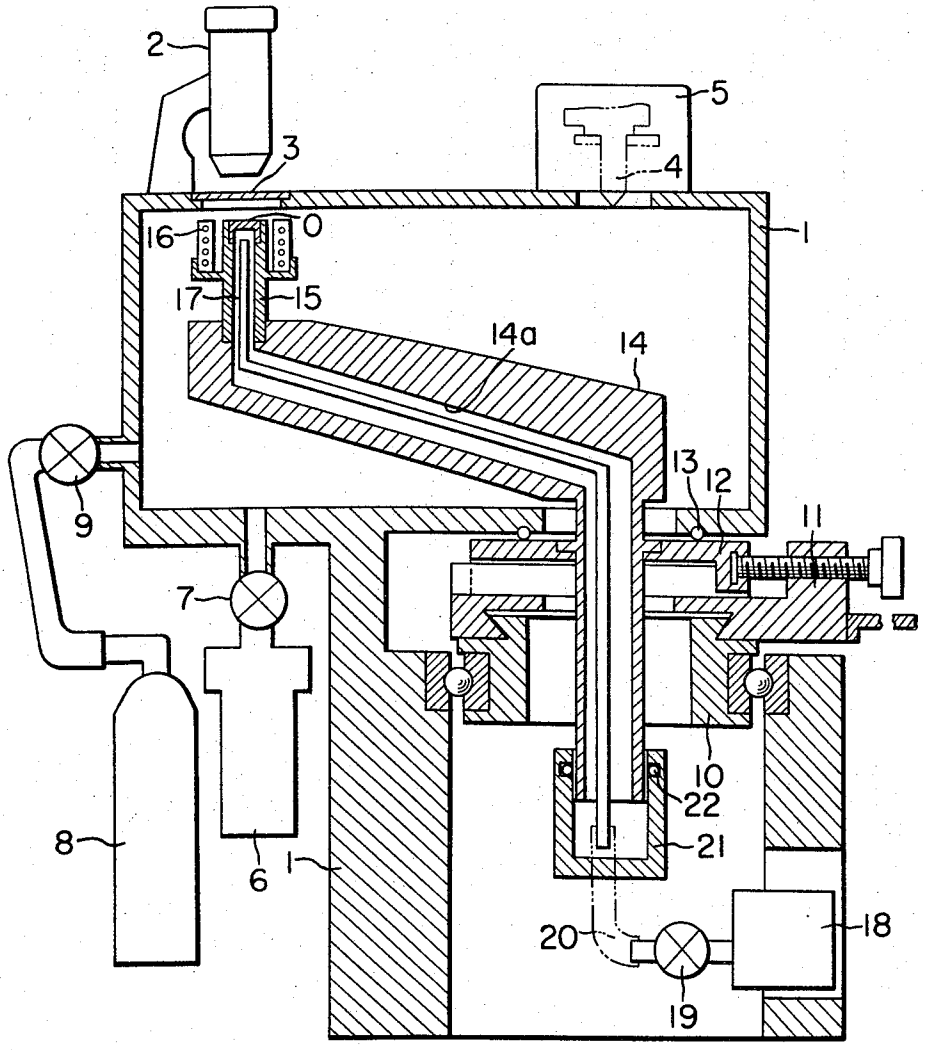
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DEVICE FOR QUENCHING AND COOLING A SPECIMEN IN A HIGH-TEMPERATURE MICROSCOPIC VIEWING SYSTEM

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DEVICE FOR QUENCHING AND COOLING A SPECIMEN IN A HIGH-TEMPERATURE MICROSCOPIC VIEWING SYSTEM

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ABSTRACT OF THE DISCLOSURE

In a high-temperature microscopic viewing system a specimen heating furnace is installed around the specimen and is in the form of a hollow cylinder having one end thereof closed to provide a test surface, and a cylindrically shaped specimen holder open at opposite ends carries the specimen on top thereof, the hollow interior of the holder communicating with the exterior of the hermetically sealed chamber while maintaining a gas-tight seal with respect to the interior of the chamber. A pipe extends through the holder along the length thereof for passing a coolant from the exterior of the hermetically sealed chamber to the inner side of the test surface of the specimen.

BACKGROUND OF THE INVENTION

Field of the invention

This invention relates to a high-temperature microscopic system, and more particularly to a device used in such system for heating a specimen in a vacuum or a desired gaseous environment, and for quenching or further cooling the test surface of the specimen under non-oxidizing conditions, all so that structural variations in the surface may be microscopically observed.

DESCRIPTION OF THE PRIOR ART

Metallic materials are varied in their structure when subjected to thermal treatments such as heating, quenching, and cooling to very low temperatures. Practically all thermal treatments comprise a combination of these processes.

Nevertheless, in conventional high-temperature microscopic viewing systems, types of thermal treatment available for a specimen were generally limited to heating and natural cooling, and this condition has imposed great limitations on the research activities abole to be carried out by the use of such systems. A conventional method of quenching a test surface in a non-oxidizing environment has involved the step of injecting inert gas such as helium or the like against the test surface, but the use of such gas, whose cooling power is very much lower than that of water, has given rise to the necessity of greatly reducing the thickness of the specimen to obtain a sufficient cooling rate. Such limited thickness of the specimen has suppressed the growth of crystal grains and could only result in the formation of flat crystal grains. Thus, such a thin sample material, when quenched, has presented a mode of structural variation different from that of ordinary large samples having cubic crystal grains. For this reason, the conventional method described above has not been practical enough for research purposes.

Another more popular method has involved the procedure of reading the cooling rate of a specimen from the temperature variation presented by a thermocouple welded to the specimen. However, where the specimen is so thin as mentioned above, heat input and output of the thermocouple becomes appreciably great and this makes it extremely difficult to provide a uniform temperature distri-

bution over the test surface. In fact, during quenching, the temperature variation presented by the thermocouple is nothing other than the temperature variation in the hot contact portion of the thermocouple, and this differs widely from the temperature variation occuring in a region of the test surface which is remote from the hot contact. Thus, this method has also been unsuitable for research purposes.

As a further technique of non-oxidizing annealing, a method has been considered which involves the steps of forming an opening through a wall of a hermetically sealed chamber, sealing the opening by means of packing in such a manner that the test surface of a specimen faces the interior of the hermetically sealed chamber while the reverse side of the specimen faces the exterior atmosphere, drawing a vacuum or like non-oxidizing atmosphere on the chamber, heating the specimen and injecting water or other coolant from the exterior atmosphere against the reverse side of the specimen. The annealing temperature of metals is usually above 800° C. for steel, about 800° C. for copper alloys and above 500° C. even for aluminum alloys, whereas the usable temperature of sealing packing members is at best 200 and 300° C. for fluoric rubber and silicon rubber and there is available no packing member which can maintain a sufficient gas-tight seal at temperatures above 500° C. Therefore, in order to protect the packing, this method would involve the requirements that the specimen must be elongated in form and positioned with its test surface sufficiently spaced apart from the contact surface of the packing, and that only the test surface and adjacent area of the specimen must be heated while the portion thereof adjacent to the contact surface of the packing must be cooled. In such cases, however, the heating efficiency would be very low because the specimen is partly heated and partly cooled, and thus it would become difficult sufficiently to raise the temperature of the test surface. Also, a reduced thickness of the specimen adopted in an attempt to increase the heating efficiency would cause a reduced area of the test surface. An elongated shape of the specimen might be quite difficult to obtain or entirely unobtainable when the blank from which the specimen is derived is very small in size. For these reasons, in such a method which uses a packing member interposed between the sample object and the hermetically sealed chamber, materials for the packing are limited to those of low heat conductivity and the size of the original blank must be sufficiently large to permit a specimen to be derived therefrom. Moreover, deriving such a specimen would require complex processes. Thus, this method is not very practical.

SUMMARY OF THE INVENTION

Essentially, the present invention provides, in a high temperature microscopic system, a device for quenching and further cooling a specimen to very low temperatures, which has eliminated the various disadvantages of the prior art and which is very convenient to use and of high utility.

The device according to the present invention is embodied in a high temperature microscopic viewing system of the type in which a specimen placed with in a hermetically sealed chamber is heated and the test surface thereof is observed with the aid of a microscope from outside the hermetically sealed chamber through a viewing window. The specimen may be in the form of a hollow cylinder having one end thereof closed to provide a test surface. A sample heating furnace is installed around the specimen, and a cylindrically shaped specimen holder open at opposite ends carries the specimen on top thereof. The hollow interior of the holder is communicated by a cavity with the exterior of the hermetically sealed chamber while maintaining a gas-tight seal with respect to the

interior of the hermetically sealed chamber. A pipe extends through the cavity along the length thereof for passing a coolant from the exterior of the hermetically sealed chamber to the inner side of the test surface of the specimen. Thus, the coolant may be injected against the inner side of the test surface and flow through the cavity for discharge into the exterior of the hermetically sealed chamber to thereby cool and quench the specimen to very low temperatures. Gas introduced into the hermetically sealed chamber may pass through a clearance between the specimen and the holder into the latter and further into the exterior of the chamber thereby to prevent the atmosphere within the holder from flowing back into the chamber and enable the specimen to be heated, quenched and cooled to very low temperatures without the test surface thereof being contaminated.

BRIEF DESCRIPTION OF THE DRAWING

There has thus been outlined rather broadly the more important features of the invention in order that the detailed description thereof that follows may be better understood, and in order that the present contribution to the art may be better appreciated. There are, of course, additional features of the invention that will be described hereinafter and which will form the subject of the claims appended hereto. Those skilled in the art will appreciate that the conception upon which this disclosure is based may readily be utilized as a basis for the designing of other structures for carrying out the several purposes of the invention. It is important, therefore, that the claims be regarded as including such equivalent construction as do not depart from the spirit and scope of the invention.

A specific embodiment of the invention has been chosen for purposes of illustration and description, and is shown in the accompanying drawings, forming a part of the specification, wherein:

The sole figure is a longitudinal cross-sectional view of an embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the drawing, a housing **1** defines a hermetically sealed chamber and a microscope **2** is fixedly mounted on top of the housing **1** so that a specimen **0** may be observed through a viewing window **3** formed in the upper wall of the housing. Impression loading means **5** for depressing a pressing member **4** against the specimen **0** is also mounted on top of the housing **1** but at a location remote from the microscope **2**. Beneath the housing **1** there is evacuating means **6** which is communicated with the interior of the housing **1** through a vacuum valve **7**. Adjacent to the evacuating means **6** is a gas cylinder **8** which is connected to the interior of the housing **1** through a gas cock **9**. By these means, the hermetically sealed chamber within the housing **1** may be selectively made into a vacuum atmosphere and a desired gaseous chamber.

For moving the specimen **0** from its position corresponding to the microscope into a position corresponding to the pressing member **4**, there is provided a rotatable bed **10** in the lower portion of the housing **1**, and moving means **11** for moving the test surface of the specimen **0** is provided on the rotatable bed **10**. Between the uppermost portion **12** of the moving means **11** and the apertured surface of the housing **1**, there is interposed an O-ring **13** to maintain a gas-tight seal therebetween. A support member **14** for carrying the specimen is fixed to the portion **12** of the moving means **11** and it extends downwardly obliquely within the hermetically sealed chamber and then vertically downwardly through the center portion of the moving means **11**. The support member **14** is tubular, having a bore **14***a* formed therethrough so as to extend complementarily to the outer configuration of same. The upper end of the bore is opposed to the microscope **2** and the lower end leads to the exterior atmosphere. The downwardly oblique and then vertically downward formation of the bore permits smooth passage of water therethrough without leaving any residue. The upper end of the support member **14** carries a sample holder **15** which is in the form of a cylinder open at opposite ends. The upper end of the holder **15** holds the specimen **0** thereon in non-gas-tight manner. The holder **15** further holds a sample heating furnace **16** thereon. The lower end of the holder **15** is fixed to the support member **14** in a gas-tight manner and may be cooled. The holder **15** is an elongated cylinder formed of material such as stainless steel having a low heat conductivity and a good heat resistance so that the heat loss from the upper to the lower part of the holder may be reduced thereby to increase the heating efficiency of the specimen. A nozzle **17** for injecting a coolant against the specimen extends from the exterior of the chamber through the bore **14***a* into the interior of the holder **15**, to such an extent that the upper end of the nozzle is closely adjacent the inner side of the test surface of the specimen. Coolant delivery means **18** is connected to the nozzle **17** through a cock **19** and a delivery pipe **20** so that when the cock **19** is opened, coolant may be injected against the inner side of the test surface and then flow downwardly through the bore **14***a* for discharge to the exterior atmosphere.

A cap **21** is provided to close the lower end of the cavity in the support member **14**, and this cap, together with an O-ring **22**, also serves to seal the bore **14***a* and nozzle in a gas-tight manner with respect to the exterior atmosphere.

The use and principle of the described device will now be discussed. First, the specimen **0** is set on the holder **15** and an unshown thermocouple for measuring the temperature of the specimen is positioned so that the hot contact thereof is point-welded to the surface of the specimen while the cold contact is led out of the hermetically sealed chamber **1** and connected to a thermometer (not shown). Subsequently, the cap **21** is placed to cover the lower end of the bore **14***a*, and the evacuating means **6** is operated with the gas cock **9** closed and the vacuum valve **7** open, whereby the hermetically sealed chamber **1** is evacuated to a vacuum condition and accordingly, the interior of the holder **15**, the bore **14***a* and the interior of the nozzle **17** are all similarly evacuated because of the non-gas-tight relationship between the specimen **0** and the holder **15**. When these various parts are all evacuated in this way, the vacuum valve **7** is closed and the gas cock **9** is opened to admit a predetermined gas from the cylinder **8** into the hermetically sealed chamber **1** and thereby increase the internal gas pressure to a level higher than the atmospheric pressure (usually 1), whereafter the cap **21** is removed while the gas is continually introduced into the hermetically sealed chamber so that all the amount of gas present in the chamber may pass through the clearance between the specimen **0** and the holder **15** into the interior of the holder **15** and further into the bore **14***a* and finally exhaust into the exterior atmosphere. Thus, no air can enter the hermetically sealed chamber. The described admission and discharge of the gas may take place either before or after the specimen is heated. When it is desired to quench the test surface of the specimen and observe the variation occurring in the structure thereof, or measure the hardness of the test surface, the hermetically sealed chamber may be made into a non-oxidizing atmosphere of argon gas or the like, and the specimen heated to a predetermined temperature, whereafter the moving means **11** is moved to bring a desired point on the test surface into the view field of the microscope **2** so that the structure of the test surface at that point may be observed. At the same time, the nozzle **17** and the coolant delivery means **18** are connected together by the delivery pipe **20** and the cock **19** is opened to pass and inject the coolant through the nozzle **17** against the inner side of the test

surface of the specimen **0** thereby to quench the specimen to a predetermined temperature, whereupon the supply of coolant to the specimen and the power supply to the heating furnace **16** may be adjusted to maintain the specimen at the predetermined temperature. The adjustment of the cooling rate may be selected over a wide range depending on the thickness of the sample object, the type and temperature of the coolant, the rate of injection of the coolant and other factors.

Where a very high cooling rate is desired, water may be used as coolant. The water, having flowed through the sample holder **15**, is directed downwardly through the bore **14***a* due to gravity and is discharged into the exterior atmosphere, while the steam produced by the water is also carried away through the bore by the argon gas flowing from the chamber **1** into the specimen holder **15** through the clearance between the specimen **0** and the holder **15** so that the steam is discharged into the exterior atmosphere without flowing back into the chamber **1** to oxidize the test surface. Thus, the test surface of the specimen may be protected against oxidation even after quenching and variations caused in the structure of the test surface by the quenching and subsequent heating can be observed.

Where the specimen **0** is to be further subjected to a very low temperature cooling treatment known as subzero treatment, liquid nitrogen or very cold nitrogen gas may be used as the coolant supplied by the coolant delivery means **18**, and such coolant is injected through the nozzle **17** against the specimen to maintain the same at a very low temperature. If the hardness of the test surface at the point observed is to be measured, the rotatable bed **10** will be rotated to bring the test surface into alignment with the pressing member **4**, whereupon the pressing member **4** is lowered to form an impression or recess in the test surface and then raised again, whereafter the test surface is returned to its initial position within the field of view of the microscope **2** so that the impression or recess formed in the test surface may be measured to obtain the hardness thereof by means of the microscope.

The present invention results in such excellent advantages as will be described hereunder. Through very simple steps of operation, namely, evacuating the hermetically sealed chamber, continuously introducing a charge of gas into the vacuum chamber, supplying power to the heating furnace to heat the specimen and supplying coolant thereto, the specimen can be continuously subjected to a series of thermal treatments such as heating, quenching and very low temperature cooling without its test surface being oxidized and without the need to mount and remove the specimen in the course of operation, and the variations caused in the structure of the test surface at any desired point thereof can be microscopically observed. Moreover, the specimen, which is small in size and relatively simple in shape, is very easy to make and quite readily attached and removed with respect to the holder. In addition, the excellent heating efficiency of the specimen makes it readily possible to obtain a quenching temperature for almost any material forming the specimen; and water or other fluid of great cooling power can be freely chosen as the coolant to obtain a very high cooling effect. This is turn enables substantially all practical alloys to be subjected to quenching experiments. For example, in case of ordinary carbon steel (such as JIS SK5) which is one of the most unquenchable alloys, if a value less than 1 mm. is chosen as the thickness of the test surface of the specimen and water chosen as coolant, then a martensite structure in the form of bamboo leaves will be observed on the test surface as the result of quenching down from 900° C. The thickness of 1 mm. also serves to provide a considerably uniform temperature distribution over the test surface not only during the high-temperature heating but also during the quenching process, and therefore the temperature variations as measured by the thermocouple are fairly in accord with the temperature variations at various regions of the test surface, which means that it is possible to study the relationship between the cooling rate and the structural variations. Further, since the 1 mm. thickness allows crystal grains to grow sufficiently large and cubic, the structural variations resulting from the described quenching may be considered in connection with the structural variations resulting from the ordinary quenching practised with ordinary parts, and thus more practical research can be pursued. Furthermore, the device of the present invention may be applied to a high-temperature hardness meter as shown in the drawing, whereby it is possible to measure the hardness of the varied structure. Also, by placing the sample object in a crucible and mounting the crucible on top of the holder **15**, it wil be feasible to melt the sample object and quench and solidify the molten material through the crucible.

I believe that the construction and operation of my novel device will now be understood, and that the several advantages thereof will be fully appreciated by those persons skilled in the art.

I claim:

1. A device for quenching and cooling a specimen to low temperatures in a high-temperature microscopic viewing system in which the specimen placed within a hermetically sealed chamber is heated and the test surface thereof is observed with the aid of a microscope from outside the hermetically sealed chamber through a viewing window, said device comprising:

a cylindrically shaped specimen holder open at opposite ends and adapted to carry the specimen on top thereof with a clearance therebetween;

means for introducing a non-oxidizing gas at greater than atmospheric pressure into the interior of said hermetically sealed chamber;

means effecting communication between the interior of said holder and the exterior of said hermetically sealed chamber while maintaining a gas-tight seal with respect to the interior of said hermetically sealed chamber;

a specimen heating furnace supported in said hermetically sealed chamber to surround the specimen; and

means located in said communication means for passing a coolant from the exterior of said hermetically sealed chamber to the inner side of the test surface of a specimen mounted in said holder;

whereby the coolant is injected against the specimen to quench the specimen to very low temperatures, and the non-oxidizing gas introduced into said hermetically sealed chamber passes through the clearance between the specimen and said holder into the latter and further to the exterior of said chamber to thereby prevent the atmosphere within said holder from flowing back into said chamber and enable the specimen to be heated, quenched and cooled to low temperatures without the test surface thereof being contaminated.

2. A device according to claim **1**, wherein said means effecting communication between the interior of said holder and the extrior of said hermetically sealed chamber is a tubular member.

3. A device according to claim **2**, wherein said coolant passing means includes an elongate nozzle extending through said tubular member to a point adjacent said specimen holder.

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