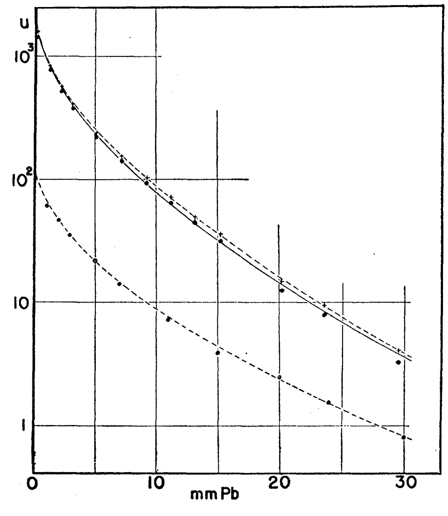

FIG. 1. Absorption curve of the outer bremsstrahlung. The dotted curve above is the experimental absorption curve of the radiation of RaE, when surrounded with a platinum radiator. The results of actual measurements are marked by crosses. The other dotted curve is the experimental absorption curve of the inner bremsstrahlung. The black circles represent the difference between the measurements marked by crosses and the corresponding values of the inner bremsstrahlung absorption curve. Accordingly, the black circles represent the experimental measurements of the absorption of the outer bremsstrahlung in lead, while the *theoretical* curve is the full curve on the figure.

energy between k and $k+dk$ to be emitted by the action of any beta-ray of RaE, at any time of its run.

Now having the spectral distribution of the outer bremsstrahlung for a platinum radiator, we can easily determine quantitatively the absorption curve of that radiation in lead, as we did for the inner bremsstrahlung.

The comparison with the experimental data is made in Fig. 1. *The agreement is good, within the limits of an admitted error of a few percent.*

It should be emphasized again that the comparison is here, as previously, both qualitative and quantitative.

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December 15, 1939.

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[1] E. Stahel and J. Guillissen, J. de phy. et rad. (in press).

[2] W. Heitler, *Quantum Theory of Radiation* (Oxford, 1936), p. 165, formula 16.

[3] F. Flammersfeld, Physik. Zeits. 38, 973 (1937).

New High Pressures Reached with Multiple Apparatus

It has been suggested a number of times that hydrostatic pressures of any magnitude could be obtained with a nest of pressure vessels, one within the other, exposed to progressively higher pressures. The practical complications of such a scheme are, however, obviously great. By the partial use of such a scheme, in which the most vulnerable part of the pressure vessel receives external support, I have been able to extend useful measurements to 50,000 kg/cm^2.[1] This note reports a more complete application of the idea, which has made it possible to reach pressures considerably higher.

The gain in doubling the pressure apparatus may be considerably more than double because of the increase in intrinsic strength under high hydrostatic pressure. This was clearly foreshadowed by the experiments of Griggs,[2] who found that the crushing strength along the c axis of a single quartz crystal was increased from 22,000 to about 120,000 kg/cm^2 by a confining pressure of 20,000 kg/cm^2. I have now applied to a Carboloy piston without fracture a compressive stress of between 200,000 and 250,000 kg/cm^2. The crushing strength of Carboloy under normal conditions is not more than 70,000 kg/cm^2. The confining pressure was afforded by bismuth undergoing transition, so that the confining pressure was automatically kept at about 25,000 kg/cm^2. Under ordinary conditions Carboloy is highly brittle, and breaks with practically no plastic deformation, but under a confining pressure of this magnitude the Carboloy piston was plastically and permanently shortened by 5.5 percent, and considerably bent, with no perceptible cracks or other obvious damage. Glass-hard steel under the same confining pressure similarly shows an increase of compressive strength and very considerable plastic deformation, and also an appreciable increase of compressive strength at atmospheric pressure after the cold working afforded by the plastic deformation while supported. I have verified Griggs' observation of the great increase of the strength of quartz single crystal under a confining pressure of 25,000, applying without fracture compressive stresses of the order of 150,000. The strength in the c direction is greater than at right angles, as was also found by Griggs. The effective Young's modulus appears to be increased at this stress by something of the order of 25 percent. Quartz glass has its strength increased by something of the same order as the crystal. Quartz glass compressed in this way ruptures on release of pressure into characteristic disks perpendicular to the axis of compression, and Mr. Griggs finds that optical anisotropy has been developed, indicating some permanent plastic flow. He finds no optical anisotropy in any fragments of quartz crystals ruptured at high pressures.

A "one sided" compressive stress in a piston may be converted into an approximately equal hydrostatic pressure in a thin disk of softer material compressed by the end of the piston, lateral extrusion of the soft material being prevented by friction. In this way I have applied a hydrostatic pressure of between 200,000 and 250,000 kg/cm^2 to a thin plate of single crystal graphite at room temperature with no conversion to diamond. This extends the negative result beyond the pressure of 100,000 kg/cm^2 which I have already reported.[3] Since the pressure of thermodynamically reversible transition is according to the most recent[4] thermodynamic evidence not far from 20,000, it is probable that no pressure, however high, will accomplish the conversion at room temperature. This is suggested by the theory of Tammann, according to which the speed of formation of nuclei of a new phase at first increases as pressure is increased beyond the thermodynamically reversible transition point, but then passes through a maximum and drops again.

The experiments just described were mostly performed in my apparatus for 50,000 kg/cm^2, support being usually afforded by bismuth in transition, but sometimes by lead. My apparatus for 30,000 affords opportunity for support by a true liquid, for experiments on a somewhat larger scale, and for measurements of greater precision and complication. In this apparatus several exploratory measurements have been made on materials confined in a small cylinder of $\frac{1}{16}$ inch bore and $\frac{7}{16}$ inch outside diameter, compressed by a $\frac{1}{16}$-inch Carboloy piston. The cylinder of the 30,000 apparatus contains in addition to the transmitting liquid (iso-pentane) and a manganin gauge for measuring pressure a large block of bismuth, the function of which is to maintain pressure in the supporting liquid at 25,000 during the transition, during which the motion of the main piston, 0.5 inch in diameter, is approximately 0.1 inch. The initial quantity of liquid is so chosen, after preliminary trial, that the 0.5-inch piston makes up on the $\frac{1}{16}$-inch piston at the moment that the transition pressure of bismuth is reached. The pressure on the $\frac{1}{16}$-inch piston is then given roughly by the excess pressure on the 0.5-inch piston. In this way I have observed at pressures estimated to be between 125,000 and 150,000 kg/cm^2 an elastic volume compression in NaCl of something over 20 percent. The compression at 50,000 is known to be 13 percent,[5] and the relation deviates markedly from linearity. It is therefore probable that NaCl has no transition with important volume change to the CsCl type of structure, unlike the rubidium and potassium salts, and as predicted by Jacobs[6] on theoretical grounds. Sulfur has also been compressed to approximately the same pressure with about 30 percent loss of volume, and no irreversible change to a more metallic form, which is to be looked for in analogy with black phosphorus. Incidentally the possibility of reaching pressures so high in a cylinder of the above dimensions means an increase in strength of the cylinder for internal pressure (that is, in tension) markedly greater than would be accounted for merely by the additive effect of the supporting pressure of 25,000.

Finally, preliminary exploration shows the feasibility of using inside the 30,000 apparatus and supported by uniform hydrostatic pressure, a miniature double container, supported by an external cone in the same manner as now employed in my 50,000 apparatus, with resulting further increase in the range of controllable and measurable hydrostatic pressure.

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January 18, 1940.

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