on materials and equipment, the design and supply of special measuring apparatus, replacement parts for machinery and small precision tools, and about half the time of the Laboratory has been spent on similar work for Government Departments. Major investigations during the year included vacuum-pressure impregnation of timber with synthetic resins, the moulding of plywood, the thermal efficiency of open-hearth fires and the design and construction of micro-wave meteorological radar. In addition to its butter-fat investigations, the Fats Research Laboratory has used a molecular still of novel design for the preparation of fish liver-oil concentrates. In addition to vitamin analyses, the Plant Chemistry Laboratory has conducted a successful trial of new hormone weed-killers. Work under the Plant Research Bureau included an extensive breeding programme for garden peas and field peas, as well as for barley and other field crops. A vegetable research section was established, and the Botany Division made further surveys of vegetation and extended its collections of agar seaweed and of carrageen (Irish moss). The Grasslands Division carried out further work on pedigree strains of pasture species, blind-seed disease of rye-grass and soil conservation, while in addition to therapeutic testing the Plant Diseases Division studied tree-tomato mosaic, lettuce mosaic, halo-blight of beans, and soil disinfection. An investigation was also commenced on boron and its relation to the incidence of yellow leaf.

PHOTO-ELASTIC INVESTIGATION OF INTERNAL STRESSES IN SILVER CHLORIDE CAUSED BY PLASTIC DEFORMATION

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INTERNAL stresses in cold-worked metals cannot be investigated fully by means of X-ray diffraction because in most cases the stresses vary considerably in distances comparable with the cross-section of the X-ray beam. For this reason, X-ray methods can indicate only the presence and magnitude of internal stresses, but not their distribution in space. A more powerful and direct method of approach is provided by the photo-elastic effect in transparent crystals. Cubic crystals are particularly suitable, since they are optically isotropic when unstressed; the magnitude and orientation of their birefringence, and its distribution over the crystals, thus give a direct picture of the distribution of internal stress. There is no reason at present for supposing that the plastic deformation of transparent crystals differs fundamentally from that of other crystalline substances, and one may reasonably expect that results derived from experiments on such materials will also be applicable to metals.

Since December 1946 a series of observations has been made on polycrystalline silver chloride, a material that is transparent, cubic in structure, and also very ductile. Rolled sheets, of thicknesses from 0·3 to 1 mm., supplied by the Harshaw Chemical Company of Cleveland, Ohio, showed patches of birefringence when placed between crossed nicols. These patches disappeared when strips cut from the sheets were recrystallized by heating for two hours at 400° C. and cooled slowly. (The melting point of silver chloride is 455° C.). Subsequent plastic deformation of such flat strips gave patterns of birefringence of which an example is shown in Fig. 1. This photograph was taken in white light between the crossed nicols of a polarizing microscope after unloading the strip; the polarization directions of the nicols are horizontal and vertical. Light areas indicate residual stresses. The pattern is not coloured because, with sheets of this thickness, the path differences due to the stress birefringence are smaller than the wave-length of light. The average width of the grains is large compared with the thickness of the sheet. Most of the grains are crossed by one, or sometimes two, sets of light and dark bands, similar to those observed in transparent single crystals by Brewster[1], by Reusch[2], and by Obreimow and Schubnikoff[3]. They appear to be the result of deformation by glide or by kinking[4]. Other interesting points are visible: for example, plastic distortion in grain *A* has evidently contributed to the stress pattern seen in the neighbouring grain *B*. When an external stress is applied to the strip the grains lighten and the progress of further plastic deformation can be watched. (I gave a demonstration of these phenomena at a conversazione held by the Royal Society on May 29, 1947.) A small portion of another strip is illustrated in Fig. 2, also photographed between crossed nicols; several intersecting sets of bands are shown. In Fig. 3 a grain boundary *XX* separates two grains, each of which is crossed by a particularly sharp set of birefringent bands, produced in this case by bending. The polarization directions of the nicols are again horizontal and vertical. If the nicols are turned through 45° the light stripes become dark and the contrast of the pattern is much reduced. Such observations combined with the use of a compensator make it possible to calculate the distribution of stress within the bands.

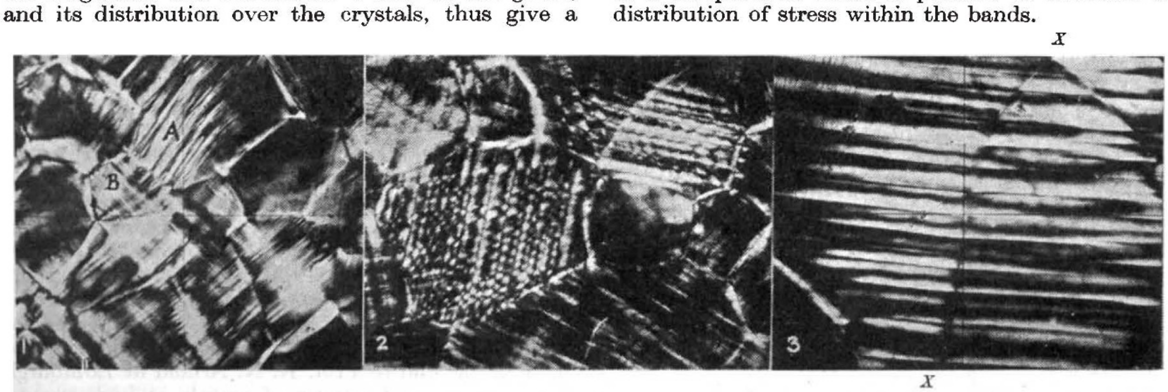

Fig. 1. × 13 Fig. 2. × 25. Fig. 3. × 41

Bands of a very similar nature have been reported in diamond by Raman and Rendall[5], and investigated in detail by Ramachandran[6]. These authors attribute the bands to the stresses set up in alternate layers of diamond having two different lattice spacings. It would be interesting to know whether they are not really the consequence of plastic deformation.

Examination of a plastically deformed strip of silver chloride that was annealed in stages shows that heating near the melting point causes a gradual reduction of the intensity of the picture, but leaves the pattern unaltered. We may conclude that, during annealing, there occur no large-scale migrations of dislocations, but only localized processes of atomic rearrangement.

Although they are optically isotropic when unstressed, cubic crystals under stress behave differently from glass and the usual plastics used in photo-elastic tests. The crystal classes T_d, O, O_h require not two but three constants to describe their photo-elastic behaviour, and, as has recently been pointed out[7,8], the T and T_h classes (also in the cubic system) require four. This fact makes the full interpretation of the stress birefringence pattern dependent upon a knowledge not only of certain combinations of these constants, but also of the crystallographic orientation of the grains concerned. It also leads to a striking phenomenon observed in the elastic stress range: when a bending moment is applied to an annealed strip, viewed either between crossed nicols or in a circular polariscope, the grain boundaries are seen to flash out brightly. The effect is completely reversible; if the load is removed the light regions return to their original dark state. The explanation seems to be that, when the bending moment is applied, the light passing through a grain traverses a layer of tension on one side of the strip and a layer of compression on the other side. The birefringence of the two layers cancels out, and the total path-difference between the two oppositely polarized rays will be zero. However, grains with different crystallographic orientations will have different stress-optical constants; consequently, whenever a grain boundary is not perpendicular to the sheet, rays crossing the boundary will pass through different grains on the tensile and compressive sides, and the total path difference will not vanish. In contrast to the grains themselves, therefore, the grain boundaries will be lightened. A more exact mathematical treatment of the effect is possible and its results are supported by other observations, but the above argument contains the essence of the explanation. Such bending moments cause the lightening seen at some of the grain boundaries in Fig. 1.

A fuller account of these and other photo-elastic experiments on plastically deformed materials, carried out with the financial support of the British Iron and Steel Research Association, will be published elsewhere. I am greatly indebted to Dr. E. Orowan for suggesting the possibility of using transparent, polycrystalline materials in the way described and for discussion of the results.

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SCIENTIFIC RESEARCH AND INDUSTRY

SIR EDWARD APPLETON'S address to the Scottish Council (Development and Industry) at Glasgow on February 13 on "Science and the Progress of Industry" will increase the impatience with which the scientific and industrial world awaits the resumption of publication of the annual reports of the Department of Scientific and Industrial Research. Indeed, it could well be held that here again, as in the recent speech at Letchworth of the Lord President of the Council (see *Nature*, February 7, p. 214), by using a speech to a sectional or limited audience, which even in normal times could only be imperfectly reported in the Press, as the occasion for important announcements of policy or disclosure of developments, the Government is showing lack of courtesy to the scientific man and to the industrialist. Such statements should be put on permanent record in a proper fashion. Whatever may be the rights and wrongs of any policy—for example, the present dispute between the Government and the medical profession—it is to be hoped that the Government will learn that it is wiser to court than to flout the expert and professional experience upon the co-operation of which the smooth running of so many Departments of State depends. As Burke once remarked in another connexion, magnanimity in politics is not seldom the truest wisdom, and little minds go ill with a great State department or with a great Empire.

After a tribute to the work of Scottish men of science in the past, Sir Edward suggested that for an overall picture of the pattern of the scientific effort in Great Britain, it is useful to think of its three great sections—research in universities and technical colleges, Government research and research in industry itself—as being situated at the three corners of a triangle and thus linked directly together. He believes that the first task is to foster fundamental research in universities and technical colleges, where the really revolutionary industrial advances usually have their origin. Such fundamental research knows no national frontiers, but Sir Edward paid here a further tribute to the Scottish contribution, before referring more specifically to the essential contribution of the geologist to those problems of making the best use of familiar materials and of developing in the national interest materials so far regarded as economically useless. The Scottish Branch of the Geological Survey was always ready to help, but the problems of application involved belong to other branches of science. If the inquiries now being carried out by the Scottish Council revealed gaps in the facilities available for research, the Department of Scientific and Industrial Research would always be ready to consult with the Council as to how they could best be filled.

Before dealing with the work of the Department itself, Sir Edward indicated a few of the special grants made to workers in the Scottish universities; for example, to Prof. P. I. Dee in Glasgow and Prof. N. Feather in Edinburgh for work on nuclear physics, to Dr. C. Horrex at St. Andrews for work on the relative speeds of the decomposition of certain organic compounds, to Prof. G. D. Preston at Dundee for work on the development and use of the electron microscope, and to Prof. R. N. Arnold at Edinburgh for work on the cutting of metals at high speeds.