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M. J. GORMAN

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METHOD FOR HEAT TREATING STEEL DIE BLOCKS

Filed April 18, 1940

2 Sheets-Sheet 1

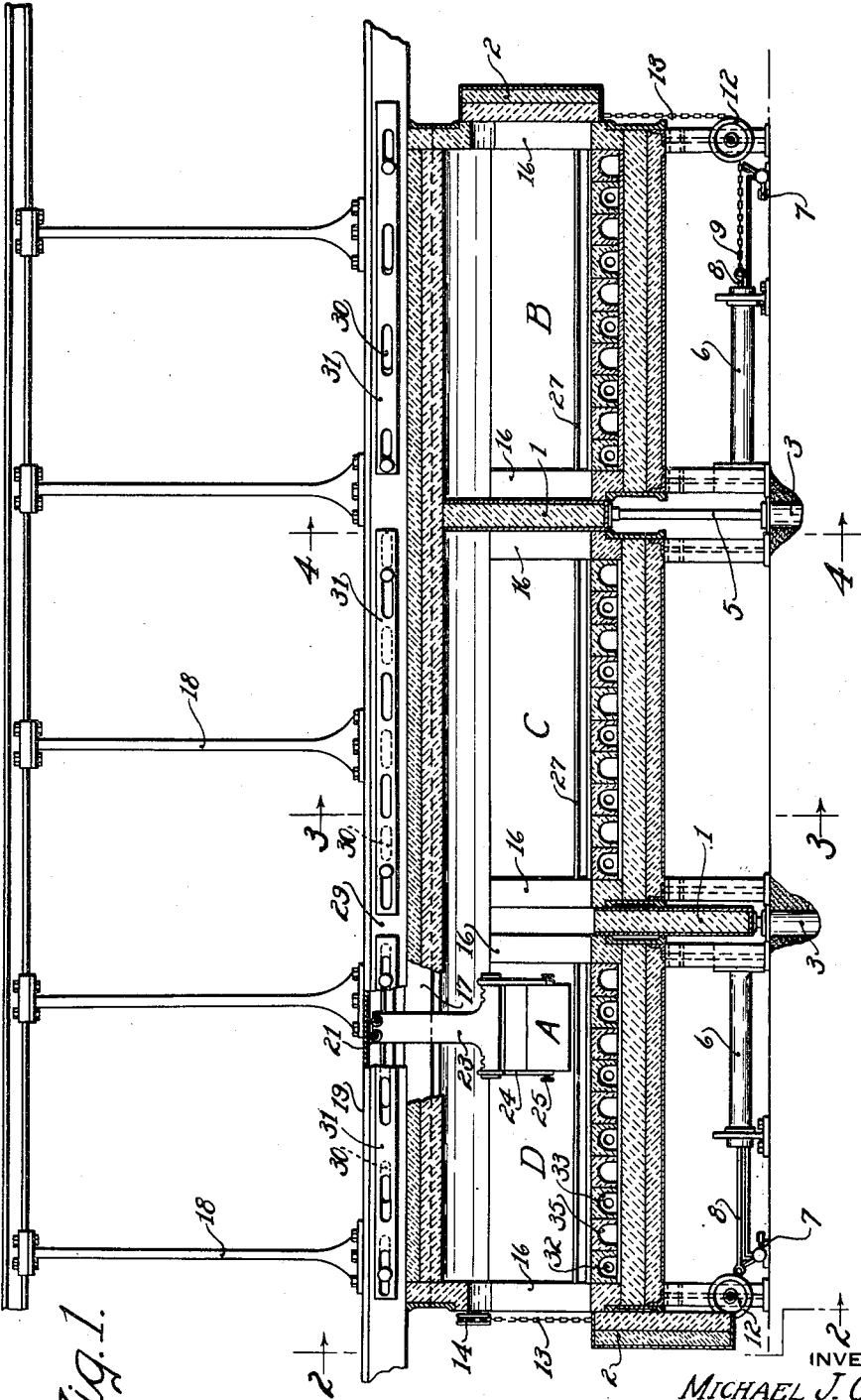


Fig. 1.

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Fig. 2.

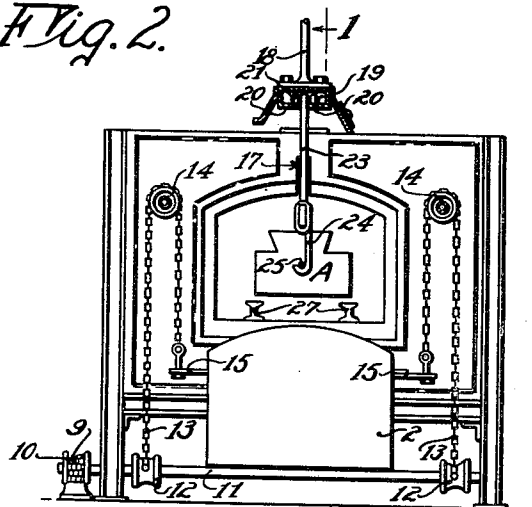


Fig. 3.

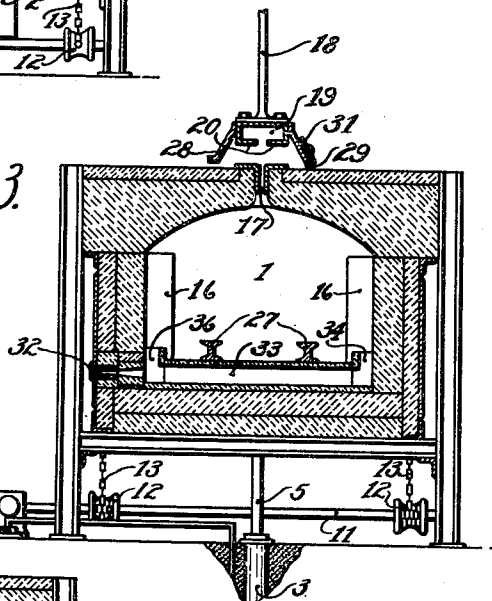
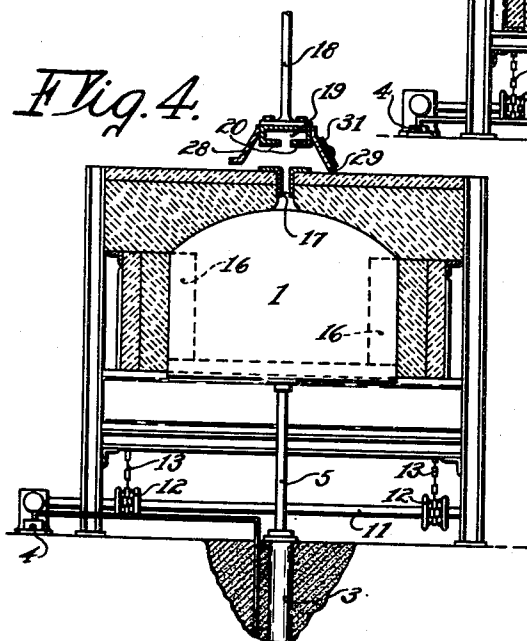


Fig. 4.



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METHOD FOR HEAT TREATING STEEL DIE BLOCKS

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4 Claims. (Cl. 148—16)

This invention relates to a method for making die blocks of steel and its alloys used for example in making drop forging dies, and has particular reference to hardening such die blocks.

To avoid distorting the die pattern, the prior art practice has been to rely either upon the long experience and the acquired skill of the man who personally directs the hardening operation, or upon the operations of sinking the die by machining after the die block is hardened. The fact that all the extra labor, time, and expense are spent in sinking a die after the die block is hardened as a common prior art practice, shows one difficulty my invention will avoid and do so without depending on the exceptionally skilled man in the art.

This laborious die sinking operation is now carried on because there is too much danger of distortion in hardening the die block after the die is sunk therein. By hardening the die block first and then sinking the die, the die pattern cannot be distorted in the hardening operation.

The liability of distortion in the hardening operations becomes increasingly serious as the size of the die block increases. I do not desire to limit the range of my invention unless the prior art now unknown to me may require it. But as a practical matter I emphasize the fact that this invention is directed particularly to hardening large die blocks. In practice such blocks commonly run to very heavy weights, well over a thousand pounds. As to when they begin to be large, I may say from experience that as the weight approaches a hundred pounds the difficulties I mention of distortion of a die pattern in hardening the die block begin to be serious. The point is that if the die is first sunk in the block and the latter distorts in hardening, there is so much expense in correcting the distorted pattern that, as I have stated, many firms practice the steps of hardening first and sinking the die afterwards. This practice avoids distorting the pattern but even then it is liable to leave the die block under undesired strains which tend to cause cracking in uses such as die forging. All this trouble results from the difficulties in the hardening operations.

Some firms have a man sufficiently skilled to harden large die blocks after the die is sunk and avoid the distortions with enough success to practice that way. But this practice depends on high skill. As I will point out, my new method and apparatus will do even better and more uniform work with much less skill.

I will disclose the method with general refer-

ence to the accompanying drawings, in which—

Fig. 1 shows a longitudinal section of a multiple furnace assembly;

Fig. 2 is a view on line 2—2 of Fig. 1 in the direction of the arrows;

Fig. 3 is a section on line 3—3 of Fig. 1; and Fig. 4 is a section on line 4—4 of Fig. 1.

This furnace structure and its devices for manipulating heavy die blocks show the preferred form of apparatus used to carry out my method. The apparatus as a whole will be described in more detail after the method is disclosed.

As one example of my new method I will detail the operations on a steel alloy die block weighing about 1200 pounds.

The steel alloy of this die block may be, for example, as set out in the Finkl Patent 1,464,174 of August 7, 1923. This alloy is in commercial use. The man in the art will understand that I refer to it as an example and not as a limitation of a steel alloy to be used in my method steps.

The preferred method of proceeding is to sink the die pattern in block A. The block is then suspended and carried into furnace B. Furnace B is fired to heat the suspended block A to a uniform body temperature of about 600 degrees Fahrenheit. This will take four or five hours. The idea is to have this temperature low as compared to the next step, and I prefer not to have it above 675°.

The block A is now moved in suspended condition into furnace C and the latter is closed. Here the temperature is in the beginning about 1200°. The die block is heated at this temperature until its body heat is uniform throughout and up to the temperature of 1200°. This will take about three hours. Then the "fire" in furnace C is adjusted to slowly raise the temperature. I prefer a rise of about 1° a minute until the temperature rises to about 1350°. When it has reached that temperature it is held there until the block A is uniformly heated throughout its body.

A critical change is going on in this furnace C, in that block A is being heated to or slightly above the temperature at which it will harden if quenched. Also, it is in this stage when any exposure to air or the wrong "atmosphere" of gases will cause scale on the heated block. The block is in what might be called now a critical condition due to being at or above its critical temperature and very quickly damaged if not treated properly with full appreciation and regard for its condition.

In this condition the block A is carried while still suspended into furnace D, its door being opened for the purpose and then closed. The block has not been exposed to the air, the furnaces being heated and providing their own "atmosphere" and one which guards the condition of the block in the best manner.

Furnace D is heated to 1400°. The die block A is brought throughout its body to this temperature in furnace D, in about two hours. Then the temperature of the furnace D is slowly raised, at about ½° a minute up to between 1450-1600°. It is kept there until the body of the block is uniformly heated to the higher furnace temperature.

Block A, in the example given, will attain its maximum hardness if now taken from this furnace D and promptly quenched from this temperature.

The more important operations are carried on with respect to the character of heating in furnaces C and D and the character of treating the die block while in these furnaces and in moving the block from one furnace to the other.

It is in furnace C that the critical temperature is reached. At this temperature the metal is easily put under strain and distorted. Even a strain that does not distort the die pattern may render the die block liable to crack when put to its final uses, as for die forging.

To give block A the preferred treatment in furnace C, the following things are done: The furnace is fired to about 1200° before the block is put in it. The furnace "atmosphere" is one of burning gases which will not attack the metal. The furnace is built, as will be described, to fire efficiently and maintain such an "atmosphere" through the range of its heating of block A to its critical temperature and while block A is in that furnace. To guard the treatment of the block it is held suspended in the furnace so that the furnace "atmosphere" will envelop the block on every side. This "atmosphere" of burning gases enveloping every part of the block results in heating it by radiation and to no extent by conduction. It is important to completely avoid the latter kind of heating as would be operating if the block were resting on the furnace floor or on supports through which heating of the block would be carried on to a partial but definite extent by conduction through the supporting area. The reason why such heating by conduction should be avoided is that the block is unevenly heated by conduction at the spots where it rests on the furnace. Any such uneven heating tends to put the metal under strain, and to decarbonization at the spots where conduction takes place. In such cases the block will not harden so well at the decarbonized spots. While these spots may be located so that their lack of the best hardening at such areas may not be so important the fact is that uneven hardening puts strains in the block and strains are objectionable in the block regardless of the location of decarbonized spots.

It will be seen from the method outlined that block A is treated without even momentarily exposing it to air in transferring it from one furnace to another at its high temperature and particularly when anywhere near its critical temperature. The method of handling the block from one furnace heat to another furnace heat is, as disclosed, a real mechanical convenience. But that convenience is not the primary consideration with regard to the method. The primary consideration is in the plan for carrying the

block through the steps which will harden it while avoiding the dangers of distorting the die pattern, of straining parts of the block, and of undesirable changes in the steel alloy at the surface of the block, due to gas attack or uneven heating by conduction from furnace supports for the block.

There are important practical advantages in carrying out my method in the arrangement of independent but connected furnaces as illustrated in the preferred apparatus of the drawings. As pointed out, the character of furnace "atmosphere" enveloping the die block is important. My multiple furnace arrangement makes it economical for me to obtain and maintain the desired "atmosphere" in each furnace while that furnace is fired most efficiently.

Furnace C, for example, may be fired efficiently by the gas burner arrangement of passages to be described later in detail. It may be easily adjusted for its range of heating temperature, i. e., between 1200° and 1350°. In that range the desired burning gas "atmosphere" may be maintained for enveloping the block A for heating it. And the fuel consumption will be economical over that range. The same is relatively true of furnace D in which it is very important to maintain the desired "atmosphere" of burning gases over its heating range. It is also true of furnace B. But it will be appreciated by the man in the art that the heating temperature of furnace B in the example given of my method is not high enough to make the "atmosphere" of that furnace or the transfer of the block from that furnace to furnace C anywhere near of the same importance as in the case of the transfer between furnaces C and D and the "atmosphere" in each of them.

Instead of quenching the block at the high temperature of between 1450-1600° in the example before given a maximum hardness plus a greater toughness may be given by additional treatment in the furnace C. This can be obtained by moving block A back from the 1450-1600° heat of furnace D to furnace C. When back in furnace C the block will drop in temperature slowly to between 1375-1425° until its body has one uniform heat. While in this condition it is passed, for the purposes of exit, suspended through furnace D and quenched after leaving the latter furnace. This manipulation, known as the hi-low treatment, will give not only the maximum hardness but a tougher character to the block thereby providing every possible precaution against distortion or cracking.

Sometimes a die block is not intended to be used for a maximum production of parts from it. In such cases, it is still very important to safeguard the block as outlined in my method. But it is not important to give it the maximum hardness. In such cases it saves expense to carry the block through the above steps of my method except those in connection with furnace D. Instead of using the latter, the following procedure is carried on. When the block reaches 1350° uniformly throughout its body in furnace C, it is then very slowly raised for a uniform body heat, to between 1375° and 1380°. The rate I prefer for this slow rise in temperature is about ¼° a minute. Then the block A is taken from furnace C and quenched. It will not be so hard but hard enough for its intended use. It will also be very tough, having the characteristics of the above heating method involving the return to furnace C, but not its hardness. Its toughness and security against cracking will be superior to the

method of quenching directly from furnace D.

Each of the furnaces B, C, and D taken by itself is of a known construction except for the longitudinal slot 17 in its roof for permitting the carrying of the suspended work through the entrance and exit doors and along the furnace and of suspending the work in the furnace while it is being heated. This feature so far as I know is new. Of course it could be adapted to other specific types of furnaces. It is also new so far as I know to arrange two or more separately heated furnaces in tandem arrangement and particularly with a slot or similar means permitting the work to be suspended as desired for my method in each furnace separately and also to be moved from one to the other. This arrangement permits me not only to suspend the die block while being heated by only one furnace but also to move the block to the next furnace without exposing it to the air and with a minimum loss of time and labor. It is only necessary to open a door separating the two furnaces in my arrangement and roll the trolley supporting the suspended work to a position above the next furnace and the work will then be suspended in this furnace.

An intermediate door 1 as shown is controlled by hydraulic cylinder 3 and is raised to closed position by piston rod 5. The foot valve 4 controls the cylinder 3 (see Fig. 3). The same independently operable means is provided for each intermediate door 1.

Foot valve 7 controls cylinder 6 and piston rod 8 to close an end door 2 by means of chain 9 and winch 10. The winch 10 turns shaft 11 causing the winches 12 to operate chains 13 which raise the door 2 through pulleys 14 and bars 15 fixed on the door. The members 16 are door frames. Each end door 2 is provided with the same kind of independently operable opening and closing means.

I prefer as shown to have the trolley and the work supported independently of the furnace roof as the latter can then be built without providing for the extra load of the trolley and the work carried by it. To this end rods 18 hang from the ceiling carrying the trolley rail box 19 with rails 20 providing a track for the wheels 21 the axles of which suspend trolley hook 23 within the furnace chamber below the trolley. The rail box 19 is shown broken off beyond the furnace arrangement. It will be readily understood that the trolley has its rails provided to carry past convenient work stations not shown. The hook 23 suspends the block A by hooks 24 and pins 25 set in customary holes of block A. Channel bars 27 inside the furnaces are provided only for an emergency in case the die should slip. Due to the slot 17 in the arch of the furnace, provision needs to be made for extra supports in the roof structure for supporting the broken arch.

While I have referred above to the furnace tunnel with end doors and intermediate doors my preferred construction embodies separately fired and controlled individual furnaces B, C, and D, the more important pair being C and D.

The skilled man in the art of hardening die blocks will understand what I mean by arranging the furnace "atmosphere" so it will not attack the metal. I can do this conveniently and at the same time maintain very efficient heating conditions in the tandem heating furnaces. The tandem furnace arrangement for this pur-

pose will now be described, referring to furnaces C and D.

Furnace C in its firing arrangement per se is of known construction, see Fig. 3. The fuel is premixed and fed through gas passage 32, starts burning in bottom cross passage 33, turns up stub passage 34 and enters the main furnace chamber upwardly directed along one of the side walls. The upwardly directed burning gases are turned across the furnace by the arch ceiling and some of the gases taking this general course are sucked down the stub passage 36, on the other side from passage 34. The ingoing gases from 32 suck down other gases from passage 36, so the fresh gases are mixed with some that have been burning in the furnace. This is the regenerative principle. The gases are put in under pressure, there is very little venting and that carefully controlled by providing a hood over slot 17. Side member 28 hanging above the top of the furnace affords a constant minimum vent while the holes 30, see Fig. 1, in side member 29 are regulated by means of the shutter plate 31. The shutter may be regulated manually or automatically according to the setting of the valve mechanism for firing the furnace. Air will not leak in the vent passages or elsewhere as the "atmosphere" in the furnace is under a little more than atmospheric pressure.

The cycle of gas feeding and burning just described in reference to Fig. 3 is repeated in all the series of cross passages indicated in Fig. 1. The arrangement is to have many gas feeding passages in staggered arrangement. The passages 35 adjacent that shown in Fig. 3 will feed from opposite sides of the furnace, all as indicated in Fig. 1 at the left.

The arrangement permits a very close control of the burning "atmosphere" in the furnace. Of course the gases mix in the main furnace chamber but they are before that controlled so they burn evenly and maintain their uniform harmless character that will not attack the die block A. Furthermore, they are burned so that they heat the die block by radiation as the block is completely out of contact with any furnace part heated by the gases and the latter entirely envelope the block.

This condition of the right and harmless atmosphere of the furnace C for example, can be adjusted for the particular range of heating I desire in that furnace. But if I tried to use the furnace C to perform its function and in addition the heating function of furnace D in my method there would be serious practical difficulties. For example it would not be so difficult to raise the temperature of furnace C to that for which furnace D is used, but to raise the temperature and in addition maintain the right "atmosphere," would be very difficult in consuming time for such major adjustment, the temperature range being so great, and the die block already heated to its critical temperature in furnace C, would present difficulties with respect to its environment while the transition was being made to adjust furnace C to do the work of furnace D. By arranging the furnaces in tandem as described, I can carry out the desired steps of the treatment and heating of the die block with the least difficulties. The preliminary heating in furnace B in tandem with furnace C enables me to keep the latter furnace closely adjusted for efficient firing with the desired "atmosphere" and with the least interruption of the work.

With my apparatus particularly constructed and arranged to carry on my method single die blocks or a series of die blocks (preferably using additional trolleys) can be hardened safely in a minimum amount of time, and efficiently with respect to the cost of fuel and labor handling. In addition, and more important, the work can be done by following my method without the need of either the highly skilled artisan or the precaution of hardening the die block before sinking the die pattern in it.

What I claim is:

1. The method of preparing a heavy steel die block for quenching which consists in sinking the die pattern in its block before any hardening of the latter, heating the die block to a body temperature well below the temperature at which it may be easily damaged, then holding it in suspended condition in a furnace heated by burning gases which entirely surround the block, such gases being maintained as an "atmosphere" harmless to the metals of the block while such block is kept out of harmful heat conducting contact with the furnace parts, firing the furnace while maintaining these conditions until the block is raised to a uniform body temperature at or above that critical temperature which if then quenched the block will harden, then transferring said block to another furnace while maintaining the aforesaid conditions and firing the latter furnace to a temperature high enough above said critical temperature to cause the constituents of the steel to enter into that condition which if quenched afterward will give the block substantially its maximum hardness.

2. The method of preparing a heavy steel die block for quenching which consists in sinking the die pattern in its block before any hardening of the latter, heating the die block to a body temperature well below the temperature at which it may be easily damaged, then holding it in suspended condition in a furnace heated by burning gases which entirely surround the block, such gases being maintained as an "atmosphere" harmless to the metal of the block while such block is kept out of harmful heat conducting contact with the furnace parts, firing the furnace while maintaining these conditions until the block is raised to a uniform body temperature at or above that critical temperature which if then quenched the block will harden, then transferring said block to another furnace while maintaining the aforesaid conditions and firing the latter furnace to a temperature high enough above said critical temperature to cause the constituents of the steel to enter into that condition which if quenched afterward will give the block substantially its maximum hardness, and then transferring the block back into the furnace with the temperature slightly above the aforesaid critical temperature and allowing the block to reduce its body temperature to cause the con-

stituents of the steel to enter that condition which if quenched afterward will give the block substantially its maximum hardness and maximum toughness.

3. The method of preparing a heavy steel die block for quenching which consists in sinking the die pattern in its block before any hardening of the latter, holding the die block in suspended position in a furnace heated by burning gases which entirely surround the block and heating it to a body temperature well below that at which it may be easily damaged, then transferring it to a second furnace likewise heated by burning gases which envelope the block, such gases being maintained as an "atmosphere" harmless to the metal of the block while such block is kept out of harmful heat conducting contact with the furnace parts, firing the said second furnace while maintaining these conditions until the block is raised to a uniform body temperature at or above that critical temperature which if then quenched the block will harden, then transferring said block to a third furnace while maintaining the aforesaid conditions and firing said third furnace to a temperature high enough above said critical temperature to cause the constituents of the steel to enter into that condition which if quenched afterward will give the block substantially its maximum hardness.

4. The method of preparing a heavy steel die block for quenching which consists in sinking the die pattern in its block before any hardening of the latter, holding the die block in suspended position in a furnace heated by burning gases which entirely surround the block and heating it to a body temperature well below that at which it may be easily damaged, then transferring it to a second furnace likewise heated by burning gases which envelope the block, such gases being maintained as an "atmosphere" harmless to the metal of the block while such block is kept out of harmful heat conducting contact with the furnace parts, firing the said second furnace while maintaining these conditions until the block is raised to a uniform body temperature at or above that critical temperature which if then quenched the block will harden, then transferring said block to a third furnace while maintaining the aforesaid conditions and firing said third furnace to a temperature high enough above said critical temperature to cause the constituents of the steel to enter into that condition which if quenched afterward will give the block substantially its maximum hardness, then transferring the block back into the second furnace with its temperature slightly above the aforesaid critical temperature and allowing the block to reduce its body temperature to cause the constituents of the steel to enter that condition which if quenched afterward will give the block substantially its maximum hardness and maximum toughness.

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