whole of the geometric area is in intimate contact. Gross seizure occurs and ordinary sliding is almost impossible. The presence of small amounts of oxygen, however, enables sliding to occur and the friction is essentially the same as for surfaces prepared in the atmosphere.

The detailed effect of the surface oxide film depends upon the relative rheological properties of the oxide and the metal substrate. If the oxide is hard and the substrate soft, the condition is like a layer of ice on mud. Penetration takes place readily and good metallic contact occurs. The friction is high and the surface damage heavy. If, on the other hand, the oxide is ductile and can flow with the deformed underlying metal, it is better able to maintain its integrity. The friction and surface-damage may be small for moderate deformation; for sufficiently heavy deformations the surface film may be ruptured with a corresponding increase in friction and wear.

The behaviour of aluminium is of particular interest since the oxide is hard and the metallic substrate soft. Consequently, as we should expect, the thin natural oxide film offers little protection to the underlying metal. Some improvement may be obtained by artificially increasing the thickness of the oxide film by anodic oxidation. These films are, in fact, more resistant to rupture than the natural films. At small loads they maintain their integrity and the friction and surface-damage are small. With increasing load the films first fail in tension as a result of the tangential frictional forces produced during sliding. At greater loads gross disintegration of the film occurs. The frictional properties of the films depend on the surface roughness. In addition, their porosity may play an important part in trapping lubricant and so reducing the friction and wear in lubricated sliding.

Brittle Solids

The two main features of the theory of metallic friction are that cold welding occurs at the interface and that, because plastic flow takes place, the area of contact is proportional to the applied load. With brittle materials it would seem at first sight that neither of these conditions is applicable. A detailed study shows, however, that the local pressures around the individual regions of contact are sufficient to prevent brittle fracture and there is considerable *plastic* flow at the interface. As a result, although some surface fragmentation may occur, the behaviour is dominated by the plastic deformation of the surface layers. In addition, under the influence of high pressures and plastic flow, strong interfacial adhesion occurs. Consequently, the mechanism derived for metals is applicable; the friction is proportional to the load and of the same order of magnitude as for metals.

The high pressures existing at the points of real contact also play a very important part in boundary lubrication. The lubricant film which is sheared during sliding is subjected to pressures comparable to the yield pressure of the metal (for steel about 200,000 lb./sq. in.). Under these conditions, the resistance of the film to shear and penetration is enormously increased.

Plastics and Fibres

Other classes of materials to which the adhesion mechanism of friction may be applied are long-chain polymers, plastics and fibres. The deformation of these materials is not, however, as clearly defined as for metals. At high loads the area of real contact is roughly proportional to the load, so that Amontons's laws are obeyed. At light loads this is no longer so. The coefficient of friction is no longer constant but increases steadily as the load is reduced. Interferometric studies show that the deformation of the surfaces is more nearly elastic than plastic. The area of contact is no longer proportional to the load, and depends on the size and shape of the specimen and on the number of points of contact. Because of this, the friction across fibres may be very different from the friction along them. If the material shows visco-elastic properties, the area of real contact at a given load will increase with the time of loading and there is a corresponding time dependency in the friction.

These and other issues relating elastic, plastic and visco-elastic properties of materials to their frictional behaviour were discussed at a symposium convened by the British Society of Rheology on February 26, on "Friction in relation to Rheological Properties". Dr. L. R. G. Treloar presided and the three main papers were given by Dr. D. Tabor, on the "Effect of Some Physical and Rheological Properties on the Friction and Lubrication of Solids", Dr. H. J. Howell on "Friction and Surface Deformation in Fibres" and Dr. F. H. R. Wright on "Frictional Behaviour of Anodic Films on Aluminium Surfaces".

D. Tabor

SCIENCE IN THE UNITED STATES

THE sixth of the annual reviews produced by the British Commonwealth Scientific Office in North America, entitled "Science in the U.S.A. for the Year ended June 1953"*, follows much the same lines as that for the year ended June 1952, which was the first to be openly published (see *Nature*, **172**, 282; 1953). In its sections on the expenditure of the Federal Government on research and development, on industrial research and development, and on university and non-profit research, it draws extensively on reports issued by the National Science Foundation. A section on scientific and technological man-power is likewise based on two reports, "Student Deferment and National Manpower Policy" and "A Policy for Scientific and Professional Manpower", issued by the National Manpower Council; these are to be followed by a third, "A Policy for Technical and Skilled Manpower". The second of these reports estimates that, of the five millions now engaged in scientific and professional work, more than a million are teachers, nearly a million are engaged in medical and health services and more than half a million are engineers; but of 155,000 workers in natural science, about 15,000 are engaged in fundamental research. Shortages in different branches of science are regarded as qualitative as much as quantitative, and it is recommended that no attempt should be made to urge school leavers to turn to particular branches of study in conformity with a predetermined national policy. Instead, expansion over the whole field of higher education is suggested, so as to overcome the

* British Commonwealth Scientific Office, North America. The BCSO Review of Science in the U.S.A. for the Year ending June 1953. (United Kingdom Scientific Mission, Canadian Scientific Liaison Office, Australian Scientific Liaison Office, New Zealand Scientific Liaison Office, South African Scientific Liaison Office.) Pp. iv+44. (London: H.M.S.O., 1954.) 2s. net.

shortages without destroying the overall balance between different disciplines, and employment practices which cause inefficient utilization of professional man-power, especially in engineering, are deplored.

During the year, new restrictions were placed on the flow of unclassified reports from the Department of Defense, which is itself financing more than a third of all scientific research in the United States, and these are likely to impede the free exchange of technical information between the United States and other countries. On March 16, 1953, the two original documentation centres of the Department of Defense were amalgamated to form the Armed Services Technical Information Agency. This Agency is expressly forbidden to make even unclassified material available except for military purposes, and those engaged in defence research are entitled to receive material only in those subject categories for which they have proved a need. Furthermore, the Agency is not to undertake the direct collection of information from foreign sources or to disseminate information to foreign governments, their nationals or representatives. Much of the unclassified material is afterwards published; but now that the services provided by the Technical Information Division of the Library of Congress are no longer available to foreign countries, delays of twelve months or more may be experienced before such information becomes available. The report points out that direct exchange between institutions may now be the best avenue still open through the International Exchange Service at the Smithsonian Institution; this, however, is limited by the small funds available and the consequent necessity of using the cheapest form of freight transport, with delays normally of several months.

It is not too difficult, however, to obtain unclassified reports from some Federal departments. The Atomic Energy Commission has always fully implemented the charge laid upon it by the United States Atomic Energy Act "that the dissemination of [unclassified] scientific and technical information relating to atomic energy should be permitted and encouraged so as to provide that free interchange of ideas and criticism which is essential to scientific progress", and the report directs attention to the wide range of the physical and biological sciences covered by the publications of the Commission and listed in *Nuclear Science Abstracts*. Expenditure on the Commission's programme during the year ended June 30, 1953, is estimated at 4,000 million dollars, of which about 300 million was spent on research and development. Most of the section dealing with atomic energy in this report is concerned with the development of nuclear power for industrial or domestic purposes. In a statement issued on May 26, 1953, the Commission proposed interim legislation to permit non-government ownership and operation of nuclear power facilities, the use and transfer of fissionable and by-product materials under suitable safeguards, and the granting of more liberal patent rights than is possible at present. It also proposed to allow research and development on specific power projects to be undertaken in the laboratories of the Commission, and that a progressively liberalized information policy should be applied in the power reactor field. The objective of this policy is to further the development of nuclear plants which are economically independent of government commitments to purchase weapons-grade plutonium.

During the past year it has become evident that commercial rain-makers are losing business, but interest and activity in the physics of rain and cloud formation has greatly increased, with the growing realization of the importance of tackling fundamental physical problems first. Work continued on the theoretical and practical aspects of the use of radar in cloud detection and of radar echo-intensity measurements in the estimation of rainfall. The importance of coalescence as a mechanism in rain formation was increasingly appreciated, and the report notes a more positive attitude on the part of the United States Weather Bureau toward cloud seeding: experimental work was to start this spring in the State of Washington.

In radio astronomy, Ewen and Purcell's discovery of hydrogen-line radiation from outer space has not been followed up, although the Carnegie Institution of Washington will shortly bring into operation an extended Wurtzberg antenna, with Ewen-type receiving equipment. Practically no 'radio star' work has been done, but three prominent 'radio nebulæ' have been identified with astronomical objects that can be 'seen'.

On April 14, 1952, a complete table of assignments covering the very-high-frequency and ultra-high-frequency bands was released, and there is considerable activity in the development of ultra-high-frequency receivers. The design of the high-power output stage presents the most difficult transmitter problem; and in colour television, while the Columbia Broadcasting System frame sequential method is at present the officially authorized system, the door has been left open for any other system that can be demonstrated successfully.

Capital expenditure of the chemical industry during the year is estimated at 1,500 million dollars, and this includes plant capable of producing 30 million lb. of orlon a year; 50 million dollars for new plant in New Orleans for acetylene, ammonia and acrylonitrile, and expanded facilities for the production of aureomycin; a 1·8 million dollar plant for dextran, a blood plasma substitute; a 14 million dollar project for defluorinated phosphate, one by-product of which will be uranium; and 7 million dollars for a plant for phenol by the new cumene process. Plans were also announced to spend more than 700 million dollars on new plants in Texas, Louisiana, Oklahoma and Arkansas, and increasing attention is being focused on the study of water pollution and atmospheric pollution accompanying the establishment of heavy industries. Probably the most interesting development in the plastics field is the production of new semi-permeable ion-exchange membranes in two forms, which permit the passage of anions or cations, respectively; it appears most improbable, however, that the demineralization of sea-water by such processes will be economically attractive, but with brackish waters the position is more promising.

In fuel technology a final report from the National Petroleum Council maintains the view that neither the hydrogenation nor the Fischer–Tropsch process approaches a cost competitive with gasoline from crude petroleum at 12 cents per U.S. gallon; oil shale is the only alternative source that could be considered commercially. Sufficient progress is claimed with development of low-temperature fluidized carbonization for the design of a full-size industrial unit. Development work on the hydraulic transport of fine coal has been completed, and this

method is regarded as an economic proposition with a 12-in. bore pipe-line over distances of 50–200 miles. In building, the report notes the trials made with hydraulically operated back-acting diggers thought to be suitable for digging foundations and drainage trenches; with the 'vacuum-processing' of concrete and the 'vacuum-lifting' of concrete units; and with the Tournalayer system of building, in which the concrete shell of a house is cast at a central point on a building site, and then carried away and placed on its foundations.

In mechanical engineering, considerable interest has been stimulated in the hot-forming and machining and grinding of titanium alloys, and in electrical processes for shaping and finishing hard materials, and increased attention is being given to the characteristics of machined surfaces. There has been an enormous growth of research in applied mechanics, and growing interest is also noted among engineers in the science of management and in the application of operational research to management problems. In metallurgy the shell-moulding process has attracted further attention; but phenol – formaldehyde resins continue to be the only ones of industrial importance as binders when casting alloys of relatively low melting point like those of aluminium. The production of nodular cast iron continues to increase, and American foundries are now investigating the effect of adding cerium simultaneously with magnesium to neutralize the harmful effects of residual elements.

EUROPEAN PRODUCTIVITY AGENCY

FIRST ANNUAL PROGRAMME OF ACTION

THE summary of the first annual programme of action of the European Productivity Agency, published by the Organization for European Economic Co-operation, Paris, points out that a campaign to increase productivity sets both technical and psychological problems, the latter being the more difficult and important. Some of the sociological effects of technological advances may be wholly beneficial, but others, such as the need for the worker to adapt himself to new processes or new trades, may cause temporary individual problems and require careful study. Resistance to change is not confined to labour; and it is important for it to be known that, under European conditions, higher productivity in the long run means increased possibilities of employment and that any temporary risk of technological unemployment is far less grave than that facing a community which allows itself to fall behind others in the efficient use of its resources. With proper co-operation between management and labour, even technological unemployment can be avoided, if everything is done to increase the speed of adaptation to new tasks by improving vocational training and to facilitate mobility of labour by housing policy and efficient labour-exchange services.

As regards general policy, the summary indicates that the Agency aims at giving an initial impetus to groups which can show a reasonable chance of continuing and developing with fresh sources of support and at making these continuing projects self-supporting to the maximum extent. The programme is summarized under six main headings: specific economic and legal problems; technical and administrative problems of industry and commerce; human factors of management and labour; applied research and technology; food and agriculture; and information and general services. Under the second heading, action is contemplated to bring European management to a wider understanding of the need for management education, and the creation or development of chairs of business administration in European universities and technical colleges. Further research is also proposed on the factors determining the attitudes of employers and employees to the scientific study of the selection of workers and conditions of workers, and the pooling of experience and effort in training supervisors.

In applied research and technology, the Agency's task is essentially to supplement what is being done in existing institutions, to co-ordinate such research and to strengthen the liaison between research and industry—for example, by facilitating contacts for exchanges of information and views between those in charge of the organization and administration of research. An essential task will be to improve existing channels for disseminating technological information and the study and development of new media. The establishment and development of specialized research and information centres in the main industrial sectors will be encouraged, and special attention will be given to increasing technological productivity in the building industry.

The Agency's efforts to improve productivity in the field of food production and agriculture will be directed towards the study of the economic organization of the farm as a production unit; the factors of input in agriculture, horticulture and fisheries; the marketing and distribution of output; techniques in production processes in these fields; and the exchange of information and techniques of communication.

TRIBUTE TO PROF. ALEXANDER LIPSCHUTZ

THE combined second and third numbers of Vol. 3 of *Acta Physiologica Latinoamericana* contain a series of thirty-one essays by distinguished contributors, offered as a tribute to Prof. Alexander Lipschutz on his seventieth birthday*. The articles are variously written in English, Spanish, French, Portuguese and German. The first, by B. A. Houssay, is a laudatory biographical sketch of Prof. Lipschutz; the remainder cover a wide range of subjects—reproductive and general physiology, cancer, steroid chemistry, and numerous miscellaneous biological matters—in most of which Prof. Lipschutz has himself been an active investigator. To summarize all these interesting essays is not possible in this short review; to single out a few for special mention must place the reviewer in an invidious position. His own interests, not the excellence of the articles chosen, can be the only criteria of choice.

Prof. Lipschutz enunciated the law of follicular constancy in 1930, and two papers are directly concerned with this. M. and C. Aron discuss the nature

* *Acta Physiologica Latinoamericana*. Vol. 3, Nos. 2 y 3: Numero de Homenaje al Profesor Alejandro Lipschutz. Pp. vi+49-202. (Buenos Aires: Asociacion Ciencia e Investigacion, 1953.) n.p.