acute housing shortage has heavily underlined the importance of building research, and quite justifiably it has been decided that building research should have a national laboratory to itself, in accordance with the recommendations made by a Building Research Committee at the end of 1943. A Building Research Unit set up in May 1947 is at present working with a skeleton staff in two hangars loaned for the purpose by the University. The Unit has been carrying on useful investigations into soil stabilization and has already obtained important results on the treatment of lime sludges from sugar factories, on cheap houses and on various problems connected with brick-making. It has also published a few brochures on low-cost housing and village housing.

For an institute devoted to building research, Roorkee was the obvious choice. A suitable 10-acre site on its eastern border has been leased by the University of Roorkee to the Council of Scientific and Industrial Research for housing the Institute. The Council has also purchased from the Defence Ministry an S.W.P. hangar (floor space about 3,500 sq. yards), and this is eventually to house the Institute's engineering division and its workshop.

The Board of Scientific and Industrial Research has made provision for a capital expenditure of Rs. 16 lakhs for the Institute, to be spread over a period of three years, and for an annual recurring expenditure of Rs. 4.25 lakhs.

The Institute will undertake research on building materials, on engineering and structural aspects of buildings and their foundations; on problems of comfort in buildings and their durability and the speed of construction. Its activities will naturally include basic research and fundamental studies, such as X-ray investigations and differential thermal analysis of clays and their electro-chemical and rheological properties, strains and stresses in structures and comfort in buildings. It will afford facilities for training men for diverse types of construction and help in the creation of a body of trained men in India.

The functions of the Institute include: (1) examination of building materials in common use and the methods of applying them with the view of economy and improvements; (2) examination of new materials and processes evolved at the Institute and elsewhere; (3) scientific diagnosis of the causes of failures in materials themselves or in their application; (4) dissemination of useful information and fostering the growth of a scientific spirit and outlook in the building industry in India; (5) preparation of standards of materials and codes of practices for various aspects of building construction.

From a slightly different point of view, the subjects of research may be grouped into three main categories: (i) efficiency of buildings, which includes problems like heating, lighting and ventilation; (ii) properties of materials used in buildings, such as cement, plaster, bricks; and (iii) structure and strength of materials.

Dr. J. N. Mukherjee, a distinguished soil chemist, hitherto working with the Indian Council of Agricultural Research, has been appointed director of the new Institute.

Pandit Jawaharlal Nehru, addressing a large gathering on the occasion of the laying of the foundation stone, said that housing is one of the most pressing problems of India. Millions of houses are needed and it would be futile to expect the Government to construct them. "The resources of the Government may be limited, but the resources of the people should never be limited." He disapproved of the attitude of those who looked towards the Government for "parental" help in everything; "the British Government might have acted in this way, but with the achievement of independence people must learn to be self-reliant". Pandit Nehru stressed that manual work must not be looked down upon. He expressed the desire that by the time he visited Roorkee next the students would have constructed some building with their own hands. He added he had seen such things done in the United States and had been impressed by them.

Sir Shanti Swarup Bhatnagar, director of Scientific and Industrial Research, Government of India, said that the eleven national laboratories are only the first stage, and that some further laboratories were already under active consideration. In particular, funds have been provided by industry for a silk and rayon research centre. A national laboratory for electronics and another for atomic energy are also needed.

Laying the foundation stone, the Hon. Mr. Sri Prakasa remarked that in India great attention has been paid in the past to houses for gods, and it is time now to attend to comfortable housing of the common man. Mr. Hart, vice-chancellor of the University of Roorkee, and Dr. Mukherjee, director of the Institute, also gave addresses.

INTERNAL FRICTION OF SOLIDS

THE Physical Society (Acoustics Section), the Institute of Metals and the British Iron and Steel Institute held a combined meeting on March 15 at 4 Grosvenor Gardens, London, W.1, at which ten speakers discussed theoretical and practical aspects of the internal friction of solids.

Prof. A. H. Cottrell (University of Birmingham) opened the proceedings with a survey of generally accepted views on the main causes of internal friction or loss of energy during the vibration of solids. For the sake of brevity he did not discuss friction associated with the magnetostrictive properties of ferromagnetic metals, and for the four main causes he outlined: friction due to the ordering of solute atoms; friction inside single crystals arising from the movements of regions of disarray, that is, of dislocations; thermo-elastic friction due to thermal currents between adjoining crystals; and friction accompanying slip along grain boundaries. The first two occur in both single crystals and in polycrystalline solids, but the other two are restricted to the latter.

The idea of damping due to the ordering of solute atoms was first conceived by Snoek[1], a typical case occurring when the carbon (or nitrogen) atoms which are dissolved interstitially in α-iron, that is, a crystal normally of the body-centred cubic type, diffuse under vibratory stress to positions between pairs of α-iron atoms in the line of stress from positions between orthogonal pairs. For carbon in iron this diffusion process has a time constant τ of about a second at room temperature. This type of contribution to friction has for its main characteristics: a maximum damping for vibrations of angular frequency ω, where $\omega = 1/\tau$, and a variation with frequency according to the usual relaxation law, that is, it varies as $\omega\tau/(1 + \omega^2\tau^2)$; independence of amplitude; anisotropy, since it varies with the inclination of stress direction to crystallographic axes; and temperature sensitivity with an exponential law corresponding to heat of activation of about 20,000 calories/mol. in the case of carbon in α-iron—this is identical with the activation energy for the diffusion process. Damping investigations in the above category have proved invaluable in providing data on rates of diffusion, equilibrium solubilities and rates of precipitation after quenching or cold working. In the latter case, the mechanism is a little different, involving diffusion to dislocations, a process investigated by Cottrell and Bilby[2] and Harper[3].

Thermo-elastic damping, continued Prof. Cottrell, arises from the heat flow between regions differentially heated by vibratory stress. A time constant $\tau (= x^2/D)$ is involved, where x is the separation of the regions and D is the thermal diffusivity. This type of damping occurs in vibrating reeds and, more commonly, in polycrystalline specimens; on account of the anisotropic nature of the crystals, heat flows across the boundaries in this case. It has the following characteristics: the damping has a maximum for $\omega = 1/\tau$ and follows the usual relaxation law; it is independent of amplitude and insensitive to temperature; and it is dependent on grain diameter x or reed thickness x because these change the time constant τ. Slip along grain boundaries, a creep phenomenon, gives rise to damping and has been thoroughly investigated by Kê[4]. The characteristics of this type of damping are: independence of amplitude; the maximum damping is much larger, half the energy being lost per cycle, than for the other causes discussed above, but this value is substantially independent of frequency, grain size and temperature; and the damping follows broadly a relaxation law with a time constant proportional to $x \exp H/\mathbf{R}T$, H being the heat of activation associated with grain-boundary creep.

The last of the four main causes of friction discussed by Prof. Cottrell was that arising from the movement of regions of disarray, that is, of dislocations inside single crystals. Such behaviour has been investigated by Read[5] and his school in the United States using high frequencies of 10–100 kc./s. It is intimately related to plastic processes going on inside the crystal grains and is extremely sensitive to cold work, the damping increasing from 10^{-5} to 10^{-2} on occasion due to mishandling. The main features of this type of friction are: damping is much reduced by annealing, hydrogen annealing of copper being especially efficacious; damping increases rapidly with strain amplitude; even at low strain amplitudes, metals such as zinc show hysteresis effects but aluminium and copper do not; copper damping is little affected by frequency, but with zinc damping decreases with frequency (Marx and Koehler[6], however, report that copper damping may show a minimum at 20–30 kc./s.); at about room temperatures, Nowick[7] finds an exponential increase in damping with temperature, whereas Bordoni[8] reports maximum damping at about 1/3 Debye temperature on metals.

The next speaker, Dr. J. D. Eshelby (University of Bristol), thought that the problem of damping due to motion of dislocations could conveniently be split into three parts: the detailed mechanism of resistance to motion, dynamics of motion, and means of dissipating energy. For the first, among other possibilities, either dislocations may be regarded as moving in potential wells produced by internal stresses or as being anchored in the neighbourhood of impurity atoms. When a dislocation moves, the stress in its neighbourhood is influenced by the whole previous history of the motion, so that the equation of motion may differ widely from that of a Newtonian particle. Many processes for dissipating energy can be visualized, but their calculation is difficult. One of them, termed 'microthermoelastic' damping, is calculable[9]. A moving dislocation possesses a varying stress field which gives rise to a varying temperature distribution near by and causes damping of Zener's[10] thermo-elastic type, as already described by Prof. Cottrell. Until more is known concerning competing effects, the importance of this mechanism cannot be assessed.

Dr. G. Leibfried (University of Göttingen) first discussed internal friction caused by the motion of dislocations; he thinks the velocity v may be related to the external shear stress X_{ij} through an equation of the form:

$$mv = X_{ij}\lambda - \alpha v,$$

where λ is the distance between nearest neighbours in the lattice, α a frictional constant and m the equivalent mass, the region considered lying between adjacent atomic planes normal to the dislocation line. Making very rough approximations, the value of the frictional constant α arising from thermal sound waves in the lattice can be calculated. The maximum value of the velocity v appears under normal conditions to rise to a tenth of the velocity of sound, and this seems also to hold at zero temperature for zero-point vibrations. Many other causes of loss may, however, be present—for example, radiation damping. Dr. Leibfried pointed out that stress caused by thermal sound waves might be very high, the root-mean-square value attaining perhaps 5 per cent of the shear modulus, so that it may far surpass any external stress which can be applied. It is to be expected that such stresses will greatly affect the behaviour of dislocations; they may enable obstacles to be overcome and so influence the elastic limit.

The work of Nowick[7] was further considered by Dr. F. C. Frank (University of Bristol). The fact that the elastic constant increment due to the motion of dislocations in a copper crystal is found to be $\frac{2}{3}$–$1\frac{1}{4}$ times the imaginary increment (that is, the damping component), the ratio being invariant with frequency or temperature, appears to rule out relaxation phenomena as the root cause, but a hysteresis phenomenon could be responsible. Dr. Frank discussed possible sources of hysteresis in dislocation movement, including a novel one stemming from the Frank–Read theory[11] of dislocation ring movement. He has calculated that such a ring, formed of a series of edge and screw dislocations joined by 'jogs', could expand even with strains of the order of 10^{-6}, for it appears that the energy required for movement with production of a vacancy (that is, about 1 eV.) or of an interstitial atom (that is, about 2 or 3 eV.) would be attained.

F. R. N. Nabarro (University of Birmingham) said that he has considered a number of mechanisms which will resist the motion of dislocations, in order to determine the applied stress under which the terminal velocity of a dislocation will reach about 70 per cent of the speed of sound. Above this stress the original avalanche processes of Frank can occur. It seems certain that this critical stress is greater than the stress applied to a single crystal in a creep test, but it may be less than the stresses applied to polycrystals during rapid deformation. The most important mechanisms of damping are those proposed by Leibfried[12], and the radiation of sound waves caused by the periodical changes in the form of the dislocation as it moves through the lattice. Leibfried's original estimate of the damping caused by the scattering of thermal vibrations involves a confusion of two mechanisms of scattering, one applicable to any imperfection of the lattice and one peculiar to dislocations. The resulting estimate is certainly too high, but this effect is obviously important.

Speaking about work done at the Royal Aircraft Establishment, Farnborough, by S. Pearson, G. B. Greenough and himself, A. D. N. Smith criticized Kê's theory[13] that the high-temperature 'background' internal friction of annealed metals is due to the presence of dislocations. Experiments show that single-crystal specimens have a greatly reduced background compared with small-grained specimens, and it seems more reasonable to suppose that the difference is due to grain-boundary behaviour rather than that dislocations give rise to very much higher damping when situated in polycrystalline metals than when situated in single crystals. The mechanism proposed by Mr. Smith and his colleagues is that creep occurs at the regions of stress concentration arising from stress relaxation along the grain boundaries at high temperatures. Kê's objection that the stress will be insufficient to cause slip is invalid, since an activated creep may occur at any stress. Experimental evidence of this relation of 'background' to creep is that, at high temperatures, and under minute stresses, wires with high 'background' creep both in torsion and stretching. Single crystals show no such creep.

Dr. K. M. Entwistle said that at the University of Manchester methods of measuring damping have been developed for very low-loss materials such as aluminium-rich alloys, so as to investigate damping during quench ageing from about 20° C. to elevated temperatures. Pains have been taken to reduce the equipment loss to well below the energy-loss figure of 2×10^{-5} per cycle, characteristic of these materials around 20° C. In connexion with Zener's proposed mechanism for damping arising from stress-induced rotation of pairs of solute atoms in certain face-centred cubic solid solutions, Dr. Entwistle thought it likely that, assuming initially random distribution of solute atoms in an as-quenched alloy (for example, aluminium–4 per cent copper), subsequent diffusion might permit localized concentration of copper so that the number of effective atom pairs would rise to a maximum and then decay. By investigating damping in these circumstances, since this will vary similarly, it is hoped to confirm this hypothesis.

At the British Iron and Steel Research Association, said E. Linacre, methods of measuring damping capacity are being developed as a tool for metallurgical research; in particular, grain boundary damping in isothermal transformations, since nucleation and grain growth both occur there in a non-martensitic phase change. The preliminary results on two different steels appear to show considerable damping capacity changes on transformation. Mr. Linacre deprecated the indiscriminate use of logarithmic decrement, Q^{-1}, tan δ and specific damping capacity to specify damping and advocated the use of the first.

K. J. Marsh reported on an investigation of damping in copper and certain tin bronzes which has been carried out at the British Non-Ferrous Metals Research Association using the Kê technique at 0·3–2 c./s. over a temperature range. On 'oxygen free, high conductivity' copper the results agree with Kê's results. Markedly different damping/temperature curves have been obtained for tin bronzes with 3, 6 and 9 per cent tin, but they differ little from each other and do not reflect differences found in their hot-working properties. The damping increases with amplitude for these alloys.

Finally, G. Bradfield referred to Nowick's work[7], pointing out that a dislocation has the qualities of a vector associated with a plane, that is, a uniform distribution of the same kind of dislocation has the nature of a six-rank tensor which is similar to an elastic constant. Such a distribution can alter the six-rank elastic-constant matrix, adding real and imaginary increments for sinusoidal stress conditions. In general, the symmetry will be reduced. The changes in velocity and the attenuation of waves due to the dislocation system will exhibit markedly anisotropic characteristics. Mr. Bradfield traced an interesting parallel between the frequency invariance and dependence on density of dislocations of damping due to the latter and the corresponding damping phenomena for foreign particles suspended in a liquid (see Urick[14]). He felt that it is not yet clear whether a dislocation represents a singularity in mass or elasticity or both. Reporting on work at the National Physical Laboratory, Mr. Bradfield said that, in addition to investigation of elastic constants of alloys, the Read technique is being extended to use quartz resonators for damping measurements up to 400 kc./s. An inductor system has been devised to determine damping on small disks weighing only 1 gm.

G. BRADFIELD

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"WHITE CORRIDORS"

HERE is a new film (produced by Vic Films and to be distributed by G.F.D.), commercially presented as having full "entertainment value" (running for 102 min.), which can be strongly recommended to men of science, medical men and educationists. It is now being exhibited at the Leicester Square Cinema, London, and will eventually be generally distributed.

The film is adapted from the novel "Yeoman's Hospital", by Helen Ashton, and the screen play is written by Jan Read and Pat Jackson. Though not a 'documentary' film, it portrays the running of a present-day general hospital. Here are depicted the workaday lives of resident surgeons and physicians, nurses and patients.

The professional medical man is not likely to find any fault with the method of presentation. The