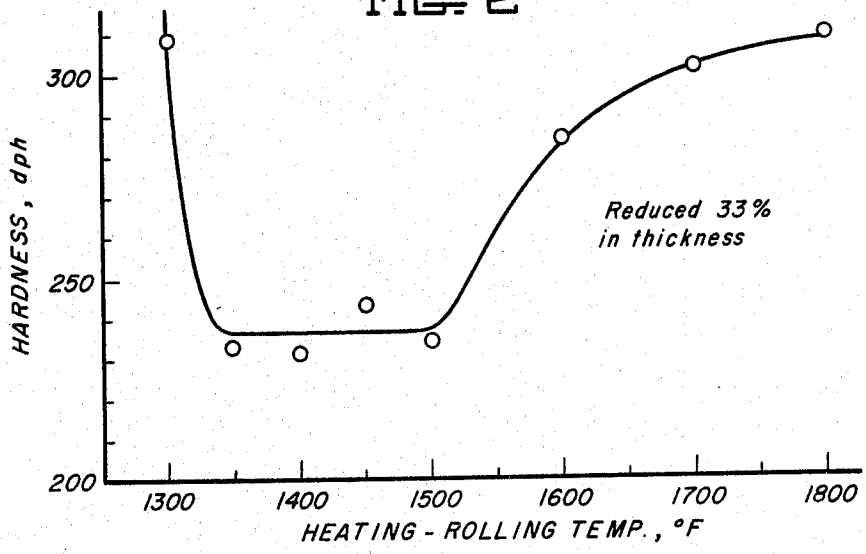


FIG. 1 -- COMPARISON OF RATE OF SOFTENING ON ANNEALING OF 1086.

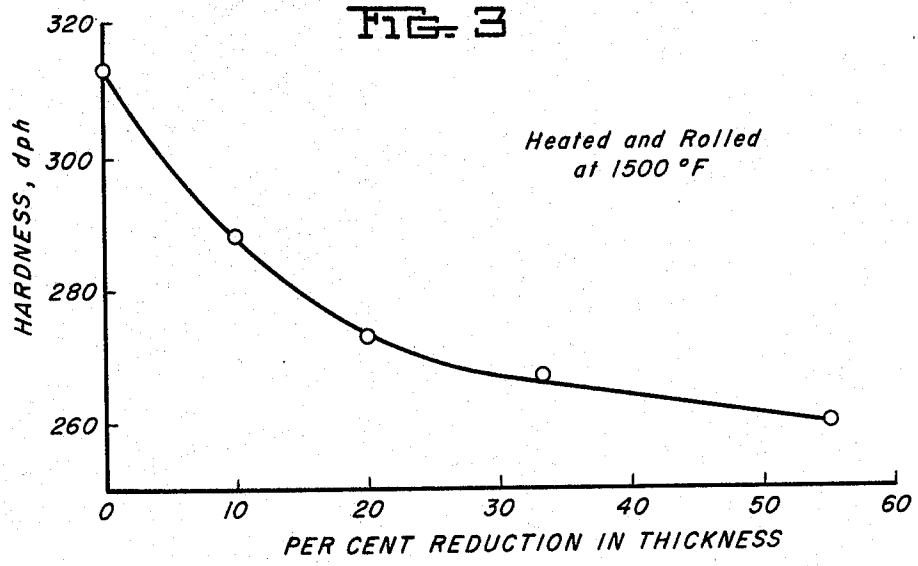
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FIG. 2



EFFECT OF HEATING - ROLLING TEMPERATURE ON HARDNESS OF AIR - COOLED 0.100 INCH THICK STRIP. (1086 STEEL)

FIG. 3



EFFECT OF AMOUNT OF REDUCTION ON HARDNESS OF AIR - COOLED 0.100 INCH THICK STRIP. (1086 STEEL)

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METHOD OF SOFTENING STEEL

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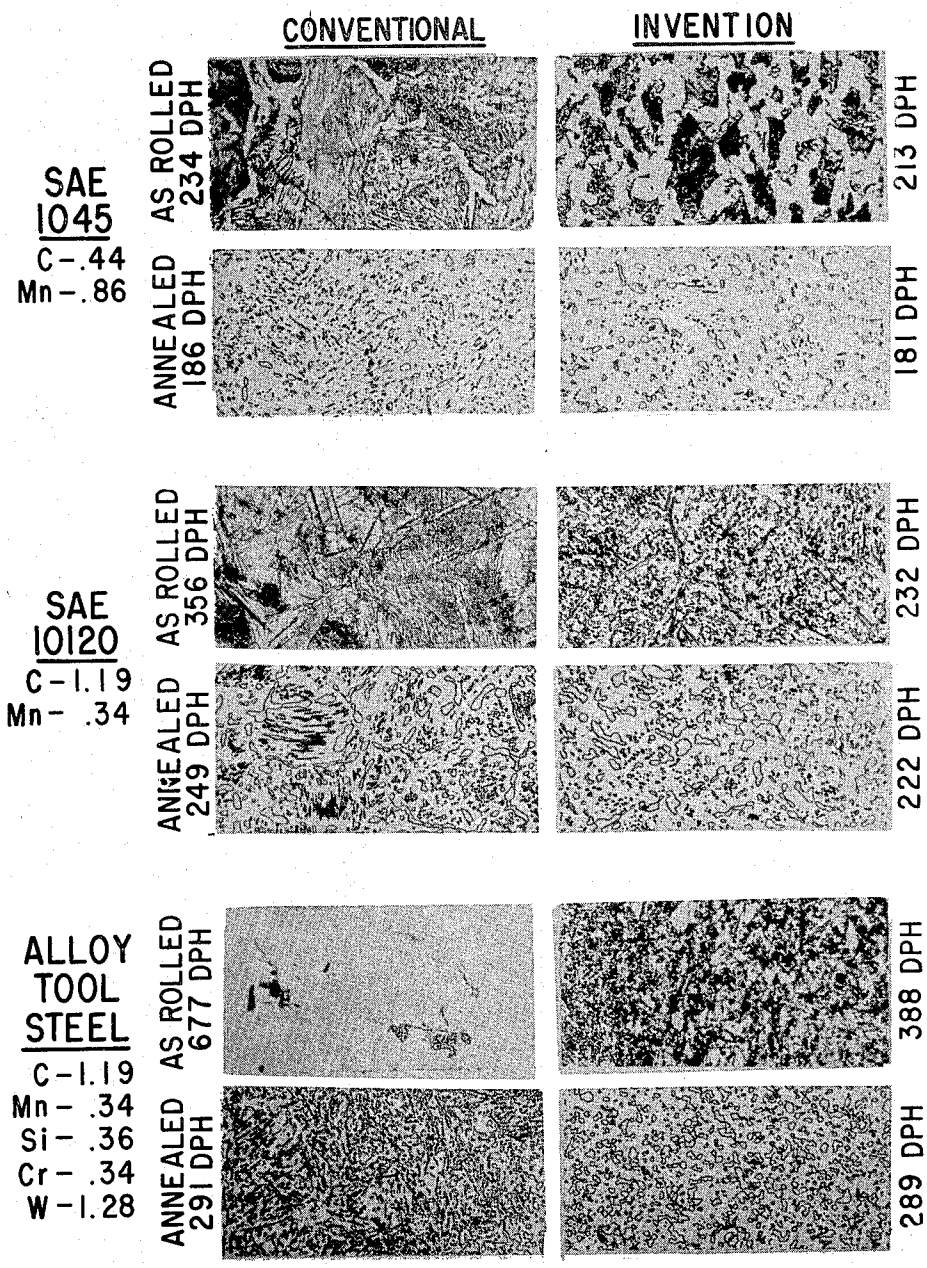


FIG. 4 -- COMPARISON OF THREE STEELS PROCESSED BY INVENTION WITH CONVENTIONALLY HOT-ROLLED MATERIAL. 0.100 INCH THICK STRIP. X1000

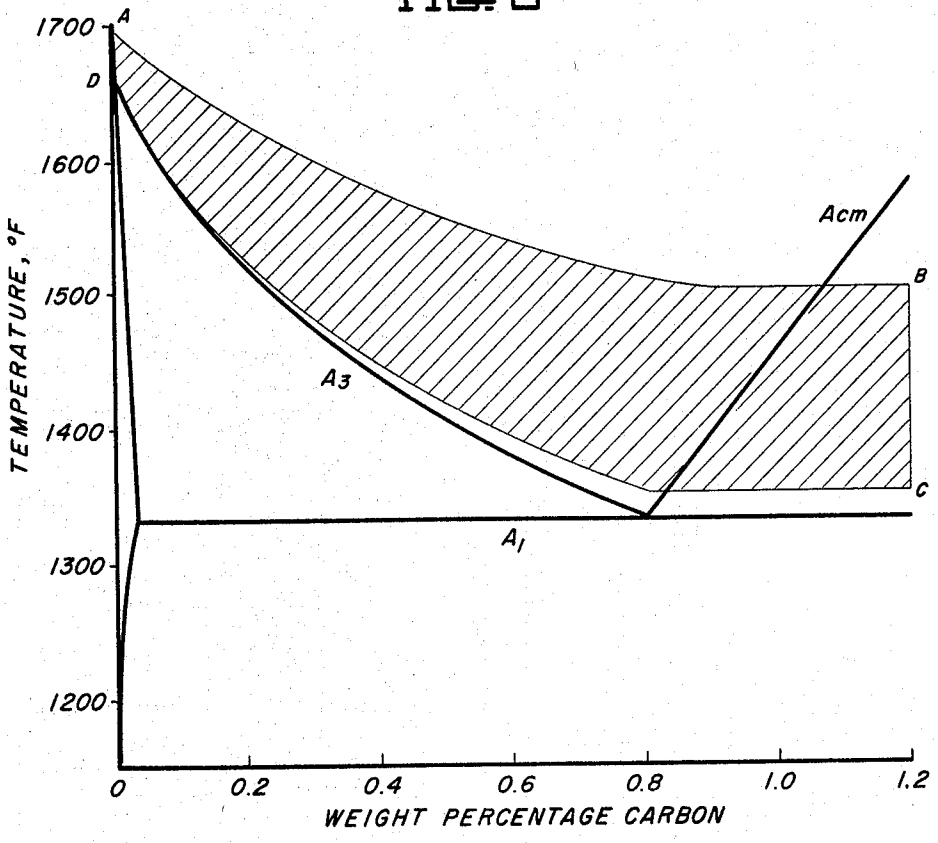
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FIG. 5



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METHOD OF SOFTENING STEEL

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4 Claims. (Cl. 148—12)

This invention relates to improvements in softening steel and more particularly to improvements in the softening of steel by spheroidize annealing.

For many purposes it is desirable to have steel in the spheroidize annealed condition. In such condition the carbide phase is present as spheroids of relatively large and uniform size produced by annealing at subcritical, i.e. below the A_1 temperature for periods of fifteen to twenty hours or more. While low and medium carbon steels, i.e. containing less than 0.8% carbon are sometimes spheroidized, the practice is more frequent with high carbon steels, i.e. steels containing over 0.8% carbon. Spheroidizing annealing produces maximum ductility and formability in most steels but in the high carbon steels, it is required for good machinability and formability and provides the preferred structure for subsequent hardening by heat treatment. However the long time at temperature required for spheroidizing adds significantly to the cost thereof.

It is accordingly an object of our invention to provide a more efficient and economical manner of producing a soft spheroidized condition in steel products.

The foregoing and further objects will be apparent from the following specification when read in conjunction with the attached drawings wherein:

FIGURE 1 is a combined graph and photomicrograph, illustrating graphically and photographically the improved softness and microstructure obtainable with the use of the treatment of this invention;

FIGURES 2 and 3 are graphs;

FIGURE 4 is a series of photomicrographs comparing the microstructure of samples of various steels conventionally rolled with samples of the same compositions treated in accordance with this invention in both as rolled and annealed conditions; and

FIGURE 5 is a graph indicating by the area ABCD the preferred austenitizing temperature for steels of the indicated carbon contents.

We have discovered that a short anneal following heating and rolling within a specific temperature range will produce results heretofore unobtainable except by extremely lengthy annealing.

In accordance with the teachings of our invention, steel is hot rolled to an oversize cross section cooled to room temperature, followed by reheating it in the range indicated by FIGURE 5 of the drawing for just sufficient time to austenitize it. It is then rolled with reductions of at least 25% and air cooled. Thereafter it is annealed at temperatures preferably below but no more than 50° F. below its A_1 for about two to four hours. Longer times may be used but are not necessary to obtain results better than could heretofore be obtained in less than 16 to 20 hours or more. The temperature of reheating and rolling must be within a limited temperature range which depends, to some extent, on chemical composition of each particular grade of steel but primarily on its carbon content. As indicated by FIGURE 2, the temperature range for softening 1086 steel by relatively low temperature heating and rolling is about 1350 to 1500° F. This same range is suitable for other high carbon steels but a somewhat higher range is required for medium carbon steels, and especially for low carbon steels, in accordance with their higher critical temperature range. The aim is to

heat only high enough and long enough to convert essentially all ferrite to austenite. The range for the various carbon contents contemplated by the invention is delineated by the area ABCD of FIGURE 5 of the drawing.

Heating for rolling in our process can be done in any convenient manner and the steel need not be maintaied at temperature for a period longer than required to bring all portions of the mass to temperature. The steel is rolled in the austenitic condition, but the temperature may be in the region of metastable austenite provided deformation is done before any appreciable transformation occurs. Usually, in small sections this allows time for only one roll pass but in heavier sections, especially when an alloy steel is being processed, more than one roll pass is feasible.

The amount of reduction following reheating must at least be enough to deform the center as well as the surface grains. Thus, thick material will require a higher overall percentage reduction than thin material. FIGURE 3 shows the effect of varying the amount of reduction in 1086 strip rolled at 1500° F. to a final thickness of 0.100 inch. This indicates that for strip material about 25% reduction is required for maximum benefits. Increased reductions produce little additional effect.

FIGURE 4 illustrates the effect of processing three different grades of steel as indicated thereon by this process compared to conventional treatment. Hardness and microstructure in both the as-rolled condition and after annealing are shown. Both the material processed conventionally and the material processed pursuant to this invention were annealed for the same time at 1300° F. Softening by the treatment of this invention was greatest in the two high carbon steels, but an appreciable effect is evident in the 1045 steel. Thus, this invention is effective in softening and decreasing the time required for spheroidization in a wide variety of steels including both carbon and low alloy grades.

While processing by rolling has been described, the low temperature reheating and working technique can be used with other deformation processes such as forging and extrusion. The process is particularly adapted to processing relatively thin sections such as sheet and strip. However, there is no section size limitation. Products of thin cross section made of high carbon steel, such as strip for razor blades, cutlery and springs, are especially suitable for processing by our method. In such products, the resulting reduction in annealing time is also advantageous to minimize undesirable graphitization which is a problem in processing such products which frequently require several spheroidizing anneals.

While we have shown and described several specific embodiments of our invention, it will be understood that these embodiments are merely for the purpose of illustration and description and that various other forms may be devised within the scope of our invention, as defined in the appended claims.

We claim:

1. A method of producing spheroidize annealed steel comprising hot working steel to a cross section at least about 25% greater than the final size desired, cooling to room temperature, reheating said steel at a temperature within the range of the area ABCD of FIGURE 5 for the indicated carbon content for just sufficient time to convert substantially all ferrite to austenite, reducing the thickness of said steel sufficiently to deform the center grains thereof before any substantial transformation of the austenite and then spheroidize annealing it at temperature below but no more than 50° F. below its A_1 temperature.

2. A method of producing spheroidize annealed steel comprising hot rolling steel to at least about 25% above the final gauge desired, cooling to room temperature, reheating said steel at a temperature within the range of

the area ABCD of FIGURE 5 for the indicated carbon content for just sufficient time to convert substantially all ferrite to austenite, reducing the thickness of said steel sufficiently to deform the center grains thereof while at said temperature and then spheroidize annealing it at temperature below its A_1 temperature for at least about 2 to 4 hours.

3. A method of producing spheroidize annealed steel comprising hot rolling steel to at least about 25% above the final gauge desired, cooling to room temperature, reheating said steel at a temperature within the range of the area ABCD of FIGURE 5 for the indicated carbon content, reducing the thickness of said steel sufficiently to deform the center grains therof before any substantial transformation of the austenite and then spheroidize annealing it at temperature below its A_1 temperature.

4. A method of producing spheroidize annealed steel comprising hot rolling steel to at least about 25% above the final guage desired, cooling to room temperature, reheating said steel at a temperature within the range of the area ABCD of FIGURE 5 for the indicated carbon content, reducing the thickness of said steel sufficiently to deform the center grains thereof while at said temperature and then spheroidize annealing it at temperature below but no more than 50° F. below its A_1 temperature for about 2 to 4 hours.

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