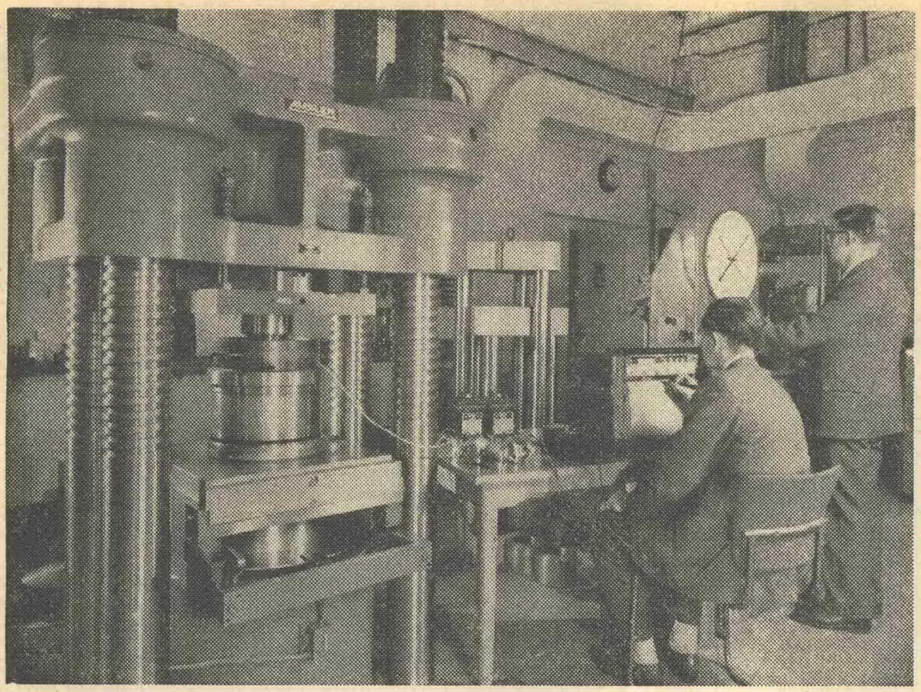

Tetrahedral anvil apparatus in use by members of the Basic Physics Division, National Physical Laboratory, for measurements on semi-conductors to pressures of 100,000 atmospheres. (Photograph by permission of the Director, NPL.)

called borazon, was also made for the first time in the General Electric Research Laboratory by use of high pressure and temperature in the "Belt" apparatus. In this case the optimum values quoted for these are 55,000 atmospheres and 1,500° C with, as in the synthesis of diamond, the use of a catalyst to increase the rate of the process and the yield. The most effective catalysts reported were lithium and magnesium in the form of nitrides Borazon has a hardness comparable with diamond and has promise as an abrasive material.

A third new substance first made by high-pressure techniques in the laboratory is a new form of crystalline silica which is 15 per cent denser than quartz. It is called coesite after its discoverer Coes, who worked in the Norton Abrasive Co., Worcester, Massachusetts. This material was unknown as a mineral before its discovery in the laboratory, but has been reported in the last year as being found in the crater of a large meteorite, where its synthesis is plausible in the temporary conditions of pressure and temperature prevailing.

Before closing this section on materials which have been made, it is perhaps worth emphasizing the difference in history between diamond and coesite. Diamond, because of its outstanding physical properties in nature, was vigorously pursued as a laboratory product. In contrast, the existence of coesite was demonstrated by laboratory experiment and then sought in nature.

There seems to be no doubt that there are fascinating possibilities of creating a whole new range of substances. These will range from laboratory curiosities of interest only to the physicist, like coesite, to new substances of technical value, where the high-pressure modification can be quenched and become available for use in ordinary conditions even though not thermodynamically stable. In the first category we have a possible metallic modification of hydrogen which it is calculated might exist above 400,000 atmospheres. Study of this substance would be of great theoretical interest in understanding the metallic state as it was brought into being from atoms whose properties were well understood.

Forecasts about technical materials are much harder to make, but a few pointers can be given. Subjecting a solid to very high pressures increases the degree of order by decreasing the volume available between crystals and for imperfections. It might therefore be used to promote the growth of more nearly perfect crystals, with consequent improvement in electrical and mechanical properties. The former could be of great importance in the technology of semi-conducting materials. There is already some evidence that subjecting steel to high pressure will make it stronger. Since this effect should operate throughout the bulk of the material, it may be an alternative to hardening by the usual heating and quenching process where conduction of heat confines the hardening to surface layers. Finally, polymerization of simple molecules by the use of pressure alone may give rise to a new family of plastics.

The Basic Physics Division of the National Physical Laboratory has this year started a new research programme on extremely high pressures. This may be considered as having three branches. First, an existing programme of research in pressure measurement is being directed to the high-pressure range. Second, work has been started on physical measurements of samples at pressures up to 100,000 atmospheres, with particular emphasis on optical properties. And lastly, a start has been made on some high-pressure syntheses.

Let me at this point anticipate a question. Is it really necessary to emphasize so strongly the need for physical measurements? Now that we know how to make high-pressure apparatus, if we want new substances why not just go ahead, try a few things in the apparatus, and make them? In reply, let me remind you of the history of diamond. When, after careful study and measurement, it was realized what was really required in the temperature and pressure conditions, success followed quite soon. In a way diamond was a favourable case to start with because nature, by giving the diamond such outstanding properties, drew attention to what was possible. In the less spectacular cases we will first have to look for what we want to make, and measurement of physical properties while the pressure is applied will make this easier. We may then need to go on to study the kinetics of the system to see if the properties can be "quenched in" and give us something new to use at ordinary pressures.

Looking ahead, it may not be too much to hope that one day there will be available a revised catalogue of chemical substances. Their chemical composition may be familiar, but, because they exist as unusual phases, their physical properties may not be. This may be compared with the advent of technical nuclear chemistry, when chemically familiar atoms became available as isotopes with widely different and useful physical properties. This subject of very high-pressure synthesis is a new one, offering great scope for original work by physicists, chemists and engineers.