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(71) Applicant: **Moore, William H.**
644 Dolphin Road
Fripp Island South Carolina 29920(US)

Applicant: **Lehtonen, Ari**
Nuumaentie 9 D
SF-02710 Espoo(FI)

(72) Inventor: **Moore, William H.**
644 Dolphin Road
Fripp Island South Carolina 29920(US)
Inventor: **Lehtonen, Ari**
Nuumaentie 9 D
SF-02710 Espoo(FI)

(74) Representative: **Harrison, Michael Robert et al**
Urquhart-Dykes & Lord 91 Wimpole Street
London W1M 8AH(GB)

(54) Improved method of heat treating ferrous metals.

(57) An improvement of the austempering process, which in the prior art has included a transfer of castings from the austenitizing furnace to a bath containing a liquid medium. Castings in the improved process are instead cooled in situ by the application of fluids such as air and water jets, and the same furnace is used for both austenitizing and austempering.

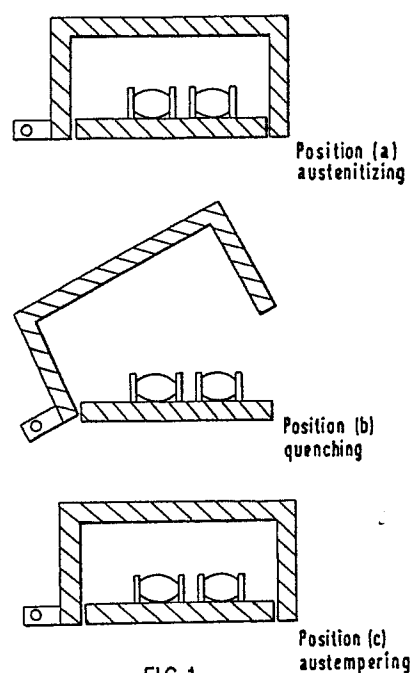


FIG.1

EP 0 281 249 A1

IMPROVED METHOD OF HEAT TREATING FERROUS METALS

This invention relates to methods of heat treating cast iron or steel. More particularly, it relates to an improved method of treatment to produce a bainite structure and improved mechanical and physical characteristics.

Background of the Invention

It is well known that cast iron or steel may be cooled from an elevated temperature where it is austenitic in structure, at such a rate that normal formation of pearlite is suppressed and austenite and martensite occur instead. The austenite and martensite are stable at lower temperatures, such as room temperature. It is also known that if the cast iron or steel is held for a period of time at a selected temperature between the higher austenitizing temperature and room temperature, and if pearlite has first been suppressed, then a structure of bainite is formed instead. This bainite may contain varying quantities of pearlite, austenite or martensite, depending on the exact cooling conditions that prevail and the exact composition of the cast iron or steel.

This process of producing bainite by heat treatment is known as austempering. Conventional procedures involve heating the cast iron or steel to a temperature in excess of 1300 degrees F so that it becomes austenitic in structure. This temperature is known as the austenitizing temperature. For all practical purposes this austenizing temperature is held to a maximum value of 1900 degrees F and the period of time is usually 1 hour plus 30 minutes for every one inch of casting section. This time period is also somewhat dependent on the total mass of casting shapes in the furnace load and on the heat input into the furnace. The cast iron or steel is then cooled rapidly to the holding temperature called the austempering temperature usually between 400 degrees F and 800 degrees F. After holding at this temperature for 1 to 4 hours, depending on mass section and composition, the cast iron or steel is then cooled to room temperature.

Austempering is usually conducted in a bath of hot salt or hot oil or any liquid medium that can be maintained at the austempering temperature. Shapes in cast iron or steel are transferred from a furnace at austenizing temperature and are quenched in the austempering bath. Such treatment involves two furnace systems as well as the handling of hot shapes, such as forgings or castings, in cast iron or steel. Further, after cooling to room temperature, the castings or forgings have to be washed or cleaned to remove all residual salts

or traces of the quenching medium used. Because salt baths are quite expensive there is usually a limit to the size of the castings or shapes that can be austempered in the conventional manner.

Summary of the Invention

We have discovered a method whereby the heat treatment required to produce a structure of bainite in cast iron or steel may be conducted with only one furnace and without immersion in a liquid quenching medium or salt bath.

Our invention is based on the discovery that fine jets of water or a gaseous medium like liquid nitrogen or carbon dioxide gas can be applied directly to castings or forgings while in position in the furnace so that the castings or forgings may be cooled and the furnace itself may be cooled down to the austempering temperature. This avoids the necessity of transferring the castings or forgings to a second furnace for austempering.

Thus, one object of our invention is to reduce the cost of the austempering process.

A further object is to provide a means of using only one furnace for the complete austempering process.

A further object is to economically allow the austempering of large castings or forgings.

Further objects will become apparent from the claims submitted herein, and from the description of a preferred embodiment of the invention together with the Figures, in which

Figure 1 is a diagrammatic illustration of the preferred process of the invention.

Figure 2 is a graph depicting typical time vs temperature cooling curves for the prior process and for the improved process of this invention, and

Figure 3 is a photomicrograph of a nodular iron bar cooled by the process of this invention.

Description of a Preferred Embodiment of the Invention

The cooling of a furnace and a load of castings with air saturated with water or with the circulation of cold gases is governed by complex heat-transfer laws which relate to the specific heat of water, the latent heat of evaporation and the specific heat of air or gas used for circulation. We prefer to utilize water and air for the rapid and inexpensive cooling required to suppress the formation of pearlite during the cooling cycle.

It will immediately be apparent to those skilled

in the art that the cooling of the furnace itself from the austenitizing temperature to the austempering temperature represents a greater problem which relates to the heat held by the furnace refractories. Conventional refractories used for lining the furnace would present problems with a large heat mass and with spalling of the refractories caused by the rapid cooling required.

For this reason we prefer to use a furnace that is lined with refractory fibre which is light in weight, insulating in nature and capable of rapid changes in temperature without deterioration.

In the preferred embodiment of the process of this invention the furnace is raised above the castings or is tilted back in order to expose the castings. This makes it easier to cool the furnace and to cool the castings. As soon as both the furnace and the castings have reached the required austempering temperature, the furnace is lowered or tilted back over the castings and the temperature of the furnace is then maintained for the desired length of time at the austempering temperature.

The whole process of austempering may in this manner be conducted without the necessity of moving the castings or of having a second furnace.

Figure 1 is a diagrammatic illustration of the preferred method of the invention. Position (a) shows a furnace containing a casting on the furnace bottom plate and with the furnace in the austenitizing mode. Position (b) shows the furnace tilted back for cooling and the quenching mode. Position (c) shows the furnace back in position over the casting and the casting in the austempering mode.

Figure 2 shows a typical temperature time cooling curve when a given casting, in this case a 3" diameter bar, is quenched in a salt bath and is subsequently held in this bath to produce bainite. Shown also is a curve indicating the cooling rate obtained when water is applied to the casting in a furnace and the casting as well as the furnace are cooled by air circulation to the austempering temperature. We have found that manipulation of the amount of water used as well as the amount of air circulated will allow the cooling rate in the casting to be varied over a relatively wide range of cooling rates.

In Figure 2 the curve A represents the cooling rate obtained in a salt bath where the line CC is the austenitizing temperature and line DD is the austempering temperature. The austempering temperature is reached in a 10 minute time period. F and at this time the furnace was tilted back to cover the castings after cutting off air and water circulation.

The furnace was maintained at a temperature of 620 degrees F for a period of 2 hours and the

casting load was then removed from the furnace.

Several bars were then sectioned and examined under a microscope. It was found that these bars had a fully bainitic structure with from 15-20% of retained austenite in the heavier bars and from 20-35% retained austenite in the lighter bars.

The temperatures, velocities and amounts of the fluids applied to the mass of the castings, will determine the rate of cooling in a manner known to or easily determinable by those skilled in the art. That rate must suffice to cool the castings within a ten to twenty minute period in order to avoid the formation of pearlite and thereby to obtain the desired bainitic structure. While the rate of cooling required to suppress pearlite will vary according to the composition of the ferrous metal involved and may be exactly determined by means of a time-temperature-transformation diagram for the particular metal involved, the time required for cooling normally will be less than 20 minutes.

We have run similar tests using liquid nitrogen to cool the air blown on the castings and using solid dry ice on carbon dioxide placed in the casting load but in general we find that water and air are easier to use and control. The rate of cooling is such a case is accelerated by increasing the rate of water flow. Curve B represents the cooling rate when air was circulated in the furnace while water was applied to the casting. In this case the austempering temperature was reached in a 12 minute time period.

Figure 3 shows the bainite structure resulting from a nodular iron bar cooled by water treatment at the rate indicated in Figure 2.

Example

A load of castings consisting of twelve bars ranging in diameter from 2" to 4" and about 24" in length were placed in a furnace 3' x 4' and 4' high. The furnace was lined with fibre refractory and was pivoted at its back end so it could be tilted back from the castings placed on a fixed floor. The furnace had as a heat source a series of propane-air burners.

The furnace load was heated to 1650 degrees F and was held at this temperature for 2 hours when the propane was shut off and the furnace was tilted back to expose the casting load. The air was circulated from the burners while the furnace was tilted back and an additional fan was used to blow air on the furnace to cool it down to 620 degrees F.

A fan was used to blow air directly on the casting and water was introduced by pressure jet so as to impinge directly on the casting load. A thermocouple placed strategically in the casting load was used to indicate when this load had

reached an approximate temperature of 600 degrees

We have also found that cold metallic steel shot or copper shot when added to the casting load when it is being cooled will accelerate the rate of cooling of the casting load but in general we prefer to use cold air and water as the cooling media.

We have described the invention with a certain degree of particularity but it is understood that modifications and variations may be resorted to without departing from the spirit and scope of the invention. Such variations and modifications apparent to those skilled in the art are considered to be within the purview and scope of the invention and appended claims.

(e) holding said castings in said furnace at said austempering temperature for a period of 1-5 hours, then

(f) removing said castings from said furnace.

Claims

1. A method of austempering ferrous castings in which the castings held in a furnace at the austenitizing temperature are cooled along with said furnace, down to the austempering temperature, and the castings are then held in this same furnace at the austempering temperature.

2. In the process of austempering ferrous castings, the improvement comprising cooling said castings from the austenitizing temperature to the austempering temperature by applying a substance or substances to said castings without transferring said castings from the furnace in which the austenitizing temperature was applied to said castings, said substance or substances being applied at such temperatures and in such amounts as to cool said castings within a period short enough to produce a bainitic structure in said castings.

3. The improvement of claim 2 and in which said substance or substances are a fluid or fluids.

4. The improvement of claim 3 and in which said fluid or fluids are selected from the group consisting of air and water.

5. The improvement of claim 3 and in which at least one of said fluid or fluids are applied to said castings by a pressure jet.

6. A method of austempering ferrous castings comprising the steps

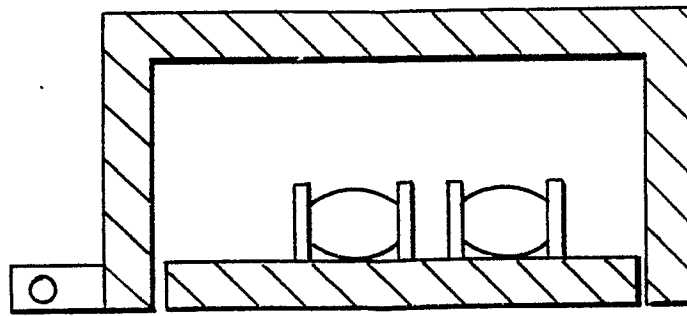
(a) placing said castings in a furnace,

(b) heating said castings to an austenitizing temperature above 1300 degrees F, and below 1900 degrees F.

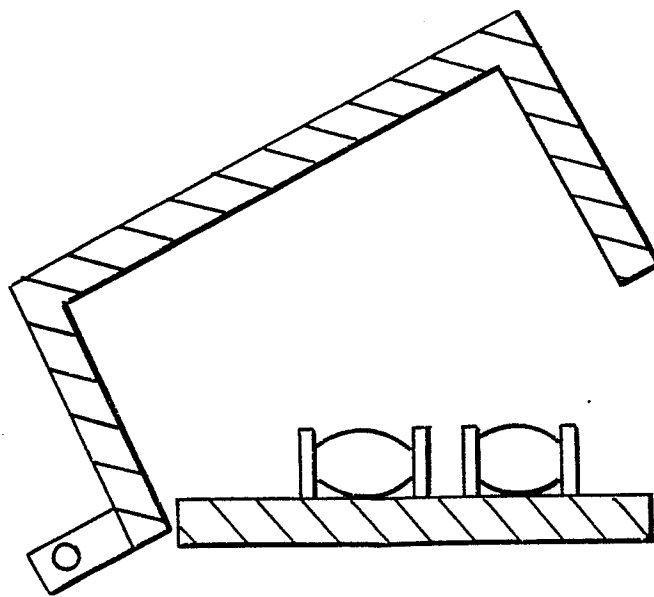
(c) holding said castings at said austenitizing temperature for 1-8 hours depending on casting section.

(d) applying a cooling medium of water and air so that both said castings and said furnace are cooled in less than 20 minutes to an austempering temperature of from 300 degrees F to 800 degrees F

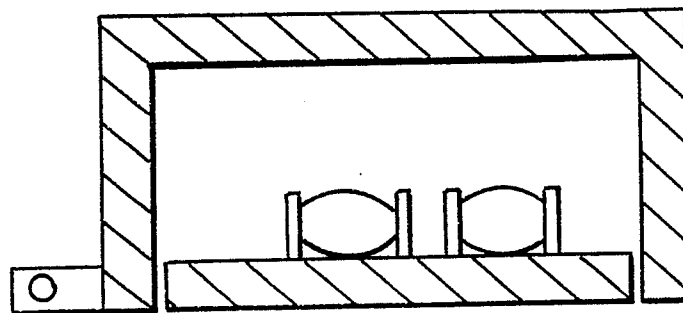
Neu eingereicht / Newly filed
Nouvellement déposé



Position (a)
austenitizing



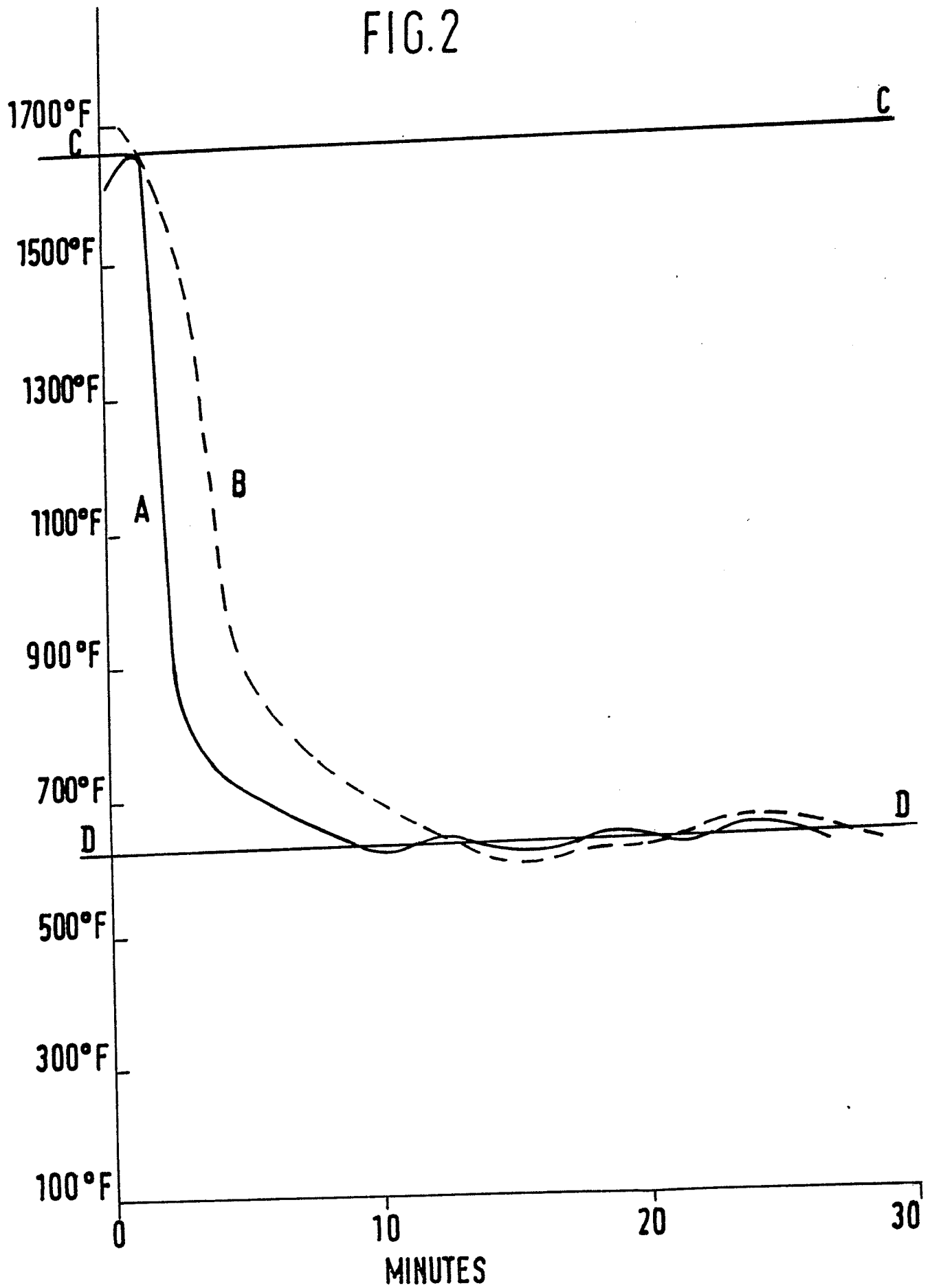
Position (b)
quenching



Position (c)
austempering

FIG.1

FIG. 2



Neu eingereicht / Newly filed
Nouvellement déposé

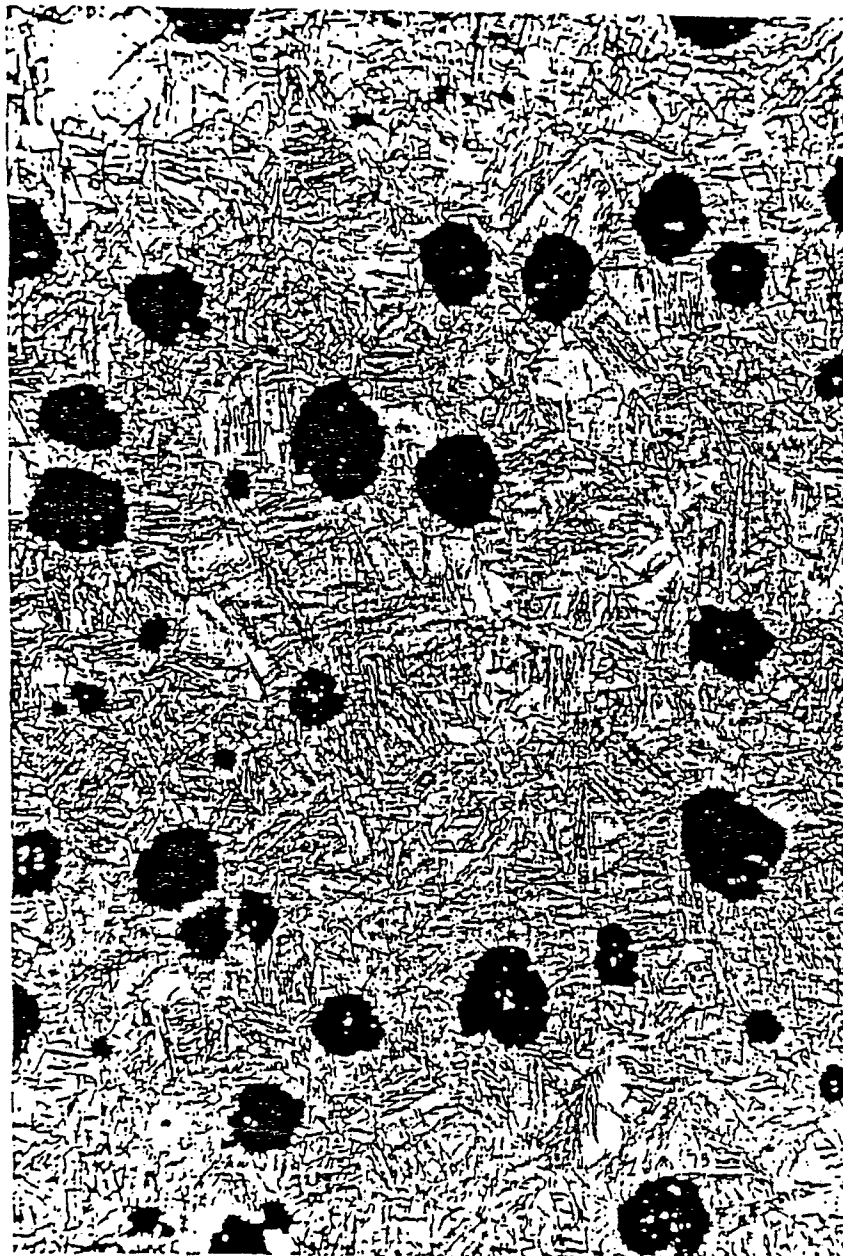


Fig. 3



DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
X	HÄRTEREI-TECHNISCHE MITTEILUNGEN, vol. 41, no. 1, January-February 1986, pages 28-32, Munich; P. LISTEMANN "Gestuftes Abkühlen zum Härten und isothermes Umwandeln im Bainitbereich zur verzugsarmen Wärmebehandlung in Vakuumanlagen" * page 31 *	1	C 21 D 5/00 C 21 D 1/20 C 21 D 9/00
Y	DE-B-1 228 643 (OFAG) * claim 1 *	1,2	
Y	DE-A-1 433 715 (BREITENBACH) * claims 1-4 *	1,2	
A	FR-A-2 379 607 (VIDE ET TRAITEMENT) * claim 1 *	1	
A	DE-C- 863 070 (OJU) * claim 1 *	1	
A	DE-C- 848 203 (SELLERBECK) * page 2, lines 10-12 *	1	TECHNICAL FIELDS SEARCHED (Int. Cl.4)
A	DD-A- 219 268 (VEB LOKOMOTIVBAU) * page 2, lines 2-11 *	1	C 21 D 1/20 C 21 D 5/00 C 21 D 9/00
A	EP-A-0 087 634 (PONT-A-MOUSSON) * claim 4 *	1	
The present search report has been drawn up for all claims			
Place of search BERLIN		Date of completion of the search 30-05-1988	Examiner SUTOR W
CATEGORY OF CITED DOCUMENTS			
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons ----- & : member of the same patent family, corresponding document	