ICE Devices

How to use the BB Board to demonstrate the nanoscale properties of metals.

The material that follows shows you how to use a BB Board to demonstrate the nanoscale properties of metals. It assumes that you are starting with a pre-assembled BB Board. [The publication ICE Devices gives you directions for *making* as well as *using* BB Boards and 10 additional tools. All these tools for the science classroom are inexpensive and easy-to-build. ICE Devices is available from ICE (see page 3).]

20 min

The BB Board

By Ron Perkins, Illustrations by Robert A. Shaner

Complex structures are understood better by using simple concrete models. The BB Board helps to show the atomic structure of solids. It can illustrate various types of crystal defects and can be used to demonstrate annealing, hardening, and tempering of steel.

Presentation: The Heat Treatment of a Bobby Pin

Materials

__ *2 steel bobby pins*

__ *Bunsen burner*

__ *tongs*

__ *1/2 cup water*

__ *BB Board*

I. Annealing

Procedure:

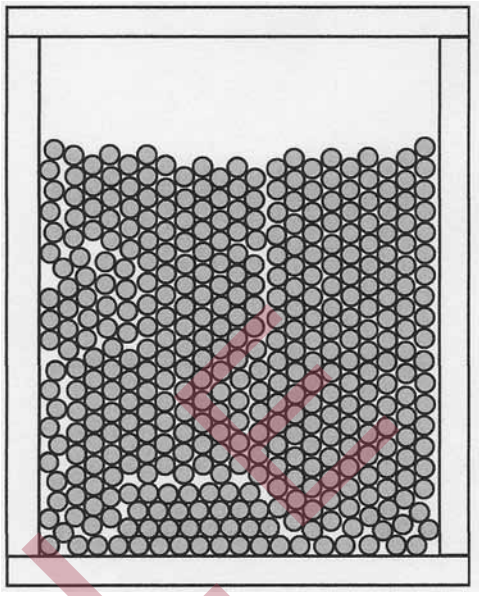
1. Heat the bent end of a steel bobby pin to a red-hot temperature in a Bunsen burner flame.
2. Remove the bobby pin from the flame and allow it to cool slowly.
3. Spread the ends of the cooled bobby pin. They will stay apart. The bobby pin is no longer springy.

Explanation: Heating to a red-hot temperature causes the metal atoms in the bobby pin to move faster and more freely. Slow cooling allows the atoms to adopt a more ordered arrangement causing a more perfect crystal of iron to form. The more perfect the crystal of a metal is, the easier it is to bend the metal because the atoms can "slide" past one another more easily.

This process of thermal treatment of a metal is called **annealing**. An example of annealed iron is wrought iron, which is easily bent into decorative railings.

BB Board Representation: Place the BB Board on the stage of an overhead projector and project the image of the BBs onto a screen. Explain that the BBs represent atoms of the iron. To represent heating of the bobby pin, slide the board rapidly from side to side. The BBs should shuffle into a random arrangement. To represent the slow cooling of the annealing process, decrease the rate at which you slide the board, moving the board back and forth ever more gently, watching the order develop. It may help to raise one end of the BB Board slightly.

It is common to see "holes" and a few "defect lines", as in the figure at right. The defect lines are seen because order develops with different orientations in different sections of the board.



II. Hardening

Procedure:

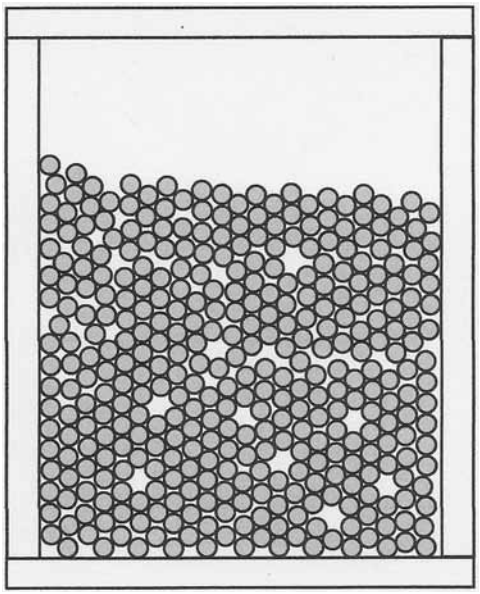
1. Heat the bent end of a steel bobby pin to a red-hot temperature.
2. While it is red-hot, quickly immerse it into water.
3. Spread the ends of the cooled bobby pin. It breaks.

Explanation: Quick cooling of the red-hot, fast-moving, iron atoms freezes them into a disordered phase with many defects. The many small areas of order, separated by defect lines, do not allow the atoms to move past each other easily. In fact, breakage can easily occur along these defect lines. A **hardened** metal is hard, but brittle.

Knives keep a sharp edge because they are made from steel which has been hardened. They often break, however, when used for prying.

BB Board Representation: To represent the fast cooling of the hardening process, rapidly slide the BB Board back and forth to produce a random distribution, as in part I above. Then stop suddenly.

You should see many "holes" and "defect lines". When a hardened piece of metal is bent far enough, it will break along these defect lines.



BB Board showing the disorder of atoms in hardened metal.

II. Tempering

Procedure:

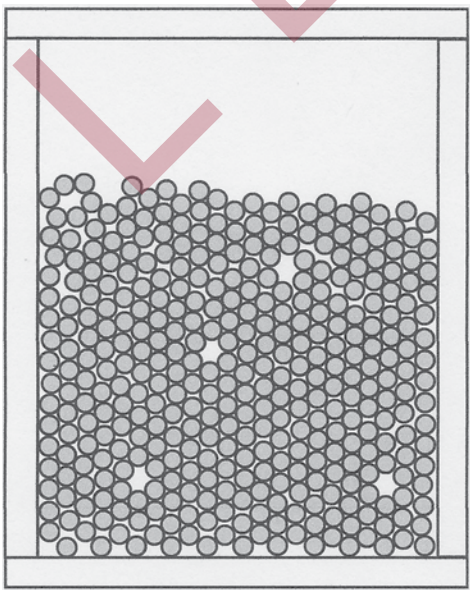
1. Slowly lower the bent end of a **hardened** steel bobby pin into an area about 10 cm above the flame of a Bunsen burner. Heat it until an iridescent blue oxide coating is observed.
2. Remove the bobby pin from the flame and allow it to cool slowly.
3. Spread the cooled bobby pin and release. The metal should spring back.

Explanation: The process of gentle heating from the hardened phase is called **tempering**. This process introduces more order into the crystalline structure, somewhere between the annealed and hardened phases. The metal becomes springy.

Bobby pins and springs are made from iron that has been tempered.

BB Board Representation: To represent the gentle heating of the tempering process, start from the random distribution of the hardening process. Gently slide the BB Board back and forth until you see a few areas of order develop. Then stop.

You should see several areas of order separated by "defect lines". The degree of ordering of the iron atoms in the tempered phase is intermediate between the hardened and annealed phase.



BB Board showing the ordering of atoms in tempered metal.

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