



DUPLICATING EARTH PRESSURES

Prof. Percy W. Bridgman, of Harvard University, with his apparatus for producing pressures like those of the earth's interior. At the right is the high-pressure apparatus, while his hand rests on the lever for twisting the samples when they are compressed.

PHYSICS

New Pressures Make Ice Hotter Than Boiling Water

Million Pounds to the Square Inch Attained at Harvard With New Apparatus; New Substances Created

DISCOVERY of two kinds of ice, one of them hotter than boiling water, a number of previously unknown forms of metals and other substances and a change in the properties of soft graphite so that it temporarily becomes diamond-like and capable of scratching glass-hard steel was announced at Harvard University by Prof. Percy W. Bridgman, as a result of recent high pressure research. (*Physical Review*, Nov. 15)

The discoveries were made with the aid of radically new apparatus which enabled Dr. Bridgman to conduct routine experiments at a pressure of 50,000 atmospheres and upon occasion to reach the tremendous pressure of 1,000,000 pounds to the square inch or 70,000 times the ordinary pressure of the atmosphere.

Formerly routine tests were confined to about 12,000 atmospheres and the absolute maximum was about 40,000 at-

mospheres, at which point the heavy steel sides of his confinement chamber bulged like lead and made measurements impossible.

At these terrific new pressures, higher than scientists have ever been able to reach before, Dr. Bridgman has been able to force atoms and molecules of some substances to take up permanently new positions, thus creating new forms of matter previously unknown to science.

In addition to the new apparatus for these pressures, Dr. Bridgman has also used a new tool for the creation of terrific stresses to "twist" the various atoms and molecules into their new positions, which has cast new light on the so-called shearing laws of solid matter. These unusual pressing and twisting tools are believed to approximate much more nearly than has been done before the tremendous pressures and strains

hundreds of miles below the surface of the earth.

Already three new kinds of solid bismuth have been found, one new kind of mercury, one of gallium, two of tellurium and a number of others, Dr. Bridgman announced.

Moreover, Prof. Bridgman found that under high pressure plus twisting:

1. Rubber was derubberized into a translucent horn-like material.
2. Paper was similarly transformed.
3. Wood and linen cloth were changed in comparable fashion.

Must be Twisted

Control tests on paper, Prof. Bridgman adds in his report, indicate that the 700,000 pounds to the square inch pressure will not, of itself, cause the transformation. The twisting or torque is also necessary.

A new kind of hot ice was described by Prof. Bridgman to a Science Service representative. "Previously five kinds of ice were known," he said. "One of these may be heated to a temperature too hot to bear with the hand if enough pressure is applied to prevent it from melting. The lowest pressure that would suffice to cause this previously known hot ice to appear was about 6,000 atmospheres.

"It is now found that there is still another variety of 'cold ice,' and also a new 'hot ice.' The old hot ice can be forced to change into the new hot ice if a pressure of about 25,000 atmospheres is applied to it. This new ice is hotter than boiling water when it melts, and it may be made to melt at much higher temperatures merely by increasing the pressure."

Dr. Bridgman continued:

"The increase in pressures, which can be reached as a matter of routine and measured with accuracy, has been made possible primarily by the use of new materials for the containers and pistons and a new design. By the new design the steel is made to support itself, the supporting pressure on the outside of the container automatically becoming greater as the internal pressure becomes greater.

70,000 Atmospheres

"This is accomplished by making the container in the form of a conical stopper, which pushes more and more tightly into an external heavy block of steel as the force on the piston increases. With this apparatus, routine measurements up to 50,000 atmospheres have been made for a number of months and pressures up to 70,000 have occasionally been reached.

"The new tool for studying matter

under high stresses is a development quite distinct from that just described. For this study the matter is squeezed in the form of a very thin disk between steel pistons, and then the pistons are rotated, so as to apply a shearing force in addition to the pressure. This shearing force has been found to produce interesting effects, . . . in combination with the pressures, which run up to 50,000 atmospheres.

"Permanent changes are produced in many organic substances. Rubber loses its elasticity after going through this treatment and becomes a translucent horny material; paper is similarly affected. It is necessary to do the twisting to get this effect, for high hydrostatic pressure alone will not give it. Brom thymol blue, a very soluble dye, becomes completely insoluble after this treatment. Red phosphorus is converted permanently into black. The electrical resistance of some metals was found to be abnormally high under this treatment."

Surprised

Lead dioxide was next tried, on the theory that the color change between lead oxide and the dioxide might be noted. Reported Prof. Bridgman:

"To my great surprise lead dioxide detonated violently, leaving a residue of metallic lead."

The first attempt at synthesis was the combination of copper and sulfur, said Prof. Bridgman, adding: "The results were at once positive; there was a detonation at pressures of 20,000 atmospheres (280,000 pounds to the square inch) without rotation, and the product was apparently the ordinary black sulfide."

Some of the explosions were so great that half of the steel pistons used in creating the pressure were blown away.

"Up to date," Prof. Bridgman added, "nearly two hundred elements and inorganic compounds have been examined, and new forms found in nearly half the cases. It is obvious that these polymorphic transitions, as these changes are called, are very much more frequent under high pressures than under ordinary conditions. They must play an important part in the constitution of the earth."

Required Force Great

"It is found that the force required to shear practically all substances under high pressure is very much greater than would have been expected from previous ideas. What is more, the possibility of internal slippage is so diminished that a number of substances which are normally soft may become harder than glass-

hard steel in certain directions and produce deep scratches in the steel.

"This is shown particularly well by graphite, which under ordinary conditions is so soft and slippery that it makes an excellent lubricant. In a special apparatus this was subjected to a pressure as high as 100,000 atmospheres, or one and a half million pounds per square inch. Under these conditions it

became so hard that it embedded itself in the glass-hard steel just as a diamond would have done. There was no permanent change, however, although a change to diamond might have been looked for because diamond is a denser form of graphite, but on release of pressure the graphite resumed its normal soft slippery state."

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ASTRONOMY

Expanding Universe May be Just Scientific Imagination

THAT the earth is near the center of an exploding or expanding universe may be just a false concept built up in the mind of man, suggests Prof. Fritz Zwicky, of California Institute of Technology.

When scientists interpret the much-observed red shift of the light from distant nebulae as proof that the separate parts of the universe are rushing away from one another with velocities as high as 15,000 miles a second, they are making only one of several possible interpretations, says Prof. Zwicky.

The California mathematical physicist points out that (*Physical Review*, Nov. 15) while the theory of relativity partially explains the red shift in terms of an expanding universe the relativity predictions are not in accordance with observation in several important respects.

The red shift of light from distant nebulae is analogous to the lowering of the pitch of a sound like that from the whistle of a locomotive speeding away from the observer at the crossing. In both cases the shift is one toward lower frequencies: for the whistle it is sound frequencies; for the expanding universe concept light frequencies are concerned. Lower light frequencies make the observed rays from the distant nebulae more reddened than they really are. The colors are not necessarily red in the observed spectral lines, but merely shifted in the red direction,—hence the so-called red shift.

In his complex mathematical scientific paper Prof. Zwicky sets up all the requirements which any explanation of the observed red shift must satisfy in order to be acceptable.

For one thing, Prof. Zwicky observes, the shift ought to come out to be the property of any point in space instead of

just that particular corner of the universe around the earth.

"We do not want to assume that our earth is just the center of things," warns the scientist. "The relativity explanation of the red shift satisfies this requirement but so do other theories."

In other requirements the relativity explanation does not meet observed conditions but Prof. Zwicky, in his report, shows how to examine broadly all possible theories and has found, surprisingly, that some theories meet all demands and may be as good as, or better, than, the relativity explanation of the red shift.

The selection among the possible alternative theories must be left to checking by observations. Some of these require new developments in astronomical technique such as the installation of the new 200-inch telescope at Mt. Palomar for the California Institute of Technology. A few years should tell the tale; and in the meantime Prof. Zwicky suggests that his colleagues avoid what in everyday jargon might be termed "getting out on a limb."

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ENTOMOLOGY

Argentina Has Ground Its Locusts and Plowed Them In

LOCUSTS, ravaging crop pest in Argentina, are being put to use in the rescue of the very fields they have stripped. Their bodies, harvested by tons from long lines of sheet-iron "locust fences," are ground up for fertilizer and plowed back into the soil. Between 2,000 and 3,000 tons of locust fertilizer are expected to be produced in Argentina this year; there will even be some for export.

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