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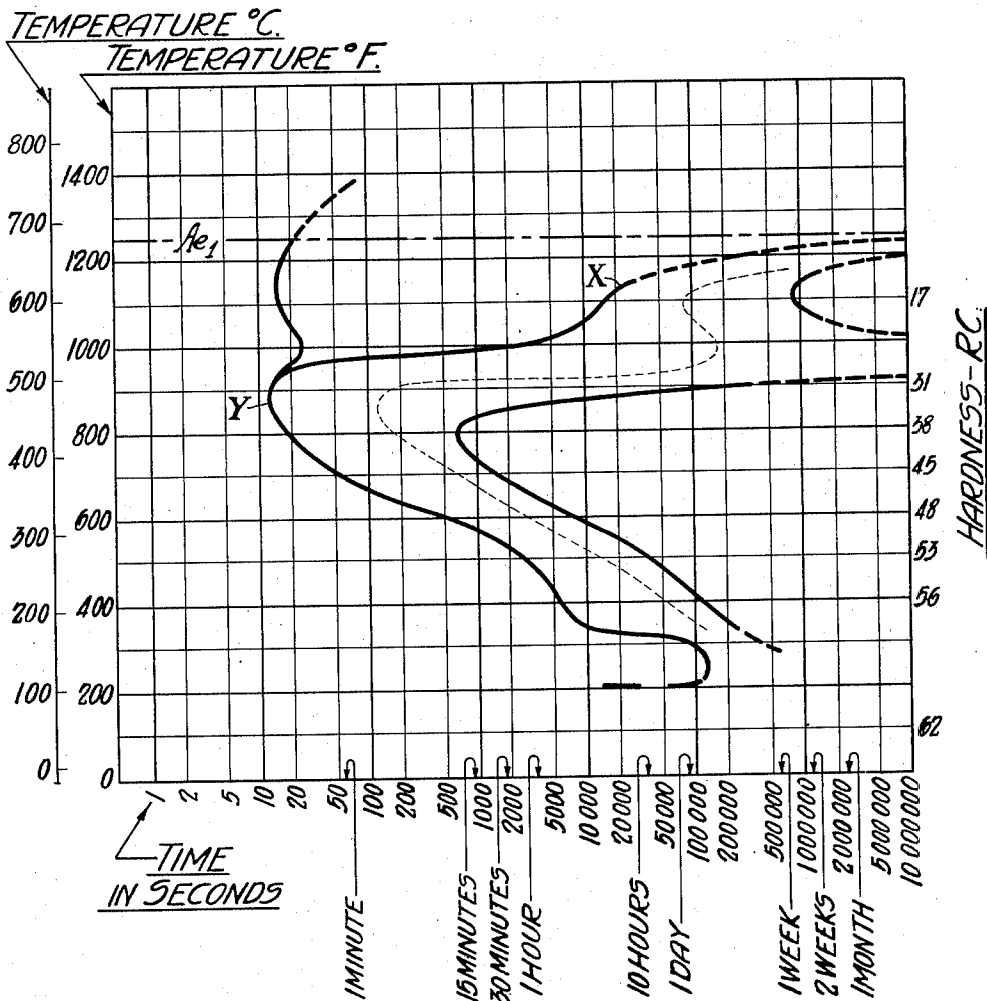
J. F. BOYCE
MACHINABILITY OF QUENCH-HARDENED ALLOY
STEELS CONTAINING RETAINED AUSTENITE

2,563,672

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2 Sheets-Sheet 1

FIG. 1.



Inventor:
JOSEPH F. BOYCE,
by: *Donald G. Dalton*
his Attorney.

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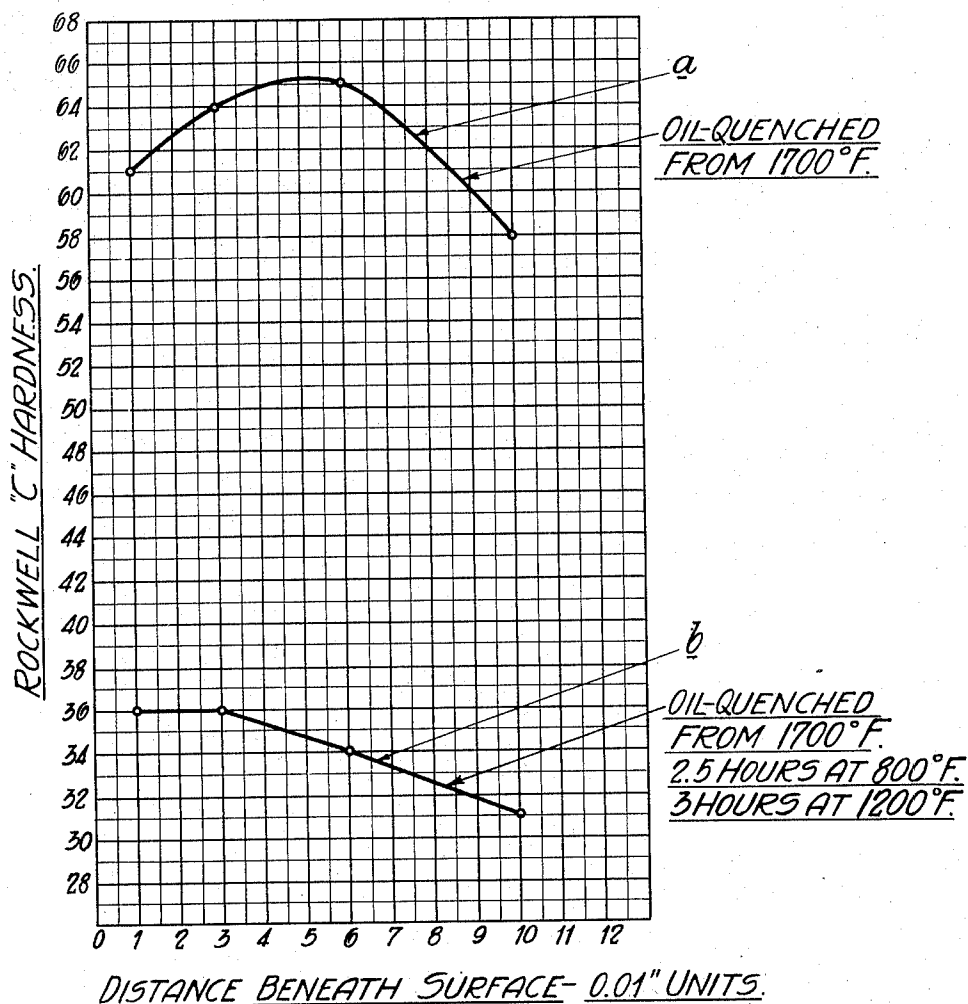
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FIG. 2.



Inventor:
JOSEPH F. BOYCE,
by: *Donald G. Dalton*
his Attorney.

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MACHINABILITY OF QUENCH-HARDENED
ALLOY STEELS CONTAINING RETAINED
AUSTENITEJoseph F. Boyce, Bloomfield, N. J., assignor to
United States Steel Company, a corporation of
New Jersey

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2 Claims. (Cl. 148—21.5)

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This invention relates to an improved method of improving the machinability of quench-hardened alloy steels containing retained austenite.

Certain low or medium alloy steels, particularly those containing high carbon as well as high-carbon regions of carburized steels, tend to contain appreciable amounts of austenite in addition to martensite upon quenching. It is frequently desirable to machine parts formed of such steels after quenching but this cannot be done, due to the hardness of the martensite and the work hardening of the austenite, unless the steel is first softened by tempering.

However, conventional tempering of quenched steels containing considerable retained austenite may actually effect an increase in hardness rather than the expected lowering thereof. For instance, a bar of carburized AISI-SAE grade 3310 steel exhibits after quenching from 1700° F., a hardness of 37 Rc. at the surface which increased to 61 Rc. at a distance of 0.06 to 0.08" below the surface. After tempering for six hours at 1220° F., i. e., just below the A_{c1} temperature for this steel, the hardness at all points between the surface and a depth of 0.04" actually increased. At the surface this increase was from 37 Rc. to 64 Rc. Thus for machining purposes, tempering at a conventional temperature even for considerably longer than usual had a bad effect on the outer 0.04" of the carburized case. While steels containing considerable retained austenite may be softened by holding at tempering temperatures for very long periods of time or by tempering several times at relatively high tempering temperatures, the time required to obtain the desired low hardness by either of these methods is excessively long for some steels.

It is accordingly an object of this invention to provide an improved method for improving the machinability of quench-hardened alloy steels containing retained austenite.

It is a further object to provide a method of improving machinability of quench-hardened alloy steels containing retained austenite in a relatively short period of time.

It is another object to provide a method of improving the machinability of quench-hardened alloy steels containing retained austenite that will transform to bainite more rapidly than to pearlite.

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

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Figure 1 is an isothermal transformation diagram of carburized steel of AISI-SAE grade No. 4815 austenitized at 1800° F.; and

Figure 2 is a graph showing the average hardness of a number of quench carburized steels before and after being treated in accordance with this invention.

The foregoing chart of 4815 steel is generally illustrative of many low and medium alloy steels in which retained austenite will transform completely to bainite more rapidly than to pearlite in that it exhibits two nose portions in the curve, i. e., an upper nose X frequently referred to as the "pearlite" nose and a lower nose Y, sometimes called the "bainite" nose. As indicated by this diagram, the austenite can be completely transformed to bainite in a relatively short time at a temperature below that ordinarily used for tempering. This temperature may vary for different steels from 500 to 900° F. and the time required from a few hundred seconds to a number of hours. As indicated by the diagram, the retained austenite in steel 4815 may be transformed to bainite in less than 30 minutes at a temperature of about 800° F. Following this, the steel is heated to a temperature below the A_{c1} point but above the "pearlite" nose and held at such temperature for a sufficiently long time to soften the bainite and tempered martensite sufficiently to permit ready machining and then cooled to room temperature at any convenient rate. If desired, the steel may be cooled to room temperature after transforming the austenite to bainite or may be transferred directly from the temperature of the "bainite" nose to the elevated temperature. The tempering of the 4815 grade of steel was at a temperature of 1230° F. for one hour whereby it is seen that the total time required for the two treatments is materially less than that heretofore required by conventional treatments.

Figure 2 further illustrates the benefits of this invention. This is a graph showing the average hardness at the distance below the surface as indicated thereon of carburized 1" rounds of SAE-AISI steel No. 4317, and steels Nos. 43B17, 46B15, and 86B15. These latter designations are more generally used to indicate steels corresponding to SAE-AISI steels of like number designation to which boron has been added. The upper line *a* represents the hardness values of these steels as being oil quenched from 1700° F. The lower line *b* indicates the hardness values obtained on the same quenched steels after being treated for 2.5 hours at 800° F. to transform the retained

austenite to bainite and then tempering the resulting bainite at 1200° for three hours. The 800° F. temperature used to transform the retained austenite to bainite is about the same as that indicated in Figure 1 as being the temperature at which the desired transformation can be completed in a minimum time.

The actual values for each of the steels represented in Figure 2 is set forth in the following table:

Table

Distance Beneath Surface	4317		43B17		46B15		86B15	
	Oil Quench Rc	Soft- ened Rc	Oil Quench Rc	Soft- ened Rc	Oil Quench Rc	Soft- ened Rc	Oil Quench Rc	Soft- ened Rc
<i>Inches</i>								
0.01	61	36	57	38	64	34	61	38
0.03	64	36	61	39	65	33	65	37
0.06	65	33	65	37	64	32	66	35
0.10	57	30	58	33	57	29	59	30

Thus it appears that quenched steels of the type containing considerable retained austenite may be sufficiently softened to enable ready machining thereof by a two-stage process whereby the steels are first heated to the temperature of rapid transformation to bainite of such steels and held thereat for sufficient time to complete transformation thereof and then held at a temperature below the A_{e1} point of such steel but above the temperature of rapid pearlite transformation for sufficient time to effect the desired softening.

The A_{e1} temperature, as now generally understood and as used herein, is the lower equilibrium transformation temperature, the highest temperature below which 100% ferrite plus carbide can exist indefinitely. It is not the same as the A_{c1} and A_{r1} temperatures which are influenced by the rate of heating or cooling employed in their measurement.

While I have shown and described several specific embodiments of my 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 my invention, as defined in the appended claims.

I claim:

1. A method of improving machinability of quench-hardened steels containing martensite and retained austenite comprising holding such steels at a temperature between 500 and 900° F. for sufficient length of time to convert the austenite to bainite and then raising the temperature of said steels to between the A_{e1} point of the steel and the temperature of the pearlite nose of the isothermal transformation diagram

of the steel for sufficient time to obtain the desired improvement in the machinability thereof.

2. A method of improving machinability of quench-hardened steels containing martensite and retained austenite comprising holding such steels at about the temperature of the bainite nose of the isothermal transformation diagram of the steel for sufficient time to transform the austenite to bainite and then raising the temperature to between the A_{e1} point of the steel and the temperature of the pearlite nose of the isothermal transformation diagram of the steel and holding it in such range for sufficient time to effect the desired improvement in the machinability.

JOSEPH F. BOYCE.

REFERENCES CITED

The following references are of record in the file of this patent:

- The Isothermal Decomposition of Martensite and Retained Austenite Preprint No. 1, page 2, published by American Society for Metals, Cleveland, Ohio, 1948.