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PROCESS FOR HEAT TREATING STEEL

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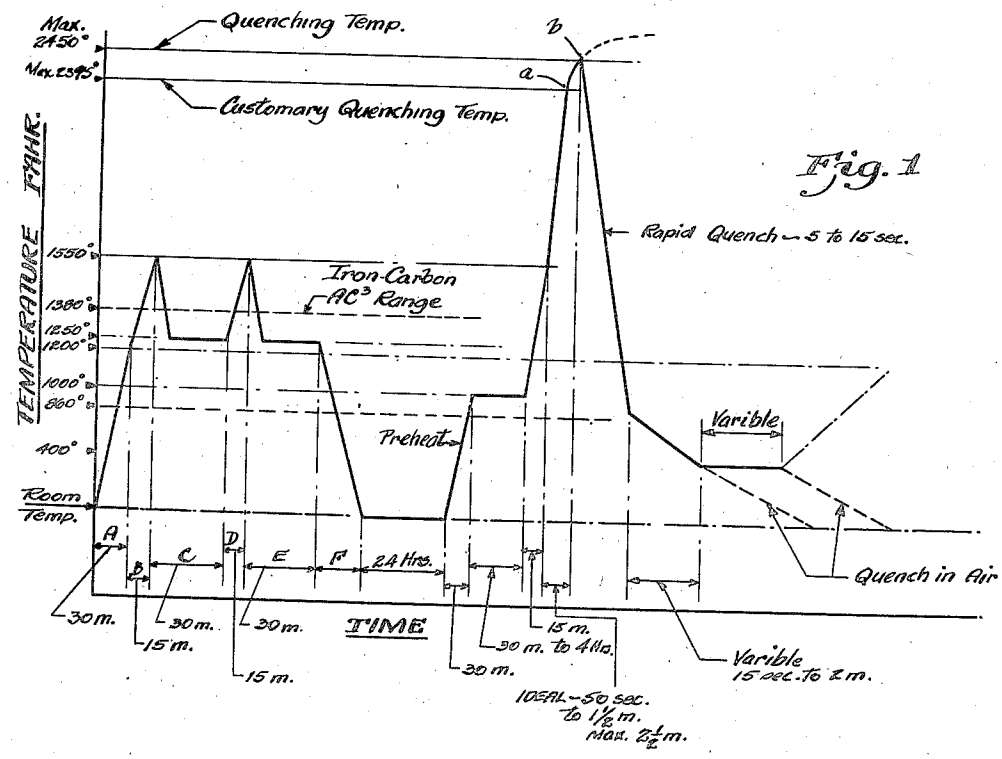


Fig. 1

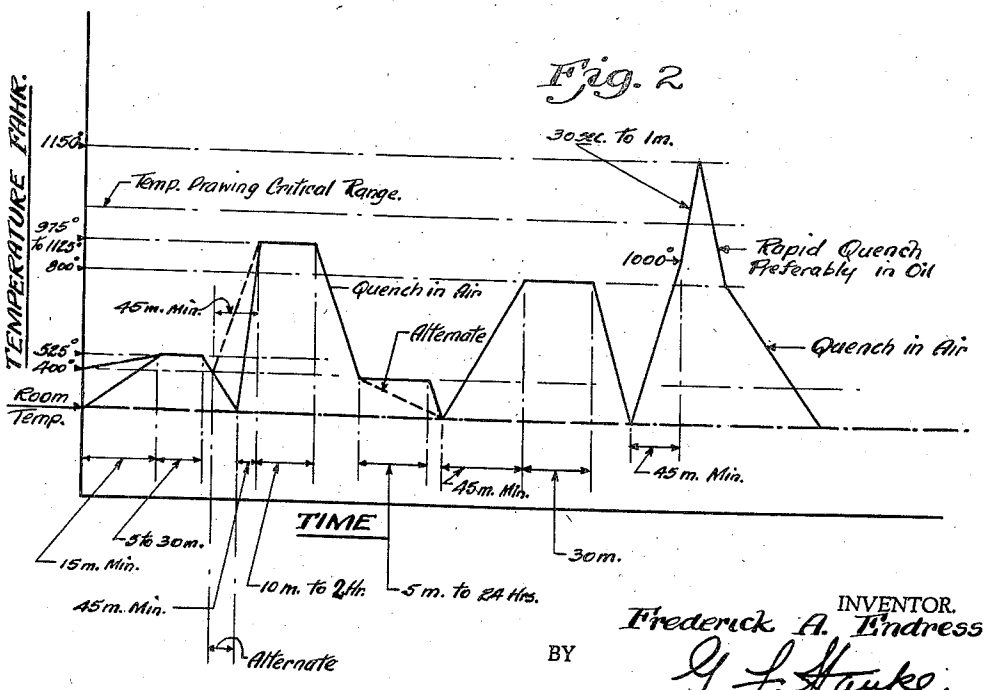


Fig. 2

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PROCESS FOR HEAT TREATING STEEL

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My invention relates to a process for heat treating ferrous materials and more particularly high speed tool steel, and for increasing the toughness and hardness of such materials which preferably have a tungsten content or some equivalent element, which have a secondary hardness range when subjected to drawing operations or heats; that is, ferrous materials which increase in hardness upon drawing from 900 degrees Fahr. to 1125 degrees Fahr. It is well known that ferrous materials of the character described above must be hard and tough to give satisfactory service, and heretofore it was found that such heat treated ferrous materials which were exceedingly tough lacked hardness and conversely, such heat treated ferrous materials which were made exceedingly hard lacked toughness or tensile strength.

During the past fifteen or twenty years, much has been done in improving the toughness and hardness of tool steels and other steel alloy materials. More particularly, such steel materials have been improved by subjecting same to various complex heat treatments, but none, as far as I am aware, have been able to obtain a uniform hardness of better than 65 degrees Rockwell "C" with a uniform toughness or tensile strength of more than 500,000 pounds per square inch. It will be appreciated that a process for treating such steels, which obtain a uniform degree of hardness and toughness as specified above, is of particular importance to the machine and tool industry, as well as to the national defense, since processed tools and other products made from high speed tool steel such as I have produced have much longer life and are exceedingly important in producing machined ferrous parts. My process for heat treating these ferrous materials may be employed most satisfactorily in producing high speed tool steel products employed in the manufacture of armament and munition supplies such as rifles, guns and other ordnance pieces and parts thereof.

An object of my invention is to provide an improved and novel process for the heat treatment of ferrous alloys such as high speed tool steel by which the ferrous alloy is made exceedingly uniformly tough and hard, far beyond any results heretofore obtained.

My improved process consists broadly in the combination of a number of individually timed operations and corrective timed heating and quenching operations, together with selective control of the various steps in the process, all cooperating to produce an ultimate uniform result far beyond normal expectancy.

Other phases of my present invention relate to certain sub-combination of steps in my process for the heat treatment of high speed tool steel materials in which maximum advantage is taken of physical and chemical changes of the material being treated, which steps may be employed alone for improving the structural character of any high speed tool steel material, but which are preferably in many instances all combined and substantially employed to obtain the unexpected high degree of uniform hardness and tensile strength never obtained heretofore.

It also will be seen that some of the steps in my process are optional and may be omitted at times, the use of such optional steps depending upon the character and design of the steel being processed, and the particular application of the steel material in service. More particularly, the various steps in my improved process are individually time controlled within certain predetermined prescribed limits, and the application of my control determines largely the ultimate results which are to be obtained.

For a more detailed understanding of my invention, reference may be had to the accompanying detail description supplemented by the accompanying graphical illustrations embodied in the drawing made a part hereof, and in which:

Fig. 1 is a graphical illustration of the heat treatment showing the temperatures and time control system of the various steps in the process, and

Fig. 2 is a graphical illustration of the drawing operations embodied in my improved process for the heat treatment of high speed tool steel alloy materials by which is obtained the desired uniform toughness and hardness.

The following process for the heat treatment of ferrous materials such as high speed tool steels results in the production of finished products having exceedingly high uniform hardness and tensile strength. It may be here pointed out that I have produced steels having a tensile strength of over 600,000 pounds per square inch with a hardness of from 65 to 68 Rockwell "C." With my process, however, we can obtain substantially uniform hardness and toughness of around 66 Rockwell "C" with a tensile strength of over 500,000 pounds per square inch.

Obviously in some applications, all of the following steps in my improved process may be employed, while for other applications, some only of the steps may be employed. It will also be

observed that the size and/or shape of the part being heat treated will vary the time control of the various steps in my process, and largely determine the precise combination of steps to be employed in my process in order to obtain the desired results.

As stated above, the process is particularly applicable for high speed tool steels having a secondary hardness range upon drawing; that is, my process is applicable to steels which increase in hardness upon drawing from 900 degrees Fahr. to 1125 degrees Fahr. Generally, my process is applicable to tungsten steels and other similar high speed tool steel alloys.

The first step in carrying out my improved process for heat treatment of such steels consists in spheroidizing the steel, particularly if it shows any signs of dendrites or ingotism. The spheroidizing process preferably consists of six separate treatments as follows; and most steels will be definitely improved by spheroidizing same as hereafter described.

A. The steel is heated slowly from room temperature to 1200 degrees Fahr., preferably in about thirty minutes for sections up to three-fourths (¾) inch square, and this time is increased approximately ten minutes for each one-eighth (⅛) inch square increase in dimension. The steel may be soaked at this temperature of 1200 degrees Fahr. for a minimum period of time of thirty minutes, if desired.

B. The temperature of the steel is now raised slowly from about 1200 degrees Fahr. to 1550 degrees Fahr., carrying same through the iron-carbon critical (AC^3) range. The time proposed for heating the steel from 1200 degrees Fahr. to 1550 degrees Fahr. is a minimum of about fifteen minutes for sections up to three-fourths (¾) inch square and the time is preferably increased approximately five minutes for each one-eighth (⅛) inch square increase in dimension of the steel piece being treated. This rise in temperature of the steel during this step in my process carries the steel through the critical iron-carbon (AC^3) range, and actually changes the iron of the steel alloy piece from alpha iron to gamma iron, in other words, the crystal formation of the iron is changed from a body center cubic lattice to a face center cubic lattice. It is known that the ideal critical iron-carbon (AC^3) range is about 1380 degrees Fahr. In order to insure a complete change in the iron from alpha iron to gamma iron, it is proposed to slowly raise the temperature of the steel piece being treated during this step, since the slower the heat change the closer to the ideal critical for iron will be the change over from alpha to gamma iron. If this heat change should be very rapid, the complete change from alpha to gamma iron may not take place when temperatures of 1550 degrees Fahr. are reached, therefore, it is essential that the steel be heated slowly during this step and the time specified above is found to be such as to effect a complete change of the iron of the piece being treated from alpha iron to gamma iron. Another advantage of employing a slow heat is that it makes it possible to take advantage of the isothermal change as the steel alloy goes through this iron-carbon critical (AC^3) range.

C. The steel is next soaked at a temperature of approximately 1250 degrees Fahr. for a minimum of about thirty minutes, permitting a further iso-thermal change to take place in the metal structure.

D. Operation "B" is now repeated by raising the temperature of the steel material again through the iron-carbon critical (AC^3) range to a temperature of approximately 1550 degrees Fahr. preferably within the same time as set forth above in describing step "B."

E. The material is now again soaked for about thirty minutes at a temperature of about 1250 degrees Fahr., substantially the same as is the case with the step as described in paragraph "C."

F. The steel is now allowed to cool slowly to room temperature, preferably in a pack box or furnace, and preferably the steel is allowed to lie around for approximately twelve hours before proceeding with the next step in my improved process.

The following step in my process is entitled "Pre-heating" and I find it is preferable to preheat the steel piece after the same has been allowed to lie around for about twelve hours at room temperature, by applying radiant heat to the steel piece. This preheating step is preferably carried out by placing the steel piece to be treated in a ceramic retort which is preferably externally heated and constructed to uniformly conduct the heat to the work by radiation. The steel piece being heated is thus heated to approximately at least 1000 degrees Fahr. to 1100 degrees Fahr. but less than the iron-carbon critical (AC^3) range in a minimum of time amounting to thirty minutes for all sections up to three-fourths (¾) inch square, and this time is increased approximately ten minutes per each one-eighth (⅛) inch square increase in dimension. Preferably the time control during this operation is had by shielding the steel being treated in any suitable manner, so as to permit the absorption of heat by the steel at a certain predetermined rate whereby to uniformly increase the temperature of said steel up to at least 1000 degrees Fahr. or 1100 degrees Fahr. within the prescribed time.

Next, the steel pieces are allowed to soak substantially at these temperatures of from 1000 degrees Fahr. to 1100 degrees Fahr. for a period of time varying from thirty minutes to approximately four hours, thereby permitting an isothermal change to take place in the iron structure, this change resembling in some respects the previous spheroidizing process and it also allows the carbide forming elements to be freed.

After pre-heating the steel to be treated at a temperature, which may be varied from 1000 degrees Fahr. to 1100 degrees Fahr. the temperature of the steel is now raised slowly through the iron-carbon critical (AC^3) range to about 1550 degrees Fahr. and not substantially exceeding that temperature, as same is preferably heated to a degree just slightly above the iron-carbon critical (AC^3) range, but preferably within a minimum of about fifteen minutes for sections up to three-fourths (¾) inch square, which time is increased approximately five minutes for each one-eighth (⅛) inch square increase in dimension. In this step the steel is also preferably uniformly heated by placing the same in a heated ceramic retort or other suitable retort providing for a radiation of heat from the retort to the steel being treated. The time of this heat is also preferably controlled by employing shielding around the steel being treated, in order to regulate the amount of heat being conducted by radiation to the steel per unit of time. It will be observed

that the steel is thus heated and passes slowly through the iron-carbon critical (AC^3) range, but in this step, the steel is never allowed to soak at the temperature of about 1550 degrees Fahr. as it is immediately raised to the quenching temperature as quickly as possible, also preferably by means of radiant heat, or by any method which will uniformly heat the steel to the required temperature within the time prescribed. Preferably the steel being treated is raised to a quenching temperature in a carbonaceous gas, in an inert gas or in a vacuum, or in any atmosphere which will not support combustion.

The ideal time for heating the steel being treated to the quenching temperature is preferably from fifty seconds to one and one-half (1½) minutes for sections up to three-fourths (¾) inch square in dimension. However, satisfactory results have been obtained with slower heating rates, up to two and one-half (2½) minutes. In larger sections, that is, for sections of one (1) inch square or over, same is preferably heated from 1550 degrees Fahr. by any suitable means to approximately 1800 degrees Fahr. and then rapidly heated by radiant heat at such a rate that the steel piece is raised to the required quenching temperature preferably within the ideal required time limit set forth above, namely fifty (50) seconds to one and one-half (1½) minutes. Quenching temperatures vary for different types of steel material from 2150 degrees Fahr. to 2450 degrees Fahr. and in order to raise the steel piece being treated to the desired quenching temperature it is preferable to heat the ceramic retort or other container to a temperature of from 2650 degrees Fahr. to 2950 degrees Fahr., preferably averaging about 2850 degrees Fahr. In all cases the time for heating the material to this maximum quenching temperature from a temperature around 1550° Fahr. must not exceed 2½ minutes, and in most cases especially for sections of small cross-section of one inch square or less, the time is preferably held to as near the minimum as is possible.

The above is suitable for steel pieces of average cross-sections which do not exceed approximately one and one-half (1½) inches square. I preferably heat the retort so that it will radiate heat to the steel piece being heated within the time limit above prescribed, and it is so controlled as to raise the temperature of the steel approximately 50 degrees Fahr. above quenching temperatures customarily employed for the piece being treated. Ideal would be to place correct size of piece in the correct size furnace at the correct temperature in order to bring piece to quenching temperature in the correct time. I also preferably accomplish this by pre-heating the retort and turning off the source of heat when the work is placed in the retort, and I preferably extract the steel piece being heat treated from the retort while the temperature of the work is still rising.

The steel material being heat treated is then introduced into the quenching medium, which step is hereinafter described. The time control for this step is very important, and the time is preferably varied in accordance with the toughness and hardness desired, and in accordance with the character and design of the material being treated, and the application of same in service. The longer the steel is subjected to the high temperatures near the quenching temperature; i. e. from "*a*" to "*b*" on the curve in Fig. 1, the resultant Rockwell "C" hardness will be increased with a consequent sacrifice in toughness. The longer the time, the more coarse the grain structure and carbide formation and, of course, this is in some instances undesirable, so it is important to control this time very exactly. If the steel piece is raised to quenching temperature in too quick a time, there is an incomplete carbide precipitation, which leaves too much of the alloy in the matrix and results in a decrease in Rockwell "C" hardness, but does result in an increase in the toughness.

It will thus be seen that by controlling the time of the step one may obtain the desired Rockwell hardness and correct toughness depending upon the type of work for which the material is to be used. Another essential factor in this step is to remove the material from the retort while the temperature of the material is still rising. This is accomplished by providing a furnace with a temperature head which is higher than the quenching temperature of the steel piece being treated. The quenching temperature of the material is preferably about 50 degrees Fahr. higher than is considered good practice in standard heat treatment practice. This is accomplished by heating a ceramic or refractory retort as hot as possible and uniformly heating the steel inserted in said retort solely by radiant heat. It is found preferable in most instances to heat the ceramic retort to 2850 degrees to 2900 degrees Fahr. and to cut off the heating of the retort when such temperatures are reached, thus allowing the heat of the retort to radiate into the material being treated. By maintaining a non-circulating gas of high CO content within the retort, the steel will become heated as high as approximately 50 degrees Fahr. over temperatures normally used without showing the usual breaking up of the grain structure. It is preferable to have a retort temperature at the time of quenching only slightly higher than the temperature of the work.

The quenching of the steel material is preferably obtained in as fast a cooling medium as is practically possible. Thus, the temperature of the steel material in quenching is preferably lowered as rapidly as possible to a temperature just about or slightly above 400 degrees Fahr. and said material is allowed to rest at this temperature preferably by immersing same in a bath of oil at a temperature of substantially 400 degrees Fahr. before further quenching to room temperature. It is necessary that the temperature of this oil bath in which the steel material is soaked should not be above 430 degrees Fahr. or below 380 degrees Fahr. The quenching medium employed for quenching the steel material may be air for sections up to about one-sixteenth ($\frac{1}{16}$) inch square. For sections from one-eighth inch square to one-half (½) inch square, the quenching medium may be light oil, and for heavy non-critical sections the steel material may be time quenched rapidly in brine or water down to 900 degrees to 1000 degrees Fahr. and then relatively slower in oil or air to just about 400 degrees Fahr.

The steel material being treated is allowed to rest at this soaking temperature of approximately 400 degrees Fahr. for various lengths of time, and the time control of this soaking operation partially controls the hardness and toughness of the product. It is very beneficial to allow the steel being treated to remain at this temperature of about 400 degrees Fahr. so that the material is of uniform temperature through its entire cross-section before being further

quenched through the last critical range (AR'''). It will be apparent that this operation will vary according to the character of the material and to the application for which the product is intended to be used.

Attention is directed to Fig. 1 of the drawing which graphically illustrates time and temperature of these steps in my improved process described in detail above. Fig. 2 graphically illustrates the drawing operation and it shows a curve in which temperature is plotted against time.

The drawing process hereinafter described is applicable with reasonable modifications to any steel having a secondary hardness range upon drawing. This operation is particularly important when heat treating a tungsten steel or other similar high speed tool steel alloy, and the sequence of operations carried out in this drawing process makes possible the building up of toughness and hardness of the steel which has been heat treated as described in the preceding paragraphs. Careful time control of the various steps in my process make it possible to uniformly attain the desired results and to produce a product which is exceedingly hard and tough.

After the steel material is quenched and allowed to rest at about 400 degrees Fahr. as described above, the steel pieces being heat treated are allowed to be cooled to room temperatures in many instances although for producing a product in which maximum toughness is desired, the steel material is drawn immediately after being withdrawn from this soaking bath. In other words, it will be apparent that the drawing operation may commence with steel pieces at room temperature or with steel pieces which have been quenched to a temperature of about 400 degrees Fahr. When extreme toughness is desired it is preferable to draw the steel material from 400 degrees Fahr. or thereabouts as stated above, as it is well known that Martensite is formed when the temperature is allowed to drop below the critical temperature of 380 degrees Fahr. and steel pieces in which Martensite is formed is unsuitable for treatment to obtain maximum toughness.

The first step in drawing the steel material is to raise the temperature of same from either room temperature or 400 degrees Fahr. or thereabouts up to approximately 525 degrees Fahr., within a minimum of approximately fifteen minutes where the material is soaked substantially at that temperature for a predetermined period of time varying from five (5) minutes to thirty (30) minutes. The resultant product will become tougher the longer the same is allowed to soak at this temperature, but this increase in toughness is had at the sacrifice of hardness. The soaking of the steel material being heated at this temperature of approximately 525 degrees Fahr. introduces carbon into the matrix as FeC_3 which is subsequently drawn to sorbite or secondary pearlite.

The material after soaking at 525 degrees Fahr. for a predetermined time within the limits set forth above is then quenched in air to the starting temperature 400 degrees Fahr. or room temperature and then uniformly heated to a higher temperature of from 975 degrees Fahr. to 1125 degrees Fahr. preferably in about 45 minutes minimum, but below the drawing critical range. After heating this material to this desired temperature in the prescribed time, the same is allowed to soak at this temperature for a predetermined time varying from ten minutes to two hours. The time control of this soaking operation controls the resultant toughness and hardness of the heat treated product, as the greater the time the material is allowed to soak, the less tough it will be with a consequent increase in hardness.

The next step is to allow the steel material to cool in air down to room temperature, or the same can be cooled down to about 400 degrees Fahr. and held at that temperature for a time varying from five minutes to twenty-four hours. If the steel material is held at this temperature of about 400 degrees Fahr., the time control has a direct effect on the resulting hardness and toughness of the product, since the greater the time the more tough is the material but less hard. It will be apparent that this dwell or resting of the material in cooling from the first drawing heat is optional and is employed when necessary to develop extreme toughness.

The steel material being treated is now allowed to cool to room temperature and then subjected to a drawing heat of approximately 800 degrees Fahr. in about 45 minutes minimum, and held there for a period of about thirty minutes and then allowed to cool to room temperature. This last drawing heat is optional, and is employed to correct for errors or discrepancies which may have crept into previous heats in order to obtain a product having the desired uniform hardness and toughness.

A further optional drawing heat may be had if desired to improve hardness and/or toughness in the treated material by subjecting the material to another drawing heat of a temperature over 1125 degrees Fahr. and preferably about 1150 degrees Fahr. This last optional drawing heat is preferably carried out by heating the steel from room temperature to about 1000 degrees Fahr. in about 45 minutes minimum and more rapidly heating the work to the 1150 degree temperature. The last step is carried out in a short time varying from 30 seconds to one minute. The material is then quickly quenched in any medium, preferably oil, to about 800 degrees Fahr. and then further quenched in air. This last optional drawing heat is employed to correct for a deficiency in toughness as this last drawing heat will slightly increase the toughness of the material being treated but at the expense of hardness.

The process which has been described in minute detail in general employs a number of treatments which build up the toughness of the steel material being treated, while at the same time maintaining a desired degree of hardness. All of these steps are substantially time controlled. Extreme care must be taken in carrying out the above described process, and careful watch and testing of the material is constantly had, so that one may slightly vary the time or temperature of this or that step, in order to obtain the best results. In some instances it is found unnecessary to carry through with the optional steps as outlined in the process, but in some cases, one or more of these optional steps are employed. It is well known that any quantity of steel that is commercially produced and distributed is held within minimum commercial limits as regards the chemical analysis, and these variations in the analysis of certain steels in any quantity which is to be heat treated, necessitates in many instances slight variations in the time

control of the various steps of the process. By carrying out the process for heat treating steel as described above, and exercising reasonable care, the products obtained can be spot tested or otherwise inspected, and where deficiencies in toughness and/or hardness occur, the time control of the steps in the process can be varied within the limits set forth to correct for these deficiencies and as a result, I have been able to heat treat steel material, and obtain uniform results with such materials. I have produced heat treated steel pieces which are exceedingly tough and hard.

The above process is exceptionally useful in connection with heat treating cutting tools, and has resulted in the production of cutting tools, which have exceedingly long life and which have materially stepped up production.

My process is therefore applicable to many uses and is particularly applicable for cutting tools, and other machine elements where extreme toughness and hardness is desirable. By the process above described, it is possible to produce finished products which uniformly have a toughness or tensile strength of over 500,000 pounds per square inch without sacrificing hardness. Ordinary treatments increase toughness at too much a sacrifice of hardness, but by carrying through with the plurality of steps as described in detail in this application, I have been able to bring up the toughness and actually produce material with a uniform tensile strength never before reached while maintaining a uniform high degree of hardness at the same time.

It will be quite apparent that by producing heat treated steel material having a hardness which is quite uniformly maintained at approximately 66 Rockwell "C," and in which the toughness is uniformly produced at over 500,000 pounds per square inch, that I have accomplished something which has never been done before. These results have been accomplished by carrying out the sequence of operations as described, and by employing the time control and the corrective steps in the preferred sequence as described above.

There are certain steps in my process which are important for the successful heat treatment of high speed tool steels in order to obtain a uniform high degree of toughness and hardness together with a molecular structure from which are fabricated machine tools and the like that have been proved by actual tests to outperform and outlive tools of a similar character now available to the industry.

It is important to control the heating rate in heating the material to the high temperatures to which the material is subjected before quenching, so that even submicroscopic fissures will not start to form. Such fissures, though not readily discernible, are indicated by the brittleness of the final product, especially at corners. Fissures may be caused also by a too rapid heating of the work in the draw and examination of the fissure will determine when the fissure was formed, as the color of the surface of the material in the fissure will show whether the fissure was formed by a too rapid heating rate during the draw or prior to quenching from the high temperatures. If examination shows that fissures have occurred and it is determined when they did start, corrective measures can be taken by slowing the heating rate during the operation which caused the fissure to occur. In this process, the preheating of the material is important for without a preheat step substantially as described herein, it is not possible to obtain the results that particularly distinguish my process from prior treatments. My preheat makes it possible to employ the rapid high temperature heating for obtaining the best results.

Another feature of my process, which is deemed to be very important, is the very rapid heating of the material being treated after being subjected to the right preheating operation from a point above the iron-carbon critical (AC^3) range and preferably just slightly thereabove to the quenching temperature within the prescribed time limit. It will be observed that the ideal time limit for this step in my process varies from fifty seconds to one and a half minutes and should not exceed a maximum of two and one-half minutes.

A further important step in the treatment of high speed steels is the rapid quenching rate employed. I find that it is beneficial in all cases to very rapidly quench the work, even as rapidly as five seconds to a temperature of about 900 degrees Fahr. In practice this rapid quenching varies from five to fifteen seconds, depending upon the cross-section and shape of the steel piece being heat treated, and it is found that the faster the rate the finer the crystalline structure and the finer the carbide size. In practice, I have found that these materials may be rapidly quenched in brine, water, kerosene, oil emulsions and oils having various quenching characteristics. The most critical sections may be quenched in number 1 fuel oil, with or without a wetting agent such as fish oil or other mechanical or chemical equivalents. Following this rapid quench, the material is further quenched in quenching oils having a relatively slower quenching rate or in air. Preferably the air quench is used when straightening of the part is necessary, otherwise I usually employ a slow quenching oil.

A still further important step is in first drawing the material being treated at approximately 525 degrees Fahr. and quenching same in air to 400 degrees Fahr. or less before heating the steel piece into the secondary drawing range. Preferably in all instances, I find it desirable to quench the piece being treated after drawing at 525 degrees Fahr. to the same temperature as was the piece when the drawing operation was started.

For other ferrous metals other than high speed steel, I have discovered that there are at least five important steps which should be carried out in sequence in order to obtain the best results.

The first of these important steps is the preheating of the ferrous material being heated which is carried out at a prescribed time rate and soaked at a temperature which is below the iron-carbon critical (AC^3) range.

Secondly, the next important step is that in which the material is heated slowly through the iron-carbon critical (AC^3) range, it being essential that the piece be heated as slowly as is practically possible.

A third important step is to heat the ferrous material as rapidly as possible to a quenching temperature and holding the material at quenching temperature no longer than is necessary to secure correct heat penetration or to secure the required hardness characteristics. In all such cases it will be observed that it is preferable to heat the material by radiation in a re-

tort which is heated to a heat which is in excess of the temperature of the work when commencing the quenching operation.

The fourth step in heat treating the steel material is to quench the work in as rapid a cooling medium as the material and shape of the piece will permit to either a holding temperature of around 400 degrees Fahr. or to room temperature. High speed tool steel is however preferably quenched very rapidly to about 900 degrees Fahr. and then more slowly to around 400 degrees Fahr.

The fifth step in the treatment of steel material is the control of the heating rate during the draw and the time during which the work is allowed to soak at the high temperature.

It will be observed that for high speed steels the various drawing steps described are more or less required in most cases, while in heat treating ferrous materials other than high speed steel, such as armor plate, it is generally sufficient to subject the material to only one drawing heat, but in order to obtain the desired results it is necessary to accurately control the time of the heating rate during this drawing operation. It will be observed that armor plate may be heat treated according to my above described process with a straight draw at about 750 degrees Fahr.

In the drawing of any high speed tool steel beneficial results are always obtained by a preliminary drawing of about 525 degrees Fahr. within a prescribed time limit, then soaking same at about 525 degrees Fahr. for a certain prescribed time, and in quenching the material to the starting temperature before proceeding with the subsequent drawing heat as heretofore described.

It has been observed that the above described method for heat treating ferrous material such as high speed tool steels above referred to, bring unusual results. The rapid quench from the high temperature and partial resting at about 400 degrees Fahr. reduces the hardness as measured on the Rockwell C scale to a degree as much as five to six points lower than the hardness which is usually had by conventional methods. The steel is then subjected to the above described drawing heats, and the first draw at about 525 degrees Fahr. further lowers the hardness while the subsequent draws increase the hardness to a degree comparable with and usually higher than the hardness usually obtained by conventional methods.

It will be apparent to those skilled in the art to which my invention pertains, that the process may be modified within reasonable prescribed limits without departing from the spirit of my invention or from the scope of my appended claims.

I claim:

1. A process for heat treating high speed tool steel having a secondary hardness range upon drawing, comprising preheating said steel first to a temperature of at least 1000° Fahr. and less than the temperature of the iron-carbon critical (AC^3) range in a minimum time of about 30 minutes, then soaking the steel substantially at this temperature for a period of time varying from a minimum of about 30 minutes to a maximum of approximately 4 hours, next slowly raising the temperature of the steel through the iron-carbon critical (AC^3) range to a temperature of approximately 1550° in a minimum time of about 15 minutes, then very rapidly raising the temperature of the steel being treated to a quenching temperature of approximately 2150° Fahr. to 2450° Fahr. within preferably a time interval of about 50 seconds to 1½ minutes and not exceeding a maximum of 2½ minutes, rapidly quenching the heated steel to approximately 900° Fahr. within 5 to 15 seconds, then further quenching the steel to a temperature of approximately 400° Fahr. within a time interval varying from 15 seconds to 2 minutes, soaking the steel at this temperature of approximately 400° Fahr. for a time sufficient to permit penetration of heat substantially uniformly throughout the section and prior to further processing of the steel, subjecting the steel to a plurality of timed drawing heats comprising the initial heating of the steel to approximately a temperature of 525° Fahr. in a minimum of about 15 minutes, soaking the steel at this temperature for a period of time varying from about 5 minutes to 30 minutes, quenching the steel to the starting temperature and at least to about 400° Fahr., heating same to a second drawing heat of about 975° Fahr. to 1125° Fahr. in a minimum time of about 45 minutes, soaking the steel at this temperature for about 10 minutes to 2 hours, and air quenching same substantially to room temperature.

2. A process for heat treating high speed tool steel having a secondary hardness range upon drawing, comprising preheating said steel by radiant heat first to a temperature of at least 1000° Fahr. to about 1100° Fahr. and less than the temperature of the iron-carbon critical (AC^3) range in a minimum time of about 30 minutes, then soaking the steel substantially at this temperature for a period of time varying from a minimum of about 30 minutes to a maximum of approximately 4 hours, slowly raising the temperature of the steel by radiant heat through the iron-carbon critical (AC^3) range to a temperature of approximately 1550° Fahr. in a minimum time of about 15 minutes, then very rapidly raising the temperature of the steel being treated by radiant heat to a quenching temperature of approximately 2150° Fahr. to 2450° Fahr., in an ideal time interval of about 50 seconds to 1½ minutes and not exceeding a maximum of 2½ minutes, rapidly quencing the heated steel to approximately 900° Fahr. within 5 to 15 seconds, then further quenching the steel to a temperature of approximately 400° Fahr. in a time interval varying from about 15 seconds to 2 minutes, soaking the steel at this temperature of approximately 400° Fahr. for a time sufficient to permit penetration of heat substantially uniformly throughout the section and prior to further processing of the steel, subjecting the steel to a plurality of timed drawing heats comprising the initial heating of the steel to approximately a temperature of 525° Fahr. in a minimum time of about 15 minutes, soaking the steel at this temperature for a period of time varying from about 5 minutes to 30 minutes, quenching the steel to the starting temperature and at least to about 400° Fahr., heating same to a second drawing heat of about 975° Fahr. to 1125° Fahr. in a minimum time of about 45 minutes, soaking the steel at this temperature for about 10 minutes to 2 hours, and air quenching same substantially to room temperature.

3. A process for heat treating high speed tool steel having a secondary hardness range upon drawing, comprising preheating said steel first to a temperature of at least 1000° Fahr. to about

1100° Fahr. and less than the temperature of the iron-carbon critical (AC^3) range in a minimum time of about 30 minutes, then soaking the steel substantially at this temperature for a period of time varying from a minimum of about 30 minutes to a maximum of approximately 4 hours, next slowly heating said steel through the iron-carbon critical (AC^3) range to a temperature of about 1550° Fahr. in a minimum time of about 15 minutes, then rapidly heating said steel as quickly as is possible to a quenching temperature of approximately 2150° Fahr. to 2450° Fahr., rapidly quenching the steel and including a soaking of the steel at a temperature of about 400° Fahr. for a time sufficient to permit penetration of heat substantially uniformly throughout the section and prior to further processing of the steel, subjecting the steel to a plurality of timed drawing heats comprising the initial heating of the steel to approximately a temperature of 525° Fahr. in a minimum time of about 15 minutes, soaking the steel at this temperature for a period of time varying from about 5 minutes to 30 minutes, quenching the steel to the starting temperature and at least to about 400° Fahr., heating same to a second drawing heat of about 975° Fahr. to 1125° Fahr. in a minimum time of about 45 minutes, soaking the steel at this temperature for about 10 minutes to 2 hours, and air quenching same substantially to room temperature.

4. A process for heat treating high speed tool steel having a secondary hardness range upon drawing, comprising preheating said material first to a temperature of at least 1000° Fahr. to about 1100° Fahr. and less than the temperature of the iron-carbon critical (AC^3) range in a minimum time of about 30 minutes, then soaking the material substantially at this temperature for a period of time varying from a minimum of about 30 minutes to a maximum of approximately 4 hours, next slowly raising the temperature of the material through the iron-carbon critical (AC^3) range to a temperature of approximately 1550° Fahr. in a minimum time of about 15 minutes, then very rapidly raising the temperature of the material being treated to a quenching temperature of approximately from 2150° Fahr. to 2450° Fahr. in a time interval of about 50 seconds to 1½ minutes and not exceeding a maximum of 2½ minutes, and rapidly quenching the heated material to approximately 900° Fahr. in 5 to 15 seconds, then further quenching the material to a temperature of approximately 400° Fahr. in a time interval varying from about 15 seconds to 2 minutes, and soaking the material at this temperature of approximately 400° Fahr. for a time sufficient to permit the penetration of heat substantially uniformly throughout the section prior to further processing of the material.

5. A process for heat treating high speed tool steel having a secondary hardness range upon drawing, which comprises subjecting same to a preheating operation comprising first raising the temperature of the steel from room temperature to a temperature of at least 1000° Fahr. and less than the temperature of the iron-carbon critical (AC^3) range in a minimum time of approximately 30 minutes, next soaking the steel substantially at this temperature for periods of time varying from about 30 minutes to 4 hours, and next slowly raising the temperature of the steel being treated through the iron-carbon critical (AC^3) range to a temperature of approximately 1550° Fahr. in a minimum time of about 15 minutes, the aforesaid preheating operation thus preparing the steel so that same can be heated quickly in a predetermined time interval to a maximum quenching temperature of 2450° Fahr. and then rapidly quenched.

6. A process for heat treating high speed tool steel having a secondary hardness range upon drawing, comprising preheating said steel to a predetermined temperature of at least 1000° Fahr. but less than the temperature of the iron-carbon critical (AC^3) range, soaking the steel for a time varying from about 30 minutes to approximately 4 hours at substantially said predetermined temperature, slowly heating the steel through the iron-carbon critical (AC^3) range and thence as rapidly as possible to a quenching temperature at which the iron carbides go into solution, and quenching said steel.

7. A process for heat treating high speed tool steel having a secondary hardness range upon drawing, comprising preheating said steel to a predetermined temperature of at least 1000° Fahr. but less than the temperature of the iron-carbon critical (AC^3) range, soaking said steel substantially at said predetermined temperatures for a minimum time of about 30 minutes, slowly raising the temperature of the steel being treated through the iron-carbon critical (AC^3) range to a temperature of approximately 1550° Fahr., then rapidly raising the temperature of the material by radiant heat to a quenching temperature at which the iron carbides go into solution and providing a head of heat in excess of the amount required to raise said steel to the quenching temperature aforesaid, and then quenching the steel while the temperature of the steel being treated is still rising.

8. A process for heat treating high speed tool steel having a secondary hardness range upon drawing, comprising preheating the steel to a temperature of at least 1000° Fahr. but less than the iron-carbon critical (AC^3) range, soaking said steel substantially at this temperature for a time sufficient to free carbide forming elements and to obtain a uniform isothermal change in the steel, slowly heating the steel through the iron-carbon critical (AC^3) range to a temperature of approximately 1550° Fahr., heating said steel to a maximum quenching temperature of approximately 2450° Fahr. in about 50 seconds to 1½ minutes and not exceeding a maximum of 2½ minutes, and then quenching the steel.

9. A process of heat treating high speed tool steel having a secondary hardness range upon drawing, comprising preheating the steel to a temperature of at least 1000° Fahr. and arresting the temperature rise of said steel between 1000° Fahr. and the temperature of the iron-carbon critical (AC^3) range for a time sufficient to free carbide forming elements and to effect a substantially uniform isothermal change in the steel, then relatively slowly heating said steel through the iron-carbon critical (AC^3) range, then subsequently heating the steel to quickly raise the temperature of the steel from a temperature of about 1550° Fahr. to a quenching temperature of from 2150° Fahr. to 2450° Fahr. in about 50 seconds to 1½ minutes and not exceeding a maximum of 2½ minutes, and quenching the steel.

10. A process of heat treating high speed tool steel having a secondary hardness range upon drawing, comprising preheating the steel to a temperature of at least 1000° Fahr. and arresting

the temperature rise of said steel between 1000° Fahr. and the temperature of the iron-carbon critical (AC^3) range for a time sufficient to free carbide forming elements and to effect a substantially uniform isothermal change in the steel, then relatively slowly heating said steel through the iron-carbon critical (AC^3) range to a temperature of about 1550° Fahr., subsequently subjecting the steel to a relatively high radiant heat in a furnace to quickly raise the temperature of the steel to a quenching temperature of from 2150° Fahr. to 2450° Fahr. in about 50 seconds to 1½ minutes and not exceeding a maximum time of 2½ minutes, and quenching the steel.

11. A process for heat treating high speed tool steel having a secondary hardness range upon drawing, comprising first raising the temperature of the steel by radiant heat from room temperature to a temperature of at least 1000° Fahr. and less than the temperature of the iron-carbon critical (AC^3) range in a minimum time of approximately 30 minutes, next soaking the steel substantially at this temperature for periods of time varying from about 30 minutes to 4 hours, then slowly raising the temperature of the steel being treated through the iron-carbon critical (AC^3) range to a temperature of about 1550° Fahr. by radiant heat in a minimum time of about 15 minutes, the aforesaid preheating operation thus preparing the steel so that same can be heated quickly to a maximum quenching temperature of about 2450° Fahr. and then rapidly quenched.

12. In a process for toughening and hardening high speed tool steel having a secondary hardness range upon drawing and which has been subjected to a time controlled preheat and a quenching temperature heat of from 2150° Fahr. to 2450° Fahr., a quenching operation comprising rapidly quenching the steel from said quenching temperature to a temperature of about 900° Fahr. in about 5 to 15 seconds, further quenching the steel at a relatively slower rate to a temperature of about 400° Fahr. in about 15 seconds to 2 minutes, and holding the temperature of the steel substantially at said temperature of about 400° Fahr. for a time sufficient to permit the penetration of heat substantially uniformly throughout the section at this temperature prior to further processing of the steel.

13. A method of preheating high speed tool steel having a secondary hardness range upon drawing preparatory to hardening, which comprises the heating of the steel from room temperature to a temperature of at least 1000° Fahr. to 1100° Fahr. but less than the iron-carbon critical (AC^3) range in a minimum time of about 30 minutes, then soaking the steel substantially at this temperature for a period of time varying from a minimum of about 30 minutes to a maximum of approximately 4 hours, and next slowly heating said steel through the iron-carbon critical (AC^3) range to a temperature of about 1550° Fahr. in a minimum time of about 15 minutes.

14. In the heat treatment of high speed tool steel having a secondary hardness range upon drawing, a process of toughening and hardening same subsequent to quench hardening, comprising first heating the steel to a drawing temperature of approximately 525° Fahr., soaking the steel substantially at this temperature, air quenching the steel to the starting temperature, and subsequently subjecting the steel to at least one more drawing heat including a drawing heat wherein the steel is subjected to heat sufficient to raise the temperature of same to approximately 975° Fahr. to 1125° Fahr., soaking said steel at this temperature for a minimum time of about 10 minutes, and air quenching same to at least the starting temperature.

15. In the heat treatment of high speed tool steel having a secondary hardness range upon drawing, a process of toughening and hardening same subsequent to quench hardening, comprising, first heating the steel to a drawing temperature of approximately 525° Fahr. in a minimum time of about 15 minutes, soaking the steel at the aforesaid temperature for an interval of time varying approximately from about 5 to 30 minutes, air quenching the steel to the starting temperature, and subsequently subjecting the steel to at least one more timed drawing heat, including a drawing heat of approximately 975° Fahr. to 1125° Fahr.

16. In the heat treatment of high speed tool steel having a secondary hardness range upon drawing, the process of toughening and hardening same subsequent to quench hardening, comprising first heating the steel to a drawing temperature of approximately 525° Fahr. in a minimum time of about 15 minutes, soaking the steel substantially at the aforesaid temperature for an interval of time varying approximately from about 5 to 30 minutes, air quenching the steel to the starting temperature, and subsequently subjecting the steel to at least one more timed drawing heat including a drawing heat of approximately 975° Fahr. to 1125° Fahr. in which the steel is heated to this temperature in a minimum time of about 45 minutes, soaking the steel at this temperature from about 10 minutes to about 2 hours, and air quenching the steel to the starting temperature.

17. In the heat treatment of high speed tool steel having a secondary hardness range upon drawing, the process of toughening and hardening same subsequent to quench hardening, comprising first heating the steel to a drawing temperature of approximately 525° Fahr. in a minimum time of about 15 minutes, soaking the steel substantially at the aforesaid temperature for an interval of time varying approximately from about 5 to 30 minutes, air quenching the steel to the starting temperature, and subsequently subjecting the steel to additional timed drawing heats including at least one drawing heat of approximately 975° Fahr. to 1125° Fahr. in which the steel is heated to this temperature in a minimum time of about 45 minutes, soaking the steel at this temperature from about 10 minutes to about 2 hours, air quenching the steel to the starting temperature, and subjecting said steel to further corrective drawing heats comprising first heating the steel from room temperature to a temperature of approximately 800° Fahr. in a minimum time of about 45 minutes, soaking the steel at this temperature for about 30 minutes, quenching the same to room temperature, next heating the steel in about 45 minutes to about 1000° Fahr., further heating the steel to about 1150° Fahr. within approximately 30 seconds to 1 minute, rapidly quenching the steel in oil to about 800° Fahr. and further quenching in air to room temperature.

18. A process for heat treating high speed tool steel having a secondary hardness range upon drawing, comprising preheating said steel to a temperature of from 1000° Fahr. to 1100° Fahr., soaking said steel substantially at this tempera-

ture for a time varying approximately from 30 minutes to 4 hours, slowly raising the temperature of the steel being treated through the iron-carbon critical (AC^3) range to a temperature of approximately 1550° Fahr., rapidly raising the temperature of the steel to a relatively high quenching temperature at which the iron carbides go into solution in a time interval varying from about 50 seconds to 1½ minutes and not exceeding a maximum of 2½ minutes, and then quenching said steel rapidly in a cooling medium.

19. A process of heat treating high speed tool steel having a secondary hardness range upon drawing, which comprises preheating said steel first to a temperature of at least 1000° Fahr. but less than the temperature of the iron-carbon critical (AC^3) range in a minimum time interval of about 30 minutes, soaking said steel substantially at this temperature for an interval of time of from about 30 minutes to approximately 4 hours, next heating the steel through the iron-carbon critical (AC^3) range to a temperature of approximately 1550° Fahr. in a minimum time interval of about 15 minutes, then rapidly heating the steel to a maximum quenching temperature of approximately 2450° Fahr. in about 50 seconds to 1½ minutes and not exceeding a maximum of 2½ minutes, and then rapidly time quenching the steel.

20. A process for heat treating high speed tool steel having a secondary hardness range upon drawing, which comprises carrying same through a plurality of heating cycles and including the heating of the steel to a temperature of at least 1000° Fahr. but less than the temperature of the iron-carbon critical (AC^3) range in a minimum time interval of about 30 minutes, soaking said steel substantially at this temperature for a time interval varying approximately from 30 minutes to 4 hours, then raising the temperature through the iron-carbon critical (AC^3) range to a temperature of about 1550° Fahr. in a minimum time interval of about 15 minutes, then very quickly raising the temperature of the steel being treated to a quenching temperature of 2150° Fahr. to 2450° Fahr. in about 50 seconds to 1½ minutes and not exceeding a maximum of 2½ minutes, and while so heating said steel to provide an adequate head of heat so that the temperature of said steel material is still rising when same reaches quenching temperature, and quenching said steel material, the heat transfer in at least some of the heating steps aforesaid being accomplished substantially by means of radiant heat.

21. A process for heat treating high speed tool steel having a secondary hardness range upon drawing, comprising preheating same first to a temperature of at least 1000° Fahr. but less than the temperature of the iron-carbon critical (AC^3) range in a minimum time of approximately 30 minutes for sections up to ¾ inch square and increasing said time approximately 10 minutes for each ⅛ inch square increase in dimension, soaking of said steel substantially at this temperature for periods of time varying from about 30 minutes to approximately 4 hours, next slowly raising the temperature of the steel through the iron-carbon critical (AC^3) range in a minimum time of approximately 15 minutes for sections up to ¾ inch square and increasing said time approximately 5 minutes for each ⅛ inch square increase in dimension, then rapidly raising the temperature of the steel in about 50 seconds to 1½ minutes and not exceeding a maximum of 2½ minutes to a quenching temperature approximately from 2150° Fahr. to 2450° Fahr., and rapidly time quenching the steel while the temperature of same is rising.

22. A process of heat treating high speed tool steel having a secondary hardness range upon drawing, comprising preheating said steel first to a temperature of at least 1000° Fahr. but less than the temperature of the iron-carbon critical (AC^3) range in a minimum time interval of about 30 minutes, soaking said steel substantially at this temperature for an interval of time from about 30 minutes to approximately 4 hours, next heating the steel through the iron-carbon critical (AC^3) range to a temperature of approximately 1550° Fahr. in a minimum time interval of about 15 minutes, then rapidly heating the steel to a maximum quenching temperature of approximately 2450° Fahr. in about 50 seconds to 1½ minutes and not exceeding a maximum of 2½ minutes, and then rapidly quenching the steel, the minimum times heretofore specified being applicable for heat treating steel material for sections up to three-fourth inch square and being relatively proportionally increased for each one-eighth inch square increase in dimension.

23. A process of heat treating high speed tool steel having a secondary hardness range upon drawing, comprising preheating said steel first to a temperature of at least 1000° Fahr. but less than the temperature of the iron-carbon critical (AC^3) range in a minimum time interval of about 30 minutes, soaking said steel substantially at this temperature for an interval of time of from about 30 minutes to approximately 4 hours, next heating the steel through the iron-carbon critical (AC^3) range to a temperature of approximately 1550° Fahr. in a minimum time interval of about 15 minutes, then rapidly heating the steel to a maximum quenching temperature of approximately 2450° Fahr. in about 50 seconds to 1½ minutes and not exceeding a maximum of 2½ minutes, then rapidly quenching the steel, the aforesaid minimum time interval of about 30 minutes for preheating the steel to approximately 1000° Fahr. being applicable for heat treating steel material for sections up to three-fourth inch square and being increased approximately ten minutes for each one-eighth inch square increase in dimension, and the aforesaid minimum time of approximately fifteen minutes for heating the steel through the iron-carbon critical (AC^3) range being also applicable for sections up to three-fourth inch square and increased approximately five minutes for each one-eighth inch square increase in dimension.

24. A process of heat treating high speed tool steel having a secondary hardness range upon drawing, which comprises subjecting a preheated steel of a temperature of about 1550° Fahr. which has been previously subjected to an isothermal change at a temperature between 1000° Fahr. and the iron-carbon critical (AC^3) temperature, to relatively high heat in a furnace to quickly raise the temperature of the steel to a maximum quenching temperature of about 2450° Fahr. in about 50 seconds to 1½ minutes and not exceeding a maximum of 2½ minutes, and subjecting the steel to a quenching operation comprising the rapid quenching of the steel from said quenching temperature to a temperature of about 900° Fahr., immediately further quenching the steel at a relatively slower rate to a temperature of

about 400° Fahr., and then subsequently air quenching the steel to room temperature.

25. A process of heat treating high speed tool steel having a secondary hardness range upon drawing, which comprises subjecting the steel to a plurality of successive preheating operations comprising the heating of the steel to a predetermined temperature of at least 1000° Fahr. but less than the iron-carbon critical (AC^3) range, soaking said steel at substantially said predetermined temperature for a time sufficient to free carbide forming elements and to obtain a uniform isothermal change in the steel structure, then relatively slowly heating the steel through the iron-carbon critical (AC^3) range to a temperature of about 1550° Fahr., from which temperature said steel is immediately subjected to further relatively higher temperature heat treatments to carry the iron carbides into solution and then quenched hardened.

26. A process of heat treating high speed tool steel having a secondary hardness range upon drawing, which comprises subjecting a preheated steel of a temperature of about 1550° Fahr. which has been previously subjected to an isothermal change at a temperature between 1000° Fahr. and the iron-carbon critical (AC^3) temperature, to a relatively high heat in a furnace to quickly raise the temperature of the steel to a maximum quenching temperature of about 2450° Fahr. in about 50 seconds to 1½ minutes and not exceeding a maximum of 2½ minutes, and subjecting the steel to a quenching operation comprising rapid quenching of the steel from said quenching temperature to a temperature of about 900° Fahr., further quenching the steel at a relatively slower rate to a temperature of about 400° Fahr., holding the temperature of the steel at said temperature of about 400° Fahr., for a time sufficient to permit penetration of heat substantially uniformly throughout the section at this temperature, and then subsequently air quenching the steel to room temperature.

27. A process of heat treating high speed tool steel having a secondary hardness range upon drawing, which consists in subjecting a preheated steel of a temperature of about 1550° Fahr. which has been previously subjected to an isothermal change at a temperature between 1000° Fahr. and the iron-carbon critical (AC^3) temperature, to a relatively high heat in a furnace to quickly raise the temperature of the steel to a maximum quenching temperature of about 2450° Fahr. in about 50 seconds to 1½ minutes and not exceeding a maximum of 2½ minutes, and subjecting the steel to a timed quenching operation comprising rapid quenching of the steel from said quenching temperature to a temperature of about 900° Fahr. in about 5 to 15 seconds, further quenching the steel at a relatively slower rate to a temperature of about 400° Fahr. in about 15 seconds to two (2) minutes, and holding the temperature of the steel at said temperature of about 400° Fahr. for a time sufficient to permit the penetration of heat substantially uniformly throughout the section at this temperature prior to further processing of the steel in which same can be immediately subjected to a drawing operation commencing at 400° Fahr. or optionally air quenched to room temperature and then subjected to a drawing operation commencing at room temperature.

28. A process for heat treating high speed tool steel having a secondary hardness range upon drawing, which comprises spheroidizing the steel by first heating same to approximately 1200° Fahr. in a minimum of approximately 30 minutes for sections up to ¾ inch square and increasing said minimum time approximately 10 minutes for each ⅛ inch square increase in dimension, then repeatedly relatively slowly raising and lowering the temperature of the steel by subjecting same to a plurality of timed heats and quenches through the iron-carbon critical (AC^3) range, then quenching the same to room temperature, preheating the spheroidized steel to a temperature of at least 1000° Fahr. but less than the temperature of the iron-carbon critical (AC^3) range in a minimum time of approximately 30 minutes, soaking said steel substantially at this temperature for periods of time varying from about 30 minutes to approximately 4 hours, slowly raising the temperature of the steel through the iron-carbon critical (AC^3) range to a temperature of about 1550° Fahr. in a minimum of time of approximately 15 minutes, then rapidly raising the temperature of the steel by radiant heat preferably in about 50 seconds to 1½ minutes and not exceeding a maximum of 2½ minutes to a quenching temperature of approximately from 2150° Fahr. to 2450° Fahr. said last mentioned heat having been obtained by means of radiant heat from a thermal head exceeding that required to heat the steel to the quenching temperature aforesaid, and then while the temperature of the steel is still rising, the quenching of same when the temperature of the steel substantially reaches the quenching temperature aforesaid.

29. A process for heat treating high speed tool steel having a secondary hardness range upon drawing, which comprises spheroidizing the steel by first heating same to approximately 1200° Fahr. in a minimum of approximately 30 minutes for sections up to ¾ inch square and increasing said minimum time approximately 10 minutes for each ⅛ inch square increase in dimension, then repeatedly relatively slowly raising and lowering the temperature of the steel by subjecting same to a plurality of timed heats and quenches through the iron-carbon critical (AC^3) range, then quenching the steel to room temperature, preheating the spheroidized steel to a temperature of at least 1000° Fahr. but less than the temperature of the iron-carbon critical (AC^3) range in a minimum time of approximately 30 minutes, soaking said steel substantially at this temperature for periods of time varying from about 30 minutes to approximately 4 hours, slowly raising the temperature of the steel through the iron-carbon critical (AC^3) range to about 1550° Fahr. in a minimum time of approximately 15 minutes, then rapidly raising the temperature of the steel to a quenching temperature of approximately 2150° Fahr. to 2450° Fahr. in about 50 seconds to 1½ minutes and not exceeding a maximum of 2½ minutes and then rapidly quenching the steel.

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