low pressures and for comparative purposes. Velikovskii uses the same method. He prefers to designate the consistency of grease by its 'mechanical equivalent', that is, the viscosity of an oil which requires the same force to produce an equal rate of flow under arbitrarily fixed conditions. Varentsov also calculates a shear modulus (γ) from Philippoff's⁸ modification of the Eizenschitz formula:

$$\eta' = \eta_{\infty} + \frac{\eta_0 - \eta_{\infty}}{1 + \frac{2}{3} \cdot \frac{P^2}{\gamma^2}}$$

where η' is observed viscosity; η_0 and η_{∞} are limiting viscosities at low and high shear rates; P is pressure.

There are also a number of useful technological papers on the rheology of greases. Rebinder, Boguslavskaya and Moki'evskii find that the yield-value is independent of capillary radius which serves as a useful criterion of consistency.

There has been considerable discussion between British and American rheologists on the nomenclature of consistency of non-Newtonian systems. Velikovskii proposes to use the term 'internal friction' (*Vnutrenn'e treni'e*) to describe the ratio of shear stress to rate of shear when this is not independent of stress or shear rate, but the symbol η is used for both this and (constant) viscosity.

The section on molten lavas, melts and slags is perhaps rather less interesting, the data consisting mainly of viscosity-temperature curves with little theoretical comment. Exceptions are papers by Volarovich, who discusses the relative merits of various viscometers for molten metals and silicates; Kozakevich, Leiba and Komar' (binary and ternary mixtures of FeO, CaO and SiO₂); and Semik, who studies the effect of addition of bases on the anomalous viscosity of surface layers of steel foundry slags. There are four good papers on the viscometry (mainly rotational instruments) of molten glasses: Fromberg, Tsyplénkova and Rabinovich; Oshchipkov and Rabinovich; Solomin; and Kumanin, Fizhenko and Zelichénok.

In the colloid section, there are two excellent papers on theoretical rheology by Finkel'shtein and Chursin, and by Rebinder; the former deals with extensions to the Einstein equation and the latter relates colloidal structure to types of flow curves. On the technological side, Branopol'skaya has a good paper on the rotation-viscometry of flour doughs, and Ravich gets a linear relation between η of high fatty acids and iodine number. There are also papers on the rheology of high polymers (Kargin and Slonimskii), casein (D'yachenko), bitumens (Korotkevich) and coal tars (Kustov and Khotuntsév). Kulakov is already known to rheologists interested in peat, and he contributes a paper on the relative merits of capillary, rotation and ball viscometers for this material. The first two methods are preferred to the ball. Serb-Serbina and Baranov have articles on the influence of electrolytes on the viscosity of clay suspensions.

In so brief a survey, one can do no more than sketch in the outlines of the contents of these books: many papers cannot even be mentioned. It is a pity that the whole proceedings cannot be translated into English. The conference undoubtedly marked a milestone in the progress of rheology, and it is to be hoped that when the War ends, language difficulties will not hinder a closer co-operation and under-

standing between British, American and Soviet rheologists as well as workers in the smaller countries.
G. W. SCOTT BLAIR.

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HEALTH RESEARCH IN INDUSTRY

THE health of the industrial worker has recently been the subject of a number of articles in the medical Press, and various aspects of it have been also discussed by medical societies. Attention has been directed to it by the endowment by the Nuffield Foundation of three university departments of industrial health; and the national importance of this field of study is further emphasized by the issue this year of two important publications. These are the second interim report of the Social and Preventive Committee of the Royal College of Physicians of London and the Medical Research Council's publication entitled "Health Research in Industry", which records the proceedings of a conference on industrial health held at the London School of Tropical Medicine during September 1944.

The report of the Committee of the Royal College of Physicians is part of this Committee's study of social and preventive medicine. Its first interim report dealt with the applications of this study in the hospital. This second interim report is the first step in the study of social medicine outside the hospital. As the *British Medical Journal* (194, Feb. 10, 1945) points out, this report fills a very obvious gap, because the Government's White Paper on national health does no more than state the present position of industrial health and does that in no more than one short paragraph and an appendix. If, says this second interim report of the Royal College of Physicians, the Government's plans for the establishment of a sense of social security are to succeed, industrial production must be efficient; and efficient production requires contented workers, and they cannot be contented unless they are physically and mentally fit. A third of the working years of most workers is spent in the places where they work, and their working and home life affect each other so profoundly that each individual's whole life must be considered.

This Committee prefaces its recommendations by a useful outline of the development of British industrial medicine. Existing industrial medical services apply only to a small proportion of industrial workers at their places of work. It is in the smaller factories that it is usually difficult to maintain good working conditions. Factory inspectors, both lay and medical, have done magnificent work, but four hundred inspectors (including the sixteen medical ones) and the two hundred whole-time and seven hundred part-time works doctors cannot adequately supervise the health of the 250,000 establishments covered by the Factories Act of 1937. The Factories Acts do not

apply to many industries and to others only certain sections of them apply. Some large businesses and some transport services (for example, railways and docks) have their own works doctors; but medical services are most deficient outside factories where they are needed most. Existing services are not adequately co-ordinated. Control is shared by the Home Office and Ministry of Labour, while the Ministries of Supply and of Fuel and Power have their own independent medical services, and other new Ministries may create theirs. A national comprehensive industrial medical service is required; it should be organized on a regional basis as an essential part of the national health service, with ultimate responsibility vested in the Ministry of Health, although certain administrative and executive functions would no doubt have to be allocated to the Ministry of Labour and National Service, the Ministries of Fuel and Power and of War Transport and the General Post Office. The Committee hopes that the Government will not adhere to its temporary exclusion of industry from its national health scheme, which lays a just emphasis on the family as a unit for medical care and extends medical care to the home as well as to the place of work.

Everyone will agree with this Committee's strong plea for much better medical care for smaller industries, such as hotels, restaurants, shops, offices, the building trade and agriculture; and for recognition of the fact that occupational disability and disease cause only a fraction of the total illness of the workers, who lose about fifteen times as many working hours as the result of non-industrial sickness and accident as they lose from industrial causes of disability; this estimate excludes, moreover, the considerable effects of subnormal health. Much preventable disease is due to factors operating outside the place of work, such as bad housing, economic stress and lack of health education. Continuous medical investigation is necessary and the co-operation of the management is important. Rehabilitation, which has figured largely in the medical Press recently, is emphasized by this Committee, which strongly supports the Government's White Paper on Workmen's Compensation (Cmd. 6551), which would do much to establish rehabilitation as part of the national health scheme.

In its discussion of the planning of the education of medical men for industrial health work the Committee refers to its first interim report, repeating that the medical student is not expected to become an expert on occupational diseases, but should understand the social problems involved and should recognize the effects of fatigue, overwork, monotony and other factors causing ill-health in industry; he should therefore visit factories and should have good and bad working conditions demonstrated to him. Here the reader of this report is reminded of the Goodenough Report on Medical Schools (*Nature*, 154, 315 and 322, Sept. 9, 1944). The family doctor should, the Committee of the Royal College of Physicians thinks, be trained as a part-time industrial medical officer, and periodical refresher courses on this subject should be available for him. More extensive training is planned for whole-time industrial medical officers; this should not be too specialized and should not be taken until two years after graduation and after one year of general practice. Consultants and specialists should be subject to the criteria for the recognition of consultants and specialists laid down by the three Royal Colleges.

The section on research with which this report concludes links it with the Medical Research Council's publication mentioned above, which outlines the development of the Industrial Health Research Board of the Medical Research Council. The Committee of the Royal College of Physicians commends the work of this Board and its parent organizations and wishes that work to continue. The Board should, this Committee thinks, tackle problems of national significance and also problems which cannot be undertaken by other research organizations. Fundamental research should not be neglected; it should be done by the university departments of industrial health which are now being created, and these should correlate their work with that of the Industrial Health Research Board and with that of the local factory department. Co-ordinated with all these there should be, in each local administrative area set up under the national health scheme, a division for field investigation.

The work of the Industrial Health Research Board was reviewed at the conference mentioned above by Sir Edward Mellanby, secretary of the Medical Research Council. Sir Edward commended another review of it by Dr. Schelling in the *British Journal of Industrial Medicine* (1, 145; 1944). Reconstituted in 1942 by the Medical Research Council, the Industrial Health Research Board was given the study of the whole field of industrial medicine and disease, and it is expected that it will act in an advisory capacity in relation to all the problems being studied by the Medical Research Council itself. The Medical Research Council has organized much work on industrial health. During the War much research has been done for all the Fighting Services, and many of the principles learned during this work can be applied to industry. As examples of this application Sir Edward referred to the work done on blood transfusion, on traumatic shock, and on the problem of fitting men to the machines which they have to use and of fitting the machines to the workers.

The problem of recording causes of sickness absence in industry is fundamentally important. The Industrial Health Research Board's Report No. 85 (1944) deals with this problem, while Report No. 86 (1945) records a study of certified sickness absence among women in industry. Certified sickness absence for two or more days was studied in five munition factories, but uncertified sickness absence, which may or may not be genuine, was excluded. Other reports on this subject are to follow and they will include the views of the workers themselves. Other problems being studied are night work, atmospheric pollution in filling factories, new methods of sampling T.N.T., the efficiency of dust-sampling instruments, lighting problems and the incidence of psychoneurosis. Another example of the work of the Medical Research Council which has valuable applications to industry is the valuable report recently issued on the treatment of burns and scalds (Med. Res. Council Spec. Rep. Ser., No. 249, 1944. H.M. Stationery Office, 4s. net). This work records the conclusions drawn from observations made during recent years by the Medical Research Council's Burns Unit working at Glasgow Royal Infirmary. Another unit is working at Birmingham on infections to which injured industrial workers are liable.

The work of the Department for Research on Industrial Medicine, which was set up at the London Hospital by the Medical Research Council, was described to the conference by its director, Dr. Donald Hunter, who also edits the *British Journal of*

Industrial Medicine. An article by Dr. Hunter on industrial poisons was reviewed in *Nature* of April 1, 1944, p. 412; but Dr. Hunter pointed out that industrial poisons form only a relatively small part of the field of industrial medicine. His department is also studying the effects of inhalation of asbestos and other dusts, the 'dead hand' from which users of pneumatic tools often suffer and the effects of some of the appalling industrial noises, such as that which has made generations of boiler-makers deaf. Dr. Hunter also discussed rehabilitation, pointing out that many jobs can be done by men with chronic disease of the heart, lungs and nervous system and quoting Henry Ford's remark that there are more jobs in industry for men with one arm than for men with two.

The views of enlightened managers were given to the conference by Lord Forrester, managing director of the Enfield Cable Works, Ltd., and a distinguished worker in industrial and social fields, who emphasized the importance of a healthy environment for the workers and of a right integration of industry with the community to which it belongs. Research into management and the teaching of management are also required. Research teams composed of young men are essential and Lord Forrester suggested problems for them. One of these is the problem of posture in industry. The position of the operator is considered in the construction of tanks and aeroplanes, but surprisingly little attention has been given to it in industry. In the discussion which followed Lord Forrester's address, Sir Wilfrid Garrett, chief inspector of factories, told the conference that a committee has recently been appointed to study this problem. Lord Forrester thought that we need a better system of keeping industrial health records. We should abandon all systems of calculating working time in hours per day or week; we should think in terms of at least a year. Shift work is another problem requiring study; the worker should have the right kind of food, and time and leisure to eat it in suitable surroundings. Sanitation and hygiene are of high significance; yet the very important question of lavatory design is almost universally ignored. The town planner, the industrialist and the industrial health expert must get together to study the problem of the environment of industry itself. The smoking chimney and similar sins must go. Loss of green sward has important effects on the health of the people. Industry need no longer disfigure the land, or pollute its atmosphere and rivers; nor need its physical appearance be an abomination.

The point of view of the trades unions was put to the conference by Mr. G. A. Isaacs, general secretary of the National Society of Operative Printers and Assistants and president of the Printing and Kindred Trades Federation, chairman of the Workmen's Compensation and Factories Committee of the Trades Union Congress, and a member of the Royal Commission on Workmen's Compensation. He pointed out that the trades unions have studied industrial health for many years and gave examples of the improvements which they have achieved by their own efforts. He did not wish it to be thought that he was complaining about the work of the Home Office and Factory Department of the Ministry of Labour, which had, he insisted, done good work and had often acted when the Trades Union Congress had little information; but they had not the complete research organization which the trades unions con-

sidered essential. Research should have ample money, staff and equipment. Eradication of industrial health risks was required, not mere recognition of and compensation for them. Prompt, accurate and scientific decisions were required as to what were and what were not occupational diseases; such decisions should not be subject to argument in a court of law. The worry caused to workers by industrial injuries had been revealed in conferences called by the trades unions. Workers would always willingly help research. Mr. Isaacs suggested that more work was needed on the effects of industrial fumes and dusts, on ventilation and lighting, on the effects of monotony, fatigue and noise and on the risks of welding. He stressed, as Lord Forrester also did, the need for communicating the results of research to the workers themselves in language which they could understand.

At the final session of this conference Dr. K. J. W. Craik described the work of the Cambridge Unit of Applied Psychology, of which he was director until his untimely death on May 7. This Unit has been studying problems arising from the needs of the Services, but some of the principles learned during this work can be applied to industry. There are, for example, the problems of suiting the job to the man, suiting the man to the job and improving performance. The problem of suiting the man to the job includes the study of the design of machinery and instruments and their lay-out and illumination by maps, panels and so forth. The position, forces and gear ratios of handles, levers and other forms of control are being studied, together with methods of getting the best results in jobs of a boring but responsible nature. The effects of fatigue, discomfort and noise and the intellectual aspects of industrial work also need study. This Unit has attached to it an Industrial Research Board team which has devised tests of mechanical ability and of performance and other qualities; it is studying night vision, the capacities of blinded officers, problems of the special senses and temperamental differences in the ability to control machinery. For the study of the improvement of performance it has invented devices which will be useful in industry after the War. A new type of recording system has been invented for the tracing of causes of absenteeism, sickness and accidents, and this is being established in a group of coal mines and in two factories. This Unit hopes for the collaboration of the National Institute of Industrial Psychology and other bodies doing similar work and with managers, safety officers and medical men. The Unit has a scheme by which factories send to Cambridge representatives who can be trained there to study their problems in their own factories.

It will be clear from this brief summary of the contents of the important publications mentioned that carefully thought-out plans exist for the amelioration and eventual eradication, wherever this is possible, of industrial health risks. It is evident that the workers will help industrial health research by every means in their power and that the medical profession and many managers are no less eager to solve this national problem. Not the least important of its many aspects is the one to which Sir Edward Mellanby referred. Much valuable information was obtained in the interval between 1918 and 1939, but this information was largely left unnoticed until the present War began. Then its value became widely recognized and industrial health research is now considered essential. Sir Edward warned

us that this may be only a war reaction. We must, he insisted, see to it that all who are concerned with industry do not cease, after the War, the efforts they are now making to create an efficient industry based on the health and contentment of the industrial worker.

G. LAPAGE.

USE OF TREES AND SHRUBS AS FOOD FOR CATTLE

IN many parts of the British Empire, the feeding of excessive numbers of low-grade stock has become a serious problem, not only for the forester but also for the agriculturalist. In an article in the *Indian Forester* (Civ. and Milit. Gazette, Lahore, Dec. 1944), J. A. Wilson, of the Madras Forest Service, discusses the place of fodder from trees and shrubs in the "Agricultural and Forestry Economy of Madras", a problem to which many of the newly founded soil conservation committees in the Colonies and elsewhere will have to give serious consideration.

It has been the practice in India in the hot-weather season and during serious famines to look to the forest for fodder for the villagers' often large herds of a very low type of cattle; the animals browsing on the trees, shrubs and young regeneration. "In common with the rest of India," Mr. Wilson writes, "the cattle population of Madras is excessive; especially is this so in dry areas and areas of reserved forest, where cattle of low efficiency and little value can eke out a living at extremely low cost. . . . The concentration of scrub cattle in such areas, combined with the extension of agriculture to absorb waste lands, previously at the disposal of the cattle, has resulted in the complete denudation of grass cover over vast areas, except during the relatively short monsoon period. In the reserved forest of the dry districts also, the pressure of the grazing animals is high, and marginal areas are for the most part badly overgrazed. While the agriculturalist provides for his utility animals during the hot weather he cannot afford to do so for his scrub animals. From February onwards therefore they have to depend on whatever cheap fodder they can pick up." From March onwards trees and shrubs put on new foliage, and the forest by the dual acts of browsing and lopping has to suffer to keep this low-grade stock alive.

It has long been the aim and the policy of the forest officer in India to bring to an end this gradual degradation and impoverishment of the forests, annually overgrazed under more or less direct orders from the civil government. The necessity, in the economic gain, for this long-continued practice is now being called in question, and not in India alone. More up-to-date management of the cattle is being considered, based on a sound soil and water conservation policy in all dry districts; improved pasture management over extensive areas of grazing grounds, involving a limitation of the head of cattle using the area and rotational closing; the storing of surplus monsoon fodder in hayricks and barns or by the preparation of ensilage.

In *La Forêt Québécoise* (9, Jan. 1, 1945, Quebec), after an interesting account of the advent from Europe to New York and eventually to Quebec of the elm disease and the large loss of trees sustained, an author has a most valuable article on this question of forest pasturage under the title "Méfais du patur-

age" with some excellent illustrations, which demonstrate his contention that unchecked grazing and browsing in a forest means its ultimate extinction owing to the impossibility of maintaining successful regeneration to replace the old trees. "La Forêt," says the author, "ne peut servir de paturage et rester en même temps productive. Soumise à cette pratique désastreuse elle abandonne infailliblement sa fonction principale qui est de produire du bois ou de la sève, et elle ne fournit en même temps qu'une pâture de bien pauvre qualité."

ELECTROMECHANICAL ANALOGIES

ELECTROMECHANICAL analogies and their use for the analysis of mechanical and electromechanical systems form the subject of an interesting paper (*J. Inst. Elec. Eng.*, 92, Pt. 2, No. 52; April 1945) by Dr. A. Bloch. After some introductory remarks which outline the problem and special features of its treatment, the author explains how the complex notation and the impedance concept can be applied directly to the analysis of mechanical systems. This leads naturally to the first or 'direct' method of constructing an electrical 'model' of a mechanical system, where a mechanical force is represented by a voltage, and a mechanical impedance, that is, the ratio of a force to a velocity, is then represented by a proportional electrical impedance. In this analogy a mass is represented by an inductance. It is shown that this representation, when established for one particular frequency, is valid for all other frequencies.

There exists a perfectly consistent alternative method of constructing such an electrical model in which all these correspondences are replaced by their dual counterparts and which is therefore called the 'indirect' or 'inverse' analogy. A mechanical force is here represented by an electric current and a mechanical velocity by a voltage. Accordingly, a mechanical impedance is then represented by an electrical admittance of proportional magnitude; in particular, a mass is represented by a capacitance. This analogy has the advantage that it enables a circuit diagram of the electrical model to be copied from the diagram of the mechanical system, if this be drawn in accordance with certain conventions. The circuit diagram found by this method is the dual of the circuit found by the first method; and as it is a routine procedure to draw the dual of a given network, the second analogy may also be useful when utilizing the first type of analogy.

The paper supplements the development of this method by showing how levers fall into the general scheme of this geometrical correspondence if they be interpreted as auto-transformers. It also shows how the circuits of both these analogies may be found with advantage by an alternative method, that of a 'method of successive generalization' of simplified systems—again without the need of establishing the equations of performance of the system. When the circuit of the inverse analogy cannot be drawn in a plane without crossing between its branches, certain difficulties arise the solution of which is dealt with in a separate paper to be published elsewhere.

Combined electrical and mechanical systems are next discussed in the paper. If the mechanical system is represented by an electrical model, then the electro-