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SCIENTIFIC UTILIZATION OF MAN-POWER

THE White Paper on machinery for the joint planning of the War which the Prime Minister has now wisely issued does not add greatly to our knowledge, although it puts into precise terms much information which has hitherto been given either informally or piecemeal. It fills a gap, and the discussion on the adequacy of our machinery can now proceed on a sounder basis. That discussion and criticism have been carried over from Parliament into the Press, notably in the *Economist* and in *The Times*. In the latter Sir Edward Grigg's able article, which has drawn comment from Lord Hankey, Lord Chatfield, Lord Swinton, Lord Strabolgi, Prof. A. V. Hill and others, advocates the introduction of a single chief of a Combined General Staff standing outside and above the three Chiefs of Staff and presenting one opinion to the Premier and the War Cabinet. The question of the best system is a practical one and not all the critics agree. Moreover, counsel is sometimes confused, and the *Economist* and Prof. A. V. Hill seem to have kept closest to the heart of the matter. The *Economist* insists that the General Staff that is required must be one trained in the technique of co-operation of all three Services but belonging to none, so that the difficulties sometimes advanced as to whether the navy is to direct military or air force operations or *vice versa* do not arise. The recent appointment of Vice-Admiral Lord Louis Mountbatten as chief of Combined Operations is an indication, however, that we are moving further than the White Paper indicates in the direction of the integration on which Prof. Hill lays his stress.

What is required, Prof. Hill holds, is an integrated war staff, a high command, designed for the purpose of planning the war as a whole, not further additions to existing machinery. Already, as the White Paper points out, to ensure that operational planning and production planning are even more closely combined, there has recently been created the Joint War Production Staff. Prof. Hill argues that a complete war staff must include several elements not present in a mere combination of Service staffs. First, a chief of technical staff, guiding research, design and development with a view to operational needs and keeping the war staff informed on technical matters; secondly, a director of operational research responsible for the scientific analysis of the results of past operations and the critical study of current operational plans and methods; third, a joint technical liaison and intelligence officer for civil defence, who could help to devise offensive and defensive policy in relation to the actual effects of bombing. The neglect of these technical elements has, in Prof. Hill's view, had much to do with our failures and disasters.

Mr. Lyttelton's announcement of the formation of a production panel promises to remedy what has long been lacking—the use of technical men of authority to report on the weak places in production, give advice on the spot, or present findings to the highest authority. Field-Marshal Lord Milne's criticism of the joint war production staff is based on the staffing of its technical personnel from the Supply Departments instead of from the Service Ministries. He points out that chief technical officers of Supply Departments are not in the position to co-ordinate operational planning, because they are solely concerned with giving effect to a policy already laid down by the Service Ministry.

That criticism is valid up to a point, but unfortunately it is equally true that Service personnel have only too often proved incompetent to assess the significance for operational planning of technical developments. The basic charge against our operational planning is, in fact, that it has been too limited by Service traditions and experience, and too remote from the new possibilities of operations that technical advance has put at its disposal. The integration of the three Services in regard to a grand war strategy is not more important than the integration with them of the technical side to which Prof. Hill has directed attention.

The nearer we approach to our maximum effort, the severer are the limitations on our resources of materials or man-power, the more important are these questions of organization, co-ordination and integration at the centre. Improvisation can no longer be tolerated. Policy must be concerted and based on a view of the problem and situation as a whole, not of bits and pieces. Mr. Lyttelton has given clear evidence in his statement that he sees his problem as a whole, and the new White Paper provides at least some evidence that the Government is moving to the evolution of a common war strategy based on a corresponding vision and served by the appropriate instruments for its execution—though the pace may seem uncomfortably slow to some of the critics.

It is clear that the volume of criticism both within and without Parliament is having an effect in clearing away departmentalism and forging closer links and fuller integration between the three Services as a single fighting unit animated by the same spirit and the same conception of a common task. That integration, however, needs to be carried further and to embrace the production side of our war effort also. The beginnings of this were indicated in Mr. Lyttelton's first statement as minister, and its importance is further stressed in the latest of the long and valuable papers on war administration which have come from the Select Committee on National Expenditure. One of these, the seventh of the present session, while dealing mainly with matter falling within the sphere of the Ministry of Labour, raises the fundamental question of the distribution of man-power between industry and the Fighting Services.

This is the basic question of man-power policy. Without an answer to it we cannot judge how near Great Britain is to ensuring that every person in the community is contributing the best of which he or she is capable, nor can we make plans to that end. None of the several committees on man-power has as yet been charged with the task of finding out whether the proposed size and equipment of the armed forces represents the maximum military effort which the country can make. Each was subject to the precedent condition that the numbers to be taken for the Forces had already been determined by higher authority. The really fundamental question, namely, the distribution between the Forces and industry which will enable the national man-power, having regard to the ever-changing needs of the war, to make the maximum contribution to the combined striking force of the United Nations, has never been put to them.

The Select Committee considers that it is essential that there should be an independent permanent body to provide at least the materials for an answer to this question—to consider and calculate the effects of any particular allocation of man-power between industry and the Services. Its principal task should be to estimate the best allocation of man-power between industry and the Fighting Services, and as part of that task it should also have the duty of examining the allocation of man-power between the broad categories of industry. The principal recommendation of the seventh report is the establishment of a permanent committee for this purpose, independent of departments and reporting direct to the War Cabinet.

A body of this character would go far to supply the breadth of conception and to stimulate the firmness of execution which are necessary for the development of the maximum military strength. Had it been in existence, for example, opposition to the fuel rationing scheme based on the pressure for release of miners for the forces could scarcely have been engendered. Moreover, there would be less danger that the need for expansion of output, here or in the munition industries, might be met by further recruitment of labour when more careful employment of the workers already engaged would have achieved the same end. The mere meeting of employers' demands for labour is not proof that the country's capacity is fully utilized, for those demands are not necessarily a measure of the real needs of the country.

What emerges from the rest of this long and searching report is the crucial importance of the human factor, as is also stressed in the report on the human side of war production, recently issued by Mass Observation (Charge No. 3. An Inquiry into British War Production. Part 1. People in Production). This report deals with the efficient use of the available men and women, and it fully corroborates the detailed analysis and recommendations of the Select Committee. Efficient production and the exertion of maximum effort are the outcome not only of wise direction and concerted policy at the centre but also of assiduous and unremitting attention to detail everywhere, above all in those matters which affect the welfare and morale of the industrial population. In this connexion the Select Committee holds that the general responsibility for welfare should rest with the Ministry of Labour, which is relatively independent of the factories and is already the principal department concerned with the well-being of employees. The reconstituted regional boards should undertake the responsibility for supervising the efficient utilization of labour, labour supply in this way being treated as an integral part of the problem of production.

The forty recommendations of this report of the Select Committee are, in fact, largely directed against departmentalism and neglect to implement provisions already made. Emphasis is laid, for example, on stricter attention to securing that officials responsible for dealing with absenteeism, etc., exercise their powers fully under the Essential Work Order, as well as on the importance of disseminating technical knowledge, such as new methods of 'de-skilling' which bring about the more economical use of labour. Greater efforts to persuade managements to make arrangements for the part-time employment of women are recommended, and there is a pointed warning that it may be necessary to reconsider the exemption from compulsion of mobile women merely on the grounds that their husbands are with the Forces. How much this is a matter of organization and initiative is well brought out in a broadsheet of P E P (Political and Economic Planning) devoted to part-time employment.

Apart from welfare matters, there are pertinent comments on concentration. The policy of concentration, the report points out, will only have achieved its purpose if the total output from the industries concerned has been reduced to the minimum required to meet the needs of the Services, the civil population, and the export trade, with the minimum of labour and other resources, and if the labour and other resources released are actually transferred to essential work. Notably in the cotton trade these conditions do not appear to have been satisfied, and the Committee recommends emphatically that in determining the degree to which an industry should be concentrated the criterion should be the level of output required to meet war needs. The criterion for determining which establishments should be retained should be efficiency, and nucleus certificates should only be granted to the most efficient firms. Statistic of output and employment should be carefully examined and any unsatisfactory increase in the output per worker investigated. Closer check should be kept on the movements of workers released as a result of concentration schemes and, in particular, great care taken to make full use of persons in supervisory grades who are released as a result of concentration is recommended.

The importance of the distributive trades as a possible source of labour is once again emphasized by the Committee, and the observations on training include the recommendation that periodic investigations should be made to discover whether trainees are being properly placed and for the maintenance of contact between training centres and their more promising trainees to secure that, if they prove suitable, the opportunity for up-grading is not wasted. The cumulative effect of these detailed recommendations should be considerable, and if implemented they should go far to eliminate many sources of wasted man-power which, even if small in themselves, in the aggregate are increasingly serious in their effect upon production.

The eighth report of the Select Committee is concerned more specifically with the organization of production, and with the relation of production to strategy. It is indeed a lucid annotation of Mr. Lyttelton's statement on his functions as Minister of Production which was made between the drafting and the publication of the report. As in the report on labour, the Committee comments on the present improvisation and the absence of sufficiently prescient and progressive planning. The main need appears to be a better use of the available forces rather than an increase in their number. While recognizing the marked improvement of the last twelve months, the Committee is convinced that the Government, industrial management and the manual workers can and must do better.

It is for the Government to give the call and the opportunity to the other two main agencies to do their best, and for this reason the report gives most of its attention to Government direction and organization. On particular points which throw light on defects in organization, it notes the insufficient attention paid to the importance of greater specialization and to distributing contracts so that each manufacturer can concentrate on a limited number of types of product suitable to him, thus providing a sufficient run on each type to secure the most economical mass-production methods. Not enough attention has been paid to directing contracts, labour and materials to the most efficient factories where the man-hours on any job are lowest, or to the proper adjustment of work and capacity in the vast field of sub-contracts. Non-essential industries are still not properly regulated, and once again the importance of good personnel management and of proper arrangements for housing, transport and general welfare is reiterated.

On the general question of organization, the Committee reaches two main conclusions. First, there must be a supra-departmental authority to plan the programme, and secondly, the planning must be informed, based on an accurate appreciation of existing factors, and adequate forethought as to probable future developments. The evidence suggests that the programme for manufacture as transmitted to industry shows signs of inadequate foresight and sureness of decision. Accordingly it should have been possible for the Services to do better than they have in getting the right kind of weapons at the right time.

On the first point the Committee is satisfied that the new Minister of Production will be in a position to ensure unified direction. On the second, it stresses the vital importance of the Minister having at his disposal an adequately staffed intelligence and programmes organization, equipped with the means for collecting and interpreting all relevant data affecting the requirements of the Fighting Services, raw materials, supplies, manufacturing capacity and manpower. On this recommendation follows the further one that the Government should examine as a matter of extreme urgency what steps can be taken to improve the existing arrangements for ensuring that Fighting Services requirements are formulated with precision and so far as possible in advance, and that these are worked out without delay in terms of 'production jobs' and introduced into the production programme with adequate notice to the manufacturers concerned.

Passing from the vital task of relating, or rather integrating, the planning of production with the planning of operations and strategy, the Committee insists upon the necessity for a clear appreciation of the proper functions of the various agencies concerned with the execution of the national programme. Strong arguments are advanced for further decentralization, particularly in arranging and supervising the details of production. Great reliance should be placed on the regional organization of the supply departments, and revision of the present constitution and powers of the regional boards is recommended. Simultaneously, the Committee directs attention to the importance of keeping regional officers fully informed by their departments on all matters which may have a bearing on their duties, as well as to the necessity of a clear chain of responsibility if there is to be effective co-ordination of departmental activities at regional level.

In all this the report is recalling established principles of scientific management which have been neglected, with the usual results. The Committee also advocates measures for devolving responsibility on industrial organizations and for fitting the smaller factories accurately into the national plan. Stress is once more laid on the importance of supervision of execution, and it is recommended that departments should take more active steps to ensure both that good methods developed in one factory are made known to others and that the most efficient works are brought up to the fullest possible employment in priority over those that are less efficient. Similarly, in keeping with Mr. Lyttelton's own statement, the report recommends that all possible steps should be taken to enable workers in factories to have a true understanding of the war position and of the conditions affecting the work in which they are engaged, as well as to encourage the formation of joint production consultative and advisory committees.

These two reports are heartening documents. Among the best of the long series that the Select Committee has given us, they put a searchlight on many weaknesses in the planning, organization and execution of our war effort, accompanied by recognition of the immense effort that has already been made. It is clear that a number of their recommendations have been anticipated, and it may well be possible that further adjustments as yet not made known have brought planning and administration at the centre even more into line with the scientific principles so clearly enunciated in these reports. The emphasis which is simultaneously placed on the need for decentralization, for concentrating in the regional organization sufficient authority to act with speed and authority comes, however, nearer to us all. It should bring into the production field the basic requirement of a subordinate officer in all the Fighting Services, namely, a thorough understanding of his superior's stragetical plan as it affects his duties, and a reliance on his own initiative in its tactical application. Given subordinates in production who can meet these requirements, we should go far to ensure that maximum co-operation and response from the human element upon which in the end both efficient production and final victory depend. Scientific workers cannot but welcome the evidence that further weight is being given to the technical factor in production and strategy, that the production general staff is itself becoming competent to contribute to the formation of strategy, and that a scientific mind and a scientific outlook are increasingly making themselves felt through the whole field of defence and offence, with the firm elimination of inefficiency or slackness wherever met, and steady, persistent improvement of methods as well as output and weapons. The new Appointments Department just established by the Minister of Labour to take over the Central Register and the Supplementary Register, implementing the reform promised last December, is only the latest evidence of this new determination to make full use of technical and professional qualifications and to distribute ability on a more scientific basis.

THE ANALYTICAL FOUNDATIONS OF CELESTIAL MECHANICS

The Analytical Foundations of Celestial Mechanics
By Aurel Wintner. (Princeton Mathematical Series, No. 5.) Pp. xii+448. (Princeton, N.J.: Princeton University Press; London: Oxford University Press, 1941.) 36*s.* net.

FROM the beginning of civilization one need must make itself felt, namely, for some form of calendar. In turn, this gives rise to the primitive study of astronomy, involving some knowledge of the sun and the moon. When the planets are added in the next stage, the astronomer needs an ephemeris or almanac; the modern Nautical Almanac, with its perfection within narrow limits, is the final outcome. There have been many stages on the road, and some apparent interruptions. But the urge has always been the same, essentially a practical one.

For the construction of the necessary tables or almanac some form of theory is required. Such a theory need not be true in order to have value, and in fact it may be grossly in error. Thus the first theory of any practical importance was the Ptolemaic, which assumed the earth to be fixed. On this were based the Alfonsine tables, completed in the middle of the thirteenth century. The results may seem crude, but with minor adjustments it is well to remember that, surviving the transition from manuscript to printing, these tables served all practical needs, however imperfectly, for three centuries; it remains to be seen whether any modern tables will last nearly as long. Then came the Copernican theory with a different frame of reference, but the results when expressed in the form of tables were no better, if indeed they were not worse. Next came the Rudolphine tables, based on Keplerian theory. Here a great advance ought to have been clearly visible, but it escaped the appreciation of all but one remarkable man, Jeremiah Horrocks. However, this theory came at last into the hands of Newton, and from this point the problem assumed its modern form.

In this shape the Nautical Almanac, or similar ephemeris, represents the practical solution of a set of differential equations. These involve a number of numerical constants, the masses of the sun, planets and satellites, and their positions and motions at some given epoch, or equivalent information ; the gathering of an adequate knowledge of such data has been a slow process of approximation. After Newton the early steps were taken by Clairaut and Euler. Afterwards we are chiefly indebted to Laplace, Le Verrier and Newcomb for planetary theory, to Hansen, Delaunay and E. W. Brown for lunar theory. These in their generation have all done their work well, so that to-day the approach to perfection in the solution of the two main types of gravitational problem may be considered quite satisfactory. For the time being, the working astronomer has been provided with the highway which he needs.

The construction of this highway means, as stated, the practical solution of a set of differential equations. In the process the astronomers, some of whom have been named, have taken what help the mathematicians of their day provided, but for the most part have evolved their own methods and, trusting to their own intuition, have had to take risks which the more rigorous mathematician might afterwards justify or might not. Thus in the course of providing for the main astronomical traffic, they have left a whole field of research open to the mathematician and one which if not inexhaustible does not show signs of being exhausted very rapidly. One question concerns the very nature of a system of differential equations, about which there is (p. 144) "Poincaré's dictum, according to which a system is neither integrable, nor non-integrable, but more or less integrable". Similarly, there is the problem of stability, which can be defined in several independent ways and must defy final solution until such definitions can be shown to be exhaustive.

There are, therefore, two different kinds of book which can be written about celestial mechanics. The one will treat mainly of the methods, usually approximate but practicable, which the theoretical astronomer uses with highly successful though limited effect. The other deals with the corresponding mathematical theory, the existence theorems needed for rigour, the provision of new and more powerful methods, and the discussion and development of points arising in the course of the severely practical problem of prediction. To the latter class the present work belongs, and it makes its appeal to the ambitious student who is not to be deterred by the technique of modern mathematics. Happily, the author is familiar with both sides of the subject, and has produced a book which, so far from being arid, is exceedingly interesting even to those who are not prepared to assimilate all its abstruse details. This is helped by unusually ample references to the historical development, ending in a final section devoted to this aspect. The value of this attention to the historical past would have been enhanced by the addition of a name index.

The course of development may be illustrated by reference to the lunar problem. Brown's treatment of this thorny subject, which gave even Newton a headache, was initiated by G. W. Hill. This is based on a periodic solution of an idealized form of the problem of three bodies, and no longer starts from a solution of the problem of two bodies. Hence arose the restricted problem, in which two bodies describe relatively circular orbits while the third is massless. The periodic motion of such a body, attracted but not disturbing, has been considered by Thiele, G. H. Darwin and with the greatest numerical detail by E. Strömgren. As a theoretical problem it has been considered by Poincaré and others. Thus, starting with transformation theory and dynamical systems, the book gravitates towards the restricted problem for which the ground has been prepared in earlier chapters. To the advanced student of celestial mechanics a knowledge of the analytical foundations is clearly indispensable, and Dr. Wintner's book can be recommended to his attention and careful study.

H. C. Plummer.

TENSOR CALCULUS

An Introduction to Differential Geometry with Use of the Tensor Calculus

By Prof. Luther Pfahler Eisenhart. (Princeton Mathematical Series, 3.) Pp. x+304. (Princeton, N.J. : Princeton University Press ; London : Oxford University Press, 1940.) 21*s*. 6*d*. net.

This book gives a thorough introductory study of the properties of ordinary points in the differential geometry of curves and surfaces in 3-space. Chapter 1 gives an account of twisted curves, Chapter 2 describes the tensor calculus. In Chapter 3 this calculus is applied to investigate the intrinsic geometry of a surface, that is to say, those properties which depend on the first fundamental form. Chapter 4 develops those properties which derive also from the second fundamental form and therefore characterize the surface as viewed from the enveloping space.

On account of the expository character of this text-book, it is Chapter 2 which gives rise to some reflections. In introducing the notion of a tensor it has become the custom, which is also adopted in this book, to emphasize heavily the transformation aspect and to leave the student very vague as to the essential simplicity of the tensor idea. There is, however, an easier and perhaps more logical approach by means of the indefinite multiplication of ordinary vectors. If $\boldsymbol{a}$, $\boldsymbol{b}$, $\boldsymbol{c}$ are vectors (tensors of the first order) and a semi-colon denotes indefinite multiplication, ordered combinations such as $\boldsymbol{a} ; \boldsymbol{b}$ or $\boldsymbol{a} ; \boldsymbol{b} ; \boldsymbol{c}$ or the sums of like combinations are tensors of the second and third orders respectively. Contraction then consists of replacing indefinite multiplication by scalar multiplication. Thus the tensor $\boldsymbol{a} ; \boldsymbol{b} ; \boldsymbol{c}$ can be contracted for example to $(\boldsymbol{ab})\boldsymbol{c}$ by taking the scalar product of the first pair of vectors. In applying the tensor calculus to differential geometry, it often becomes necessary at some stage to use a co-ordinate system, say, x^r. We can then introduce at any point P a local system of vectors, or a basis, $\boldsymbol{e}_r$, such that the vector PQ, where Q is an adjacent point x^r+dx^r, is $\boldsymbol{ds} = \boldsymbol{e}_r dx^r$, and at the same time we define the reciprocal basis $\boldsymbol{e}^r$ by the relation $\boldsymbol{e}_r\boldsymbol{e}^s = \delta_r$ in terms of Kronecker's deltas. The fundamental quadratic form is then simply $\boldsymbol{dsds} = \boldsymbol{e}_r\boldsymbol{e}_s\, dx^r dx^s$, which shows that the number usually called g_{rs} is a scalar product of two vectors of the basis. Any vector at P can be expressed either in terms of the basis or in terms of the reciprocal basis. Thus if $\boldsymbol{a} = a_r\boldsymbol{e}_r = a_s\boldsymbol{e}^s$ and

$\boldsymbol{b} = b^r\boldsymbol{e}_r = b_s\boldsymbol{e}^s$, the tensor $T = (\boldsymbol{a}\,;\,\boldsymbol{b})$ can be expressed in the three forms

$$T = a^r b^s(\boldsymbol{e}_r\,;\,\boldsymbol{e}_s) = a^r b_s(\boldsymbol{e}_r\,;\,\boldsymbol{e}^s) = a_r b_s(\boldsymbol{e}^r\,;\,\boldsymbol{e}^s),$$

which show the so-called contravariant, mixed and covariant indices, and the relative unimportance of these adjectives.

To define the Christoffel symbol of the second kind (the first kind has no essential applications) we write as definition

$$\frac{\partial \boldsymbol{e}_r}{\partial x^s} = \frac{\partial^2 \boldsymbol{s}}{\partial x^s \partial x^r} = \left\{ \begin{matrix} t \\ rs \end{matrix} \right\} \boldsymbol{e}_t, \text{ whence } \frac{\partial \boldsymbol{e}^r}{\partial x^s} = - \left\{ \begin{matrix} r \\ ts \end{matrix} \right\} \boldsymbol{e}^t.$$

These results together with the vector differentiation operator $\nabla = \boldsymbol{e}^i\partial/\partial x^i$ contain the whole manipulation of differentiation. For example, we have the tensor

$$\nabla\,;\,\boldsymbol{a} = \boldsymbol{e}^i\frac{\partial}{\partial x^i}\,;\,a_r\boldsymbol{e}^r = (\boldsymbol{e}^i\,;\,\boldsymbol{e}^r)\left[\frac{\partial a_r}{\partial x^i} - a_s\left\{ \begin{matrix} s \\ ir \end{matrix} \right\}\right],$$

which gives the covariant derivative and shows that it is a tensor.

The considerations thus briefly indicated are of general application to n-space and to tensors of any order. Moreover, they render obvious the proof of, and the connexion between, such theorems as 16·6 and 17·6, which in spite of their dissimilar enunciations are merely statements regarding the basis and its reciprocal. Similarly, the Frenet formulæ in general co-ordinates follow at once from their ordinary vector form.

The book is beautifully printed and has many excellent diagrams and illustrations. It has also another claim to the student's attention, namely, the large number of exercises, many of which contain important theorems. There are a bibliography of works to which the author refers and a useful index.

L. M. MILNE-THOMSON.

FORENSIC SCIENCE

Science for the Prosecution

By Dr. Julius Grant. Pp. vii+302+25 pl. (London: Chapman and Hall, Ltd., 1941.) 15*s*. net.

FORENSIC science, or the application of scientific investigation to the purposes of the law and the administration of justice, is an outcome of the older subject of forensic medicine or medical jurisprudence. Whereas forensic medicine deals primarily with offences against the person, forensic science covers a somewhat wider field and includes the investigation of offences against property.

It is only within comparatively recent years that the latter subject has assumed an important position in the investigation of criminal offences. The importance of forensic medicine, on the other hand, was recognized in Great Britain so long ago as the end of the eighteenth century, when voluntary lectures were given on it at Edinburgh, and were followed by the establishment by the Crown of a chair of forensic medicine in 1807 at the University of Edinburgh. This was the first of its kind in any English-speaking community. Although this subject has now become an integral part of the medical curriculum, and each medical school now has its lectureship on the subject, there is only one other full-time chair complete with its department in Great Britain, namely, that of the University of Glasgow.

Forensic science has gradually evolved from the older subject, and in connexion with this may be mentioned the names of Lombroso of Turin, Locard of Lyons and Söderman of Stockholm. Institutions for the study of forensic science are (or were) in active operation in Paris, Lyons and Lille, that of Paris being founded in 1912. In Great Britain, the Metropolitan Police Laboratory was established in 1935, and this was followed by the establishment by the Home Office of Regional Forensic Science Laboratories at Nottingham, Cardiff, Birmingham, Preston and Wakefield. Although these laboratories are there to assist the police, the reports issued from them are naturally entirely independent as to whether they favour the prosecution or the defence, and they may be used therefore afterwards in a court of justice by either side.

Dr. Julius Grant has written a most interesting and valuable book on the methods used in forensic science. As he says in his preface, he has adopted a semi-popular treatment of the subject, the book being primarily intended for the lay reader and to introduce the subject to the lawyer. One feels that although it has this general appeal, it would be better for the reader to have some knowledge and interest in science before he could fully understand and appreciate its contents. It covers a wide field, embracing the work of the physicist, the chemist, the biologist, the pathologist and the psychiatrist. In other words, there are various chapters on optical methods, including ultra-violet and infra-red rays, X-rays, spectroscopy, the microscope and the camera, chemical methods, blood-group tests and serum analysis, and lastly psychology and crime. Of all the methods discussed, probably the most important and the one most frequently used is that of microscopy. This is fully admitted by the author, especially when the microscope is used in conjunction with the camera; but even the camera may not always be necessary.

Methods of examination by ultra-violet and infra-red rays are extensively used in this type of work, and the chapters dealing with these give a very clear outline of their importance and use. Although X-rays have not been used to any great extent up to the present, the most striking results have been obtained from the examination of oil paintings of the 'Old Masters'. The pioneer work of Prof. A. P. Laurie must always be remembered with regard to this type of investigation.

The chapter on chemical methods covers a wide field, from the detection of poisons to the decipherment of charred documents, the latter having assumed a certain degree of importance during the past two years. The blood-alcohol test is also dealt with, and one is glad to see the very fair opinion given of the value of the test.

The general reader will also obtain a good knowledge of the blood-grouping tests with regard to blood stains and paternity cases, and finally there is an interesting discussion on psychology and crime. It is doubtful whether such methods as those described in the use of the 'lie detector' would ever be tolerated in Great Britain.

In conclusion, it must be said that this book contains an amount of interesting information, interestingly set forth within a comparatively limited space, and can be recommended not only to those for whom it was apparently written, but also to those who are actively engaged in forensic laboratory work. The book is well illustrated with plates and diagrams.

J. DAVIDSON.

COLOURS IN FOOD

THE practice, now widespread, of adding colouring matter to foods has not always found favour with the authorities, as is instanced by the heavy penalty of £500, imposed by an Act of 1816, for selling colouring agents for the darkening of beer. This was mentioned by Mr. D. J. T. Bagnall, city analyst for Hull, in his paper opening a discussion on "Colours in Food" held on April 13*. Foods are coloured by the addition of (1) metallic salts such as copper sulphate, although the use of copper salts is now prohibited in Great Britain; (2) natural colouring matters such as cochineal, saffron or annatto; (3) synthetic dyes, the principal method now in use. Attractive colours may also be imparted to certain foods by such processes as smoking or pickling.

The principal reasons for colouring food are to replace colour lost in processing or to imitate an article of superior quality. The process of canning entails partial loss of the natural colouring of the food, and this deficiency in tinned goods is frequently made good by the addition of artificial dyes. The need for this artificial colouring is lessened if the fruit or vegetables are freshly gathered and carefully processed, when the loss of colour is reduced to a minimum. The other motive for colouring foods, namely, to imply superior quality, is wholly reprehensible, according to Mr. Bagnall, who suggested that to colour cakes yellow to imply the presence of eggs is as serious an offence as to state on the label "Made with eggs" when in fact no eggs are present. Yellow colouring matters are added to butter and to cakes to suggest richness of quality. Chocolate cakes and chocolate biscuits are often dyed a deep brown colour to suggest the presence of cocoa, of which the actual amount may be so small that the addition of artificial essence is necessary to impart a chocolate flavour. Food dyes are sold under such poetic descriptions as 'egg yellow', 'gooseberry green', 'pea green', 'kipper brown', 'spinach green', and 'brawn pink'. Their mission is obvious from their names! A "perfect substitute for eggs" recently examined in Hull consisted of water (96·3 per cent), oil (0·5 per cent), sodium bicarbonate (1·0 per cent), cellulose gum (2·2 per cent) and a yellow dye. Without the dye this sticky liquid would have deceived no one. In the opinion of Mr. Bagnall the addition of colouring matter to foods of lower quality in order to render them more attractive is permissible only if the purchaser is notified of the lower quality and if the presence of the added colouring matter is declared.

Great Britain is the only leading country which has not a legal schedule of permitted colours. Any colouring matter may be added to food, provided it is not injurious to health, except compounds of antimony, arsenic, cadmium, copper, mercury, lead and zinc. Gamboge, picric acid, victoria yellow, Manchester yellow, aurantia and aurine are also prohibited. Other countries, including the United States, France, Canada, Australia, New Zealand, Italy, Spain, Sweden and Denmark have lists of permissible colours. Which of these two systems is to be preferred? Injuriousness to health is difficult to prove, and the effect of a dye on test animals may not be the same as on the human organism. The proportion of added colour in the food is so small that the dye could scarcely be harmful unless highly toxic, but this argument ignores the possible cumulative effects of frequent small doses. Mr. Bagnall is inclined to the view that only specified dyes proved to be non-injurious to health should be permitted, and that official standards of purity should be set up and enforced.

In the discussion which followed this paper it was suggested that Mr. Bagnall had over-emphasized the tendency to use food colours for purposes of deception. Delicate tinting of an article of food often made it more acceptable to the public, who demanded such colouring. Artificial colouring serves to compensate for the unavoidable deterioration of colour which often occurs with time and also to standardize the products.

Prof. J. W. Cook dealt with biological properties of dyes, with particular reference to those used for colouring foods. Synthetic colouring matters have long been known to have various kinds of biological activity. The staining of organisms by trypan blue and trypan red played an important part in the early development of chemotherapy, and the antiseptic action of such dyes as gentian violet, methylene blue, brilliant green and acriflavine has been much utilized. The earliest sulphonamide drugs were azo dyes (prontosil is a sulphamido derivative of chrysoidine, which has been used as a food dye). Dyes also find application in diagnostic tests. With these medicinal dyes it is scarcely surprising that their pharmacology has been much investigated. In the case of dyes used for colouring food the situation seems less satisfactory in this respect.

In a report published by the Ministry of Health in 1924 it was stated that more than ninety different dyes were supplied for colouring food in Great Britain. The actual number in common use appears to be about twenty-five, and of these the following seven are used in the largest amounts: Tartrazine, Ponceau *RS* or 2*R*, Orange I or I*S*, Orange II or *GS*, Amaranth *AS*, Erythrosine *AS*, Rhodamine *B* or Rose *BS*. The first six of these are included in the list of food colours permitted in the United States. Four of them are included in a list of thirty-six synthetic dyes which are stated in Martindale's "Extra Pharmacopœia" to be harmless for colouring foods. Recent original literature contains comparatively little reference to the biological properties of food-colouring matters. Facts are accumulating, however, which suggest that the time has come when current practice and the existing regulations relating to this matter should be reviewed.

The causes of dermatitis associated with substances used for dyeing fur and hair have been much studied by H. E. Cox[1], who concluded that in a large proportion of cases the agent primarily responsible is *p*-phenylene diamine. This undergoes atmospheric oxidation to quinone di-imine, which is a powerful irritant. In this connexion it may be remarked that *o*-aminoazotoluene, which is stated to have been used as a food dye, is metabolized by rabbits to the diacetyl derivative of *p*-toluylenediamine[2].

Baer[3], in 1934, recorded a case of dermatitis which was attributed to a green synthetic colouring matter present in salads. The symptoms included an erythematous eruption on the neck, shoulders and arm. This suggests a photodynamic action, but it is stated that the eruption occurred on covered areas of skin as well as on uncovered areas. It is now recognized that many fluorescent dyes, introduced into the body, may lead to lesions of the skin on

* Summary of contributions to a discussion held in Leeds on April 13 at a joint meeting of the Yorkshire Section and the Food Group of the Society of Chemical Industry.

exposure to light, due to photo-sensitized oxidation of protein or amino acid[4]. This possibility should be borne in mind in connexion with the use of fluorescent dyes to colour food.

Two cases of dermatitis due to handling artificially coloured citrus fruits were reported in 1937[5]. The principal dye used for this is Yellow *OB* (*o*-toluene-azo-β-naphthylamine). In these and similar cases constant and repeated exposure to the dye probably produced hypersensitivity. Toxicity experiments carried out by Climenko[6] with *o*-toluene-azo-β-naphthol, an oil-soluble dye used also for colouring the skin of citrus fruits, showed that its acute toxicity is very low. The maximum dose after which recovery took place was 20 gm. per kilogram of body weight. No serious adverse effects resulted from daily administration for six months of doses up to 100 mgm. per kilogram of body weight. Many medicinal dyes are far more toxic than this. In cases of acute toxicity the dye often appears in the urine, and the liver, kidneys and other organs are stained with the dye. These organs also show pathological changes. It is of interest that Huggett and Rowe[7] have shown that many azo dyes, particularly those which are prepared from tetrazotized diamines and aminonaphthol sulphonic acids, are effective inhibitors of blood clotting.

Malignant tumours of the liver may be produced in rats and mice by administration of large doses of two azo dyes which have been stated to be in use as food-colouring matters. This was shown by Yoshida[8] in the case of *o*-aminoazo-toluene and by Kinosita[9] in the case of *p*-dimethylaminoazobenzene ('butter yellow'). Their observations have been amply confirmed and although it is believed that these dyes are not now used for colouring food their use should be prohibited. Similar pathological changes in the liver are induced in mice by 2 : 2′-azonaphthalene[10]. These circumstances led to tests being carried out with food dyes having structural resemblance to these, with the co-operation of Dr. J. J. Fox, who supplied valuable information as to the dyes in most common use and procured samples of them. Six azo dyes were selected for test, namely, Ponceau *RS*, Orange *IS*, Naphthalene Orange *GS*, Naphthalene Fast Orange 2*GS*, Amaranth *AS* and Metanil Yellow *YKS*. Mice were fed on brown bread soaked in aqueous solutions of the dyes so that each mouse received 15–20 mgm. per week. This would correspond with about 60 gm. for a man. The experiments were of adequate duration, but no tumours were obtained[10].

Five of the six dyes used in these tests are water-soluble sulphonates and hence would be rapidly excreted. Further tests were therefore carried out with Yellow *AB* and Yellow *OB*[11]. These two oil-soluble azo colours do not appear to be used in Great Britain, but are in common use in the United States. The dyes were administered to mice by feeding, by application to the skin, and by subcutaneous injection, but no tumours have been obtained in the experimental animals[12].

Thus, there is no evidence that any of the food dyes except Butter Yellow and *o*-aminoazotoluene are associated with carcinogenic properties. The use of these as food colours is probably now obsolete. In any case, it may be noted that the amounts used to produce tumours in animals were proportionately very much in excess of those which would be used to tint foods. It would be very difficult to determine whether repeated administration of small amounts of these food dyes during many years would be followed by tumours or other pathological conditions in the human subject.

Commercial colours which are used for dyeing fabrics are liable to contain toxic impurities, and for food colouring purposes specially purified dyes are manufactured. Analytical control, particularly in regard to certain metals, is important, and Dr. D. A. Harper and Mr. N. Strafford described methods which can be used for the rapid spectrographic determination of minute amounts of arsenic, lead, copper and other heavy metals in food dyes and medicinal products.

The determination of minute amounts of metallic impurities in organic substances by colorimetric methods is a time-consuming and expensive operation and consequently spectrographic methods possess many attractions. Although methods for the determination of traces of some metallic impurities in organic substances have been described the determination of arsenic has hitherto not been provided for. The present method will detect 0·5 parts per million of arsenic (As_2O_3), lead and copper, also antimony and tin if required. 1 gm. of the sample is wet-oxidized and the metallic sulphides precipitated along with cadmium sulphide, which acts as carrier and also as spectroscopic internal standard. The mixed sulphides are filtered off on a powdered graphite filter bed and, after drying, the mixture of sulphides and graphite is arced in the D.C. arc between graphite electrodes in front of the slit of a Hilger medium spectrograph. The tests are carried out in duplicate, and by means of a Hartmann diaphragm the spectra are photographed on both sides of the spectrum of a 'specification test' in which the same amounts of the reagent have been used and to which have been added the amounts of the metallic impurities corresponding to the specification limits. If necessary, additional standard spectra corresponding to limits both below and above specification limits can be employed. By examination of suitable spectrum lines it is possible to indicate whether each metallic impurity in the sample under examination is equal to, above, or below the specification limit, and an estimate of the actual amount of each present can readily be made.

The method is similar in accuracy to the usual colorimetric methods, and it offers considerable economies. When applied on 'mass production' lines the overall cost per sample is approximately one fifth of that of the colorimetric method. Of more importance in present circumstances is the fact that only one quarter to one third of the man-power is required.

[1] Cox, H. E., *Analyst*, **54**. 694 (1929) ; **58**, 738, 743 (1933).

[2] Hashimoto, T., *Gann*, 29, 306 (1935).

[3] Baer, H., *J. Amer. Med. Assoc.*, **103**, 10 (1934).

[4] See Blum, H. F., "Photodynamic Action and Diseases caused by Light", Chapter 23 (Reinhold, 1941).

[5] Traub, E. F., Gordon, R. E., and van Dyke, L. S., *J. Amer. Med. Assoc.*, **108**, 872 (1937).

[6] Climenko, D. R., *J. Amer. Med. Assoc.*, **109**, 493 (1937).

[7] Huggett, A. St. G., and Rowe, F. M., *J. Physiol.*, **80**, 82 (1934).

[8] Sasaki, T., and Yoshida, T., *Virchows Arch. f. path. Anat.*, **295**, 175 (1935).

[9] Kinosita, R., *Trans. Jap. Soc. Path.*, **27**, 665 (1937).

[10] Cook, J. W., Hewett, C. L., Kennaway, E. L., and Kennaway, N. M., *Amer. J. Cancer*, **40**, 62 (1940).

[11] Compare NATURE, **145**, 672 (1940).

[12] Kennaway, E. L., unpublished experiments.

THE CAUSE OF EARTHQUAKES

By ERNEST TILLOTSON

THE term 'earthquake' means vibrations of the ground. These vibrations are caused by the passage of various types of waves through the ground, which has elastic properties. The ground vibrations are kinetic energy, which must be released consequent on the disappearance of some form of potential energy. The form this potential energy takes, how it is released, but more particularly how it arises is the problem before us.

The data are multitudinous, and excellent recent papers covering some of the field are "Seismology" by Beno Gutenberg[1] and "Tectonic Processes now in Action"[2] by the same author. First consider the immediate cause. The potential-kinetic change might occur by sudden collapse, expansion or fracture. The first, caused by mining subsidences and the collapse of underground cavities, is of minor importance. The second may occur by chemical change or by change of state, for example, in magma basins or by sudden contact of percolating water with heat reservoirs—possibly causing such outbreaks as the Montserrat (West Indies) swarms. Apart from such phenomena and the fact that earthquakes and active volcanoes are associated with geologically recent mountain chains, there is little connexion between earthquakes and volcanoes. The third cause, by fracture, appears to be more frequent. Most normal strong earthquakes originate near the base of the 'granitic' layer at a depth of some 16 or 17 km. below the earth's surface ('sedimentary' layer 0–10 km. thick, 'granitic' layer 13 km. thick, 'intermediate' layer 26 km. thick), and it would appear that the immediate cause of most of these shocks is the application of pressure to rocks until they fracture. The total energy released by earthquakes per annum is near 10^7 kilowatts, and most of this is released by one or two great shocks. The focus of one shock as determined from instrumental evidence may be the place where fracture starts, though this fracture may spread quickly in any direction. That such pressure exists is sometimes first seen in extensive ground tilt, for example, the recent great Chillan (Chile) earthquake[3], though such ground tilt cannot yet be used to foretell the time or place of a possible future shock. Plastic flow or a succession of small shocks may alternatively dissipate the energy. Small fore-shocks may presage larger earthquakes, though again such forerunners cannot yet be recognized as such. We have no independent means at present of probing the local strength of the 'granitic' layer to discover where rupture is likely to take place. Often between the accumulation of stress and the earthquake some small additional force such as an extra high tide, or great change in barometric pressure, perhaps a shaking from some independent distant earthquake or a mining subsidence may act as a 'trigger', thus releasing the larger energy.

Periodicities in earthquakes are still *sub judice*. With the present careful collecting of data better judgment may be passed after another 400–500 years. Artificial earthquakes caused by explosions of such material as gelignite (even the Oppau explosion—Jeffreys and Wrinch) only give rise to very minor pulsations. One of the strongest earthquake shocks has about 10^{25} ergs (Chile 1922); rather less energy was expended by the Turkish earthquake[4], less still by the San Francisco earthquake of 1906 and the Indian earthquake of 1934. To be humanly perceived an earthquake must have 10^{11} ergs, and to be recorded by a seismograph 10^8 ergs.

The long-range, or fundamental, cause of earthquakes would appear to be more important. What forces lead up to the rupture of rocks causing an earthquake and in what manner do they arise? The forces are sometimes forces of compression, on occasion of tension and often they are shearing forces. Numerous combinations of these doubtless occur, and these may possibly arise in the following ways: Geosynclines are of paramount importance in the formation of large-scale sedimentary deposits, and in the compression of these deposits to form mountain chains. In depth the geosyncline must include the 'sedimentary', 'granitic' and 'intermediate' layers which altogether may reach a thickness of some 40–45 km. Flow to give some measure of isostatic compensation must begin at some distance below this. Should it so happen that as the deposition of sediments is maintained, the compensation keeps pace with it, the sides of the geosyncline might become so steep that tension would develop by gravity action in the various layers. If this tension is sufficient to overcome the cohesion in the rocks, these break up into blocks and the act of breaking gives rise to earthquakes. The folding of the sedimentary deposits in the bottom of the geosyncline may also cause earthquake shocks if the elastic limit of these rocks is exceeded and they fault instead of bending quietly. Geosynclines could scarcely be less than, say, 700–800 km. in horizontal extent and are often much larger. Their functioning must depend on the presence of a substratum underneath the 'intermediate' layer perpetually ready to yield under the action of loads above it. The yielding need not be continuous in time, and indeed several peculiarities are explained if it is not. A sudden yielding after a period of gradually increasing tension, compression or twisting would be much more likely to produce the sudden ruptures giving rise to earthquakes than a gradual continuous yielding.

Beds of rocks of different geological periods are separated in many places by unconformities and in others by sudden alterations in lithology. Periods of quiet deposition of sediments are followed by upheavals and then new conditions of deposition. Gradual transition from one formation to another is an exception rather than a rule. Does this not point to sudden accommodation isostatically in the basin of deposition showing that the yield point of the underlying material had been attained? Joly assumed that this was caused by blanketed heating by radioactive material, though this need not be the only possible cause. The material may have an elastic yield point which the weight of the superimposed material may attain without the addition of heat. The period between a certain area being a basin of deposition and its rising to mountain peaks may be of the order of 10–100 million years, though in certain circumstances this estimate might be reduced. The forces are acting over long periods of time, and this may explain why we find with our limited period of observation that earthquakes tend to occur in the same localities as they have always occurred within the experience of our historical records. It is possible for a small basin of deposition to go through a cycle much more rapidly if the material underneath is sufficiently yielding. Minor oscillations within the geosyncline are sometimes apparent and perhaps the 'granitic' and 'intermediate' layers may yield locally.

The strength of the 'sedimentary' layer may be of the order of 10^9 or 10^{10} dynes per centimetre and the viscosity of the immediate interior according to one estimate is of the order of 10^{22} poises.

During such a period of yielding the sedimentary rocks may become folded and faulted, the process being accompanied by earthquakes with foci in the 'sedimentary' layer, seldom in the 'granitic' layer, and less frequently in the 'intermediate' layer. The movement may be started by any load of sufficient magnitude applied in one place such as the accumulation of ice during an ice age. Scotland and Fennoscandia are now rising after their Pleistocene ice has been melted away, while south-east England is falling at the rate of about a foot per century. This twisting may have set up strains in the upper layers, causing the North Sea earthquakes. Many of the Norwegian earthquakes are superficial.

Experiments made in the Geophysical Laboratory at Washington tend to confirm that rocks behave differently under forces gradually applied from what they do under forces applied quickly. The material of the earth's crust is continually tending towards hydrodynamical equilibrium. To this equilibrium the crust is continuously approaching with the passage of time, but the equilibrium is never absolutely attained owing to the resistive strength of the materials. This is Dutton's conception of isostasy. The work of Hayford, Heiskanen, the Indian Ordnance and Geological Surveys and others tends to show that although Hayford's numerical conception of isostasy has distinct computational advantages in geodesy, involving as it does gravity anomalies, yet on the available evidence it is effective over about one per cent of the earth's surface and ineffective over another 0·75 per cent. This is the extent of the earth's surface so far surveyed in this manner. Tests are now being made with seismographs in the neighbourhood of the Grand Coulee and Shasta Dams in the United States to see whether or not a small area suddenly loaded gives the necessary conditions for small earthquakes to occur. Numerous small earthquakes occur near Boulder Dam, but the pre-dam seismic history is not known.

Earthquakes with epicentres in areas subject to recent geological tectonic activity tend to have their foci in the 'sedimentary' layer, whereas foci in the 'intermediate' layer and down to 300 km. depths show some correlation with zones of Tertiary mountain building. There is still something to be said for the contracting earth theory though perhaps such forces as the *Polfluchtkraft* require more careful comment. Much seems to depend on the structure of, say, the upper 100 km. of the earth. The bed of the Pacific Ocean appears to be the only region in the world where the 'intermediate' and 'granitic' layers are absent. In the Pacific region the sima comes right to the surface, while elsewhere in the world sial overlies the sima. The vertical discontinuity is near the andesite line, and in North America it is apparent when seismic surface waves of about 20-sec. period and 70-km. wave-length cross from the Pacific Ocean bed to the land. There is much loss of energy. The discontinuity must extend at least some 25 km. down, but its vertical extent does not exceed 200 km. Such loss of energy is not apparent when similar waves cross other ocean beds, and if the evidence of seismic sounding is confirmed the North Atlantic depression has probably been caused by flexure and not by faulting.

Around the circum-Pacific line of instability in Japan, the Philippines and California, the direction of faulting shows the land moving southerly with respect to the seaward side. Is this the *Polfluchtkraft* at work in the Pacific region ?

The Atlantic and other regions would appear to be more doubtful. We must be careful, however, not to take *all* surface faults to be the *cause* of earthquakes. The cause of an earthquake and its focus may be more deep-seated, and the surface fault may be a *result* of the shock, not the cause of it.

Thus far we have not yet dealt with deep-focus earthquakes, that is, those with foci between 300 and 700 km. deep. The work of Scrase (recognition of *pP*, etc.), Turner (waves at the antipodes), and Stoneley and Jeffreys (small amplitude *L* and *M*) show that these undoubtedly occur. The Brunner depth chart constitutes a quick working tool for finding such depths. It appears that these deep-focus earthquakes could be caused by displacements resulting from the action of convection currents. The experiments of H. Bénard in 1900 showed the presence of convective 'cells' in fluid between two parallel surfaces maintained at different temperatures. Pekeris has continued this work. Deep-seated heat from the still molten core of the earth some 3,500 km. in radius may give rise to discontinuous geologically slow convection currents from this depth to, say, the 700 km. discontinuity. This discontinuity may be between vitreous and crystalline basic material and is probably marked by a magnetic discontinuity also. Below 700 km., forces would be dissipated by plastic flow, but just above 700 km. the forces might accumulate until rupture, causing an earthquake, could occur.

The part played by radioactive heat at these depths is uncertain, though heterogeneities in the interior are more important than homogeneities in deciding where convexion currents shall be, and where the elastic potential shall accumulate. Western South America, the Sunda Sea near Java, and the region between Japan and New Zealand are very active regions at the moment. A series of observations of the direction of faulting taken over large areas of the earth's surface, also the careful integration of seismograms to discover the initial movement at the focus of deep-focus earthquakes would perhaps assist in finding the direction of deep-seated convection currents should these in reality exist.

[1] Fiftieth Anniversary vol., Geol. Soc. Amer., June, 1941.
[2] *Trans. Amer. Geophys. Union* (1941).
[3] NATURE, Feb. 11, 1939.
[4] NATURE, Jan. 6, 1940.

RAMAN'S THEORY OF SPECIFIC HEAT OF CRYSTALS

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WHEN, in 1907, Einstein published his work on the specific heat of solids, nothing was known of X-ray crystallography. Crystals were apt to be regarded as a highly specialized form of solid matter. Now, as a result of the wide application of X-ray analysis to all solids, the crystalline state is known to be the normal stable state of solids. Theoretically, the crystal is a periodic three-dimensional grouping in space of an immense number of atoms, ions or molecules held together by interatomic or intermolecular forces. The unit cell, the smallest portion of the crystal to contain all the groupings of atoms characteristic of that particular form of the substance, is very much smaller than the smallest visible crystal. Nevertheless, the strength of diamond and the greasiness of graphite are inherent in the two different patternings of carbon atoms in the two different unit cells.

Properties of solids may be divided into the macroscopic, modified greatly by the shape and size of the individual specimen, and the sub-microscopic, inherent more in the patterning within the unit cell. This division of the physical properties of solids raises crucial questions when thermal properties are considered. On the kinetic theory of heat, heat is 'a mode of motion'. Are the thermal vibrations of atoms in a solid characteristic of the unit cell, or are they dependent more upon the size and shape of the particular crystal, differing for different crystals of the same substance? Sir C. V. Raman discusses these problems in a summary of his work published with six experimental studies on the subject in the *Proceedings of the Indian Academy of Sciences* (A, 14, November, 1941). The following is an account of the theory and of Raman's criticisms.

Raman's Specific Heat Theory

Let it be supposed that the thermal vibrations of a crystal may be described without reference to the fine structure of the solid. We shall be dealing with elastic vibrations. Their modes and frequencies will depend upon the speed of propagation of elastic waves and upon the dimensions and boundary conditions of the crystal. Oscillatory motions of large groups of atoms will be involved, and the larger the crystal the smaller would be the frequency differences between the successive possible modes of vibration. In the limit, the elastic vibrations of a visible crystal would give a continuous spectrum of frequencies. When, however, the wave-length of these vibrations becomes comparable with the size of the unit cell, the possibilities of another type of vibration must be considered. Here we should be concerned primarily with vibrations of atoms about their mean positions in the unit cell. The dimensions of the crystal would have a negligible influence and the frequencies of the vibrations would be much greater. Although the principal modes of vibration would be the same for all unit cells, larger-scale oscillations might occur in which there is a repetition in cells of a superlattice, the spacings being an integral multiple of the unit cell. All such vibrations would be monochromatic and would give approximately a continuous spectrum only if the number of types of superlattice was very great. In general, the first type of vibration would tend to give a continuous spectrum and the second a line spectrum in the infra-red region of the spectrum.

The distribution of thermal energy between the two types of vibration is treated as follows. The largest part of the thermal energy is taken to be that associated with the unit cell. If there are p atoms in the cell, there will be $(3p-3)$ modes of internal vibration and 3 translations for the cell as a whole. If p be fairly large, the $(3p-3)$ degrees of freedom appearing as vibrations would greatly exceed in number the 3 degrees of translation. Considering the superlattices and taking one in which the cells have twice the edge-length of the lattice cells first chosen, we have $(24p-3)$ modes of internal vibration of the atoms and 3 translations. The former $(3p-3)$ modes of vibration will be included, as well as others approaching them in character. In addition, new modes of vibration previously reckoned as simple translations of the unit cell would occur. Unless p is very small, not many superlattice vibrations need be considered. The number of vibrations of the elastic type bears to the total number of degrees of atomic freedom a ratio of the same order of magnitude as the ratio of the volume of an individual atom to the cube of the limiting wave-length. When, therefore, the wave-length limit is even moderately large in relation to the lattice spacings of the crystal, the energy of such vibrations is a negligible fraction of the whole.

The Debye Specific Heat Theory

The specific heat theory of Debye is criticized by Raman on the grounds that it associates the thermal energy of the crystal with that of elastic vibrations. Experimentally it is found that elastic vibrations travel with high speed, whereas heat energy travels very slowly indeed, at diffusion rates. The limits of using a discontinuous structure as an approximation to a continuous structure or vice versa are illustrated by the well-known example of the modes of vibration of a periodically loaded string and of a uniform string. While the specific heat curve can be uniquely derived from the vibration spectrum, a knowledge of the specific heat data is insufficient for a determination of the vibration spectrum. The Debye formula with an appropriately chosen limiting frequency fits the specific heat data in certain cases, but fails for several elements crystallizing in the cubic system. The Debye function is the integrated sum of a continuous sequence of Einstein functions over a range of frequencies with weights proportional to their squares and a sharp cut-off at an upper limit. Experimental data which fit a Debye function should therefore equally be capable of being represented as the sum of a finite number of Einstein functions with appropriate frequencies and weight factors.

In Einstein's earliest papers, he pointed out that approximate relations between atomic frequencies and elastic constants were to be expected from elementary considerations. No special significance can therefore be attached to the fact that elastic constants calculated from the specific heats come out of the right order of magnitude.

Born's Theory of the Cyclic Lattice

The Born theory is criticized on the grounds that in essence it is based on concepts derived from the macroscopic behaviour of elastic solids of the same kind as are used by Debye. Born's theory rests on his postulate of the 'cyclic lattice'. All the atomic displacements are taken to be periodic in a volume having the same shape as the unit cell of the lattice but of very great size in comparison with it. The postulate makes no distinction between the atomic vibrations of high frequency and the elastic vibrations of low frequency. All the possible vibrations are assumed to have wave-lengths which are submultiples of the external dimensions of the crystal. This is in contrast with the Raman theory, where the unit cell or integral multiples of it are taken as determining the characteristic vibrations. The size of crystal would affect the modes of vibration only in so far as the unit cells at the surface of a crystal differ from those in the interior. The differences would be of the order of the difference of specific heat as determined with a single crystal and with the same mass of small crystals.

Spectroscopic Data

Whereas the Debye and Born theories lead to vibration frequencies of a crystalline solid giving a continuous spectrum, the Raman theory leads to a line spectrum. The relevant experimental data may be got from studies of the Raman spectra, the luminescence of crystals excited by light or by electric bombardment, and the absorption spectra.

A striking feature of the spectrum of the radiation scattered when a monochromatic beam traverses a transparent crystal is the *sharpness* of the lines of displaced frequency appearing in the infra-red. This feature is characteristic of the lines associated with either extensional or distortional vibrations of the ions or molecules in the crystal lattice or with translational or rotational motions. The latter type fails to appear when the substance is in the amorphous or fluid state, being then replaced by a diffuse continuum. The monochromatism of the vibrations is therefore closely associated with the crystalline state. Two plates are reproduced showing this monochromatism associated with superlattice frequencies for quartz and diamond.

Detailed studies of the relevant data have been made in the Physics Department of the Indian Institute of Science, Bangalore, and are presented in a series of six papers. R. Norris deals with white phosphorus and quartz, B. Dayal with the cubic metals (lithium, tungsten, gold, silicon and grey tin) and with the hexagonal metals (magnesium, zinc and cadmium), V. B. Anand deals with diamond and C. S. Venkateswaran with alkali halides. Good or improved agreement of theory with experiment is found by using the Raman theory instead of the Debye theory. Numerical comparisons using the Born theory appear to be missing. The bulk of the thermal energy is associated with unit-cell frequencies appearing as monochromatic lines in the infra-red. The residue, associated with superlattice frequencies, appears in the remote infra-red, is monochromatic and is relatively important only at low temperatures.

ADVANCE IN INVENTION: ITS RELATION TO WORLD PEACE

By D. CARADOG JONES
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A YEAR after the outbreak of the present War the results were published of a study of the causes of the failure to preserve peace. The members of the study group are described as mainly officers of international organizations with headquarters at Geneva, meeting unofficially and able therefore to contribute to the discussion without reserve. The publication was issued under the authority of the Carnegie Endowment for International Peace.

World Unity

The factors that led to war are classed under three heads: political, economic, spiritual. But all three, when critically examined, are revealed as a failure to visualize the world as an organic whole. "The most startling example of the collective failure" to take a world view, under the political head, they say "was the attitude adopted toward Germany, not only in the clauses of the settlement, but still more in the manner of their presentation. . . . In particular, the refusal to negotiate with Germany created an attitude of mind in that country that was never subsequently changed." Put the rulers of Germany under restraint; yes. Make the German people suffer; impossible, unless we are prepared ourselves to suffer with them. However much they may appear to our limited vision to deserve punishment, by placing them in the dock we shall but bring judgment upon our own heads. We are reminded of an illuminating analogy due to that far-sighted statesman, Señor S. de Madariaga: "A nation, a limb of the world, misbehaves, i.e., it acts against the world community, which is the whole body. And sanctions are decided on to punish it. But, can we punish a limb without punishing the whole body ?" If we sow the wind, we reap the whirlwind.

The fundamental character of this principle of world unity comes out nowhere so clearly as in the economic aspect of international relations. The Geneva group recall the sequence of events following the attempt to extract huge reparations from Germany. Failure to grasp the fact that payment in goods would immediately put large numbers of people in the allied countries out of work may be taken as evidence that the mismanagement of affairs after the War of 1914–18 was due in large measure to a lack of understanding of elementary economics. It was as much a failure of the head as of the heart. Happily there are signs of greater enlightenment among those who are at present responsible for advising the leaders of the democratic Governments in such matters. In particular, they are fully aware of the consequences of the remarkable progress achieved in technological invention. This was causing so great a revolution in industrial production, even before 1914, that it was bound sooner or later to lead to trouble between nations if each attempted to pursue its own self-interested path regardless of the welfare of others; and this new industrial revolution may cause still greater disaster after the present War if its implications are not more widely and clearly realized. It is essential that Governments should be able to depend upon the support of public opinion for any concerted measures they may adopt for the control of output and its distribution, in the interests of the world as a whole and especially of the weaker nations.

Progress in Output

A few facts may be given which bear striking witness to the extent and the rate of advance in the output capacity of modern machinery. Colin Clark has made a comparison of the real income produced per head of the working population in different countries on the basis of a 48-hour week. His figures indicate a rise in Sweden and Japan to a level more than four times as high as that reached seventy or eighty years ago. In most highly industrialized countries the income so calculated has been at least doubled during the same period of years, and this was accomplished in spite of a considerable increase in population and decrease in the hours of work. In the last two decades the rate of progress has been even more astonishing. According to an estimate published by the Royal Economic Society, the increase in physical output per operative in the United

Kingdom, for all industries covered by the Board of Trade Census of Production, was 34 per cent between the years 1924 and 1935 and 27 per cent during 1930–1935. For engineering the corresponding increase, 1930–1935, was 57 per cent; for textiles, 37 per cent.

Even allowing a considerable margin of error in all these figures, there is not the least doubt about their general trend. Moreover, the wide range of invention is as striking as the acceleration in output. The telephone, the motor-car, the aeroplane, the motion picture, and radio have had so far-reaching an influence upon the structure of society—turning almost unknown nations into next-door neighbours overnight—that it is only with a jerk of memory we recall that they are largely the product of the present century. About a million telephones were in use and the motor-car was just being introduced into the United States forty years ago; now the telephone industry is the third largest public utility concern in the country and there is one motor-car for every five people. The aeroplane was regarded with scepticism and the other two inventions were as yet unknown. These facts are mentioned by Prof. W. F. Ogburn in a recent American publication, which directs attention also to the immense and fascinating possibilities the future holds for us, arising out of the discovery of synthetic resins and plastics: rayon, artificial cotton, and wool derived from cellulose; synthetic rubber and wood substitutes; devices such as the photo-electric cell, and many other inventions.

What does all this imply? It should surely imply a fuller and more varied life for all mankind, if only we could agree upon a fair method of sharing the products of hand and brain. There comes the hitch. The new industrial revolution burst upon us unprepared; we all know how a few primary producers were driven in sheer desperation to destroy their surplus stock, after a vain attempt to dispose of the overwhelming output of certain commodities at remunerative prices. Is there no danger that the same conditions will return when this War ends? The urgency of essential war requirements speeds up output enormously and sharpens inventive wit. It is certain, therefore, that the pace and capacity of production of our machines will be very much greater than they were when the War of 1914–18 ceased. Past experience proves, too, that it will be a relatively simple matter to change over from war to peace production. Yet, before this War started, it was estimated that the people of the United States, to take but one example, could subsist if necessary on about one third of their output, leaving the remaining two thirds to be devoted to other purposes. What is true of the United States is true, in varying degrees, of other equally advanced countries.

Problem of Surpluses

This presents the problem of surpluses in a new and significant light. It is clear that under conditions of peace, if our aim is to provide employment for all who are capable of work—since sharing the work available, by a general reduction in the weekly hours of labour, would only be a partial solution of the unemployment problem—the potential supply of many commodities, with full employment, will far exceed the effective demand for them within the country of their origin. What then can the United States, for example, do with her vast surplus? She can only hope to exchange a relatively small part of it for the few commodities which she cannot herself produce. As for the rest, she has a choice of four courses: she can destroy it, which no one would commend; she can store it or sell it on long credit, but either of these two courses would only put off the day of reckoning and make the problem more difficult to solve eventually; the one choice left open is to give it away to nations whose need is greater than her own. To put this last suggestion into practice, though at first sight revolutionary, would be entirely consistent with the fundamental principle of world unity, whereby all the peoples of the world are regarded as one people, one family of nations. The average real income per occupied person in the United States has been very roughly estimated at one hundred dollars a month; the corresponding figure in India or China would be equivalent to five or ten dollars at most. There is a like discrepancy between the standard of living among these Asiatic peoples and that which we in Great Britain enjoy, and the difference is a measure of our responsibility towards them. A carefully planned scheme of assistance, covering all aspects of life, would in course of time result in greatly improved conditions in both India and China.

How is such assistance to be given? Let us suppose that, with the return of peace, a time comes when we have in use all the labour we can effectively employ to satisfy our own needs, but that many men are still without work and our machines are not running at full pressure. Manufacturers are unwilling to take the risk of increasing their production, because they anticipate no increase in demand in the home or foreign market at existing prices. There are two courses then open. The Government may maintain these potential workers in idleness, which is bad for everybody concerned. That was the policy adopted after 1914–18. The alternative is to find work for them. India and China are in sore need of tractors and other agricultural implements. They might indeed be able and willing to pay for them with rice, tea, silk and other commodities if the price asked were not too high. But it would be far better for the British Government to make free gifts to these countries than to permit our labour force and our plant to deteriorate by remaining idle. The cost of the creation of any additional credit notes needed would be trifling, and no money is wasted, in the sense of being used up, by circulating it. Contracts would be given to engineering firms in the normal way; they would be paid fair prices and the workmen would receive good wages for the work done. Their increased earnings would result in increased expenditure, bringing extra gain to shopkeepers and others, besides extra revenue to the Government in taxation. It is thus evident that, by helping to raise the standard of living of depressed peoples, our own standard would rise simultaneously. No nation can move forward at the expense of others: we can only advance together—yet another illustration of the organic unity of the world.

International Pool Control

It should be a relatively simple matter, therefore, to accumulate a pool of surpluses of many kinds from Great Britain, the United States and other advanced countries. This pool might be placed under the control of an International Advisory Council, composed of experienced men and women of the highest integrity, capable of taking a world view in the handling of the delicate problems arising between nations. Such a Council, assisted by fact-finding Commissions of economic and other specialists, would command high authority. It would express a reasoned opinion for the guidance of Governments as to the wisest and most just plan for the control of world production and the disposal of surpluses, based upon a judicial and expert examination of all the data available. The relatively rich countries could be credited if they so wished, at agreed nominal prices, with any 'gifts' they contributed to the pool, and these credits would be regarded as giving them a call upon the pool at any future time should they themselves be in need.

It is not too soon to consider the setting up of an Advisory Council now. The judges of the Permanent Court of International Justice, seeing that they have established for themselves a reputation for wisdom and impartiality, might be invited to prepare a scheme for the selection of a panel of suitable people to serve upon it. Plans are already under discussion for the feeding and restoration of the famine-stricken inhabitants of European countries. It is too big a task for ourselves and America alone; all countries should take pride in working together for this purpose. It might well be handed over to such a body as the proposed Advisory Council. The disposal of surpluses and the feeding of the hungry are clearly complementary problems: the solution of the first is the key to the solution of the second.

One fundamental difference is to be noted between this approach to post-war problems and the Conference method adopted after the War of 1914–18. We leave the arena of politics, where each nation has its own ends in view, and become intent upon an objective and scientific task: seeking to satisfy, out of our common store, the elemental needs of all peoples. Upon that sound moral and psychological basis it should be possible to go on to build a peaceful World Order.

METEOROLOGICAL RESEARCH IN GREAT BRITAIN

AIR MINISTRY RESEARCH COMMITTEE

THE importance of meteorology to aviation has necessitated an extension of the State meteorological service far beyond the modest dreams of meteorologists of the last generation. At the present time meteorological forecasting is a vital element in the national war effort, especially in the conduct of the offensive; but the return of peace and the renewed expansion of civil aviation will maintain the need for weather prediction, which also has great importance for agriculture and many other branches of the national economy.

The science and art of weather prediction have made great progress during the present century, but it remains uncertain whether even now all the fundamental factors that determine the weather changes have been discovered, and also whether the programme of observation yet includes all the elements necessary as a foundation for prediction. The problems both of observation and of theory are extremely complicated. It is therefore desirable that, along with the day-to-day application of the knowledge already available, proportionate efforts should be made to improve our knowledge and our methods.

For this reason the Secretary of State for Air has recently appointed a Meteorological Research Committee to advise and assist in the carrying out of meteorological investigations. The Committee is constituted as follows: Prof. S. Chapman, professor of mathematics at the Imperial College of Science and Technology (chairman); Prof. D. Brunt, professor of meteorology at the Imperial College of Science and Technology; Dr. G. M. B. Dobson, reader in meteorology in the University of Oxford; Prof. G. I. Taylor, Yarrow research professor of the Royal Society; the Director of the Meteorological Office; the Director of Scientific Research of the Ministry of Aircraft Production; the Director of the Naval Meteorological Service; and representatives of the Air Staff and civil aviation.

At present the Committee will naturally be concerned chiefly with problems directly concerned with the war effort, and such work must for the time being remain secret, though any incidental results not likely to be of service to the enemy may be published.

The Committee would welcome contact and co-operation with university departments or other institutions engaged on work that bears on meteorology; as a result of inquiries in the United Kingdom, information concerning such work, and offers of assistance, have been received from several universities. Correspondence, which should be addressed to the Secretary, Meteorological Research Committee, Meteorological Office, Air Ministry, Kingsway, London, W.C.2, is invited from any other university or research institutions which can assist in this work.

Co-operation of the Royal Society

The formation of a Meteorological Research Committee by the Air Ministry, announced above, is an important and very welcome advance in the organization of British meteorological research. The Air Ministry Committee will at present confine its work chiefly to those problems which have an immediate practical application and are likely to be solved in a fairly short time. The Royal Society has been invited by the Air Ministry to co-operate with the Meteorological Research Committee by undertaking research on certain aspects of meteorology which, though of fundamental importance for the advance of the subject, may not have an immediate practical application.

The Council of the Royal Society has agreed to this request, and has entrusted the immediate responsibility for the work to the Gassiot Committee. This Committee, first constituted in 1871, was originally appointed to administer the Gassiot and other trust funds applicable to the maintenance of certain British meteorological and magnetic observatories, and to make recommendations as to their work. The terms of reference have now been enlarged to include the supervision of fundamental meteorological research such as has been asked for by the Air Ministry. The personnel of the Committee is appropriate for this purpose; the chairman is Dr. G. M. B. Dobson, and the members are Sir Edward Appleton, Profs. D. Brunt and S. Chapman, Sir Henry Lyons, Sir George Simpson, Prof. G. I. Taylor, Sir Gilbert Walker, the Astronomer Royal, the President of the Royal Astronomical Society, the Director of the Meteorological Office, and *ex officio*, the Treasurer of the Royal Society (Prof. T. R. Merton) and the Secretary of the Royal Society (Prof. A. C. G. Egerton).

These arrangements seem eminently suitable, because pure fundamental research which may have

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to be continued over a long period, and which requires the co-operation of many independent workers in university departments and laboratories, can probably be organized more easily by the Royal Society than by a Government department, however much the latter may be in sympathy with the object of the researches. The Royal Society has already shown its willingness to further such work by appointing Dr. E. Glückauf to a Mackinnon Studentship, to enable him to carry out meteorological research under the general guidance of the Gassiot Committee.

The general research in which the Air Ministry has sought the co-operation of the Royal Society is that of radiation in the atmosphere, with special reference to radiation equilibrium conditions in the stratosphere. It is fairly generally accepted that the average temperature of the stratosphere—as of the warm region above it—is determined by an equilibrium between the energy absorbed, from both the downward solar radiation and the upward terrestrial radiation, and the energy radiated by the air in the stratosphere. Observations have shown that there are large variations of temperature in the stratosphere both with time and with place, but we know little as to why such variations occur. Few meteorologists, for example, would care to be dogmatic as to why the stratosphere is some 50° C. *colder* in equatorial regions than in polar regions.

The principal gases of the atmosphere are mostly very transparent to radiation, and the radiative conditions are largely governed by such minor but polyatomic constituents as water vapour, carbon dioxide, ozone and possibly others. To understand the radiation equilibrium in the atmosphere, it is necessary to know (*a*) what gases are present which have important absorption bands for radiation; (*b*) in what proportions they are present at different levels; (*c*) how gases such as ozone are formed and decomposed; (*d*) the absorption coefficients of these gases for different wave-lengths, and whether the absorption and emission spectra have a continuous or fine line structure. Finally, when the above facts are determined, it will be necessary to calculate the radiation equilibrium temperatures at different levels and to determine how rapidly the temperature will change when the conditions alter.

The Gassiot Committee has been fortunate in enlisting expert help in particular branches of the subjects involved, and has formed three sub-committees to deal with different aspects of the above question. It is hoped in this way that the available relevant knowledge will be collected, and that those questions which require more experimental work may be defined, so that arrangements can be made for the work to be done, so far as this should prove possible under present conditions.

Dr. G. M. B. Dobson is the chairman of Sub-Committee A, which will deal with the chemical analysis and the observation of the amounts of the polyatomic constituents of the air at different levels; other members of this sub-committee are Profs. H. Dingle and F. A. Paneth, and Dr. E. Glückauf.

Sub-Committee B will deal with the photophysics and photochemistry of the atmosphere, from the highest levels downwards, and, in particular, with the changing equilibrium of ozone and any other variable polyatomic constituents; the chairman of this sub-committee is Prof. H. W. Massey, and the members are Prof. K. G. Emeléus, Dr. W. C. Price, and Dr. J. Sayers.

Sub-committee C will consider the radiation balance in the atmosphere; its chairman is Prof. S. Chapman, and its members are Prof. D. Brunt, Dr. G. S. Callendar, Dr. T. G. Cowling, Dr. A. R. Meetham, Sir George Simpson, and Dr. G. B. B. M. Sutherland.

There will be few who will not agree that the first meteorological problem thus selected for attack is a very important one, and still fewer who will dispute its difficulty. It is hoped that the scientific effort which the Royal Society can bring to bear on this work will lead to substantial progress. The Gassiot Committee is aware that at laboratories and institutions in many parts of the world work has been undertaken that bears on these problems, and the Committee would welcome co-operation in cases where the continuance of such work is possible in present circumstances.

SCIENCE AND TECHNOLOGY IN THE SOVIET UNION

SCIENCE and technology in the Soviet Union was the subject of the first of the two symposia held over the Easter week-end by the Faculty of Science of Marx House (Marx Memorial Library and Workers' School) at the London School of Hygiene and Tropical Medicine. Prof. J. B. S. Haldane presided and nine speakers took part in the two sessions. The second session, on Race and Fascism, was dealt with in NATURE of April 18, p. 426.

Prof. J. D. Bernal spoke on physical science in the U.S.S.R. A great deal of fundamental work has been done in the Soviet Union and many difficulties have been overcome. In 1920 there were only forty trained physicists in the whole country, but by 1934 in the big institutes in Leningrad there was a six years course which was more rigorous than that in the Cavendish Laboratory. Since then tens of thousands of physicists had been trained. Physics played a vital part in the general plan of development and in the preparations for the expected attack on the country.

As an example of the manner in which the fundamental problems studied arose from the needs of Soviet economy, Prof. Bernal took the transmission of electric power. Power losses which were trivial in Britain became serious because of the great distances in the Soviet Union. The properties of insulators had to be studied and this required fundamental work on the passage of electricity through crystals and on the quantum theory of the solid state. In the metal industry, also, problems arose which led to a rapid development of crystal physics under Joffe and to the working out of a dynamic theory of plastic deformation. Rehbinder's discovery that the hardness of metals varies according to the surrounding medium is a fundamental one and has already led to changes of technique in dealing with metals.

Science is planned in the U.S.S.R. as a part of economy as a whole on the basis that, statistically, the results will be proportional to the effort applied in any particular field. Only the general requirements are given from outside, and the Academy of Sciences works out in general where the main lines of attack should be made. Each group of workers in each laboratory settles its own problems of how to go about the work. To-day the whole of Soviet science has been turned to the job of winning the War, to the problems of the production and use of new weapons, to the reorganization of industry in new areas, and to the discovery of new materials and sources of supply. The present lack of contact between Soviet men of science and those of other countries is very much to be deplored, and knowledge of what they are doing would help us to realize in a rational way the possibilities of science for a new civilization.

Mr. H. P. Vowles, speaking on electrification in the Soviet Union, said that Lenin, with his genius for applying Marxist theory to a concrete situation, realized very early that the new Soviet State would be menaced from within as well as from outside so long as small-scale methods remained the dominant mode of production. He realized that it would be impossible to build up large-scale production without electrification, hence his well-known saying that in Russia "Socialism was the Soviet Power plus Electrification". On Lenin's initiative the Commission on Electrification known as GOELRO began work and soon achieved the first success of the new State in industrialization.

Mr. Vowles stated that, although the United States still leads the world in output per capita of electricity, the Soviet Union has drawn level with that country in many features of electrification and has surpassed it in rate of electric development, in the development of heat and power stations, in the mechanization and electrification of agriculture and in the correlated planning of production and consumption of electricity. The United States originally took its engineering technique from Britain, but from 1850 Britain drew increasingly on American technology and skill. The Soviet Union has been greatly indebted to the United States for the technique of power production, but already after the short period of twenty years the Americans can learn much from Soviet electrification.

Dr. N. F. M. Henry discussed the part of geology in Soviet economy. He showed that although there were a few geologists of international standing in Tsarist Russia, less than 1 per cent of the vast area of the empire had been mapped on a scale of ¼-inch to one mile. From the beginning, the Soviet Government paid special attention to geology because the fundamental position of this science in the building of a socialist economy was realized. The electrification and industrialization of the country urgently demanded coal, iron and large supplies of many other mineral substances. Because of the great distances involved it was of vital importance to develop mineral supplies in many parts of the country. It was impossible to survey the 8 million square miles of the Soviet Union square by square as was done in Britain over a period of a hundred years. Soviet geologists were faced with a double problem of teaching thousands of young geologists and of developing geochemical theory as a guide to the rapid study of the most suitable areas for mineral exploitation. The mineral output of the Soviet Union to-day is evidence that these big problems were tackled with energy and with very good organization. It is no accident that Soviet men of science should lead the world in geochemistry, for its development was urgently demanded by the needs of Soviet economy.

In 1936 the total amount spent on geological work was 1,000 million roubles (about £38,000,000), but in March 1938 it was officially stated that this was to be doubled. The permanent scientific staff of the Central Institute for Geology numbers 500, but the total number of geologists and prospectors working under its control is about 10,000. These figures show the importance of geology to the Soviet Union, and this importance is reflected in the tremendous public interest in the subject. Millions of school-children study it in the field and in the laboratories of the Pioneer Palaces. The man in the street often reads of the latest discoveries, and the leading geologists are public figures.

Mr. H. Rose spoke on aspects of Soviet developments in chemical engineering, dealing in particular with the underground gasification of coal and with the Soviet rubber industry. While proposals for the underground gasification of coal were first made many years ago by Mendeléeff, and by Sir William Ramsay who actually carried out trial bores in Great Britain, it was Lenin who first paid serious attention to the possibilities opened out by this revolution in technique. In 1937 experimental shafts were sunk, after much careful preparation, in the Donbas. The successful development on a wide scale which was begun in 1940 was made possible by the work of Kapitza, who recently received a Stalin Prize, on the low-pressure liquefaction of air, because a cheap supply of oxygen is required to improve the quality of the gas.

The social and economic implications of this new development are of tremendous importance, for one man can now do the work of ten miners. Mr. Rose believes that technical developments in steel blast furnaces will probably do away with the need for mining coal even for metallurgical coke, and then in the Soviet Union the hard and dangerous occupation of underground coal mining will disappear completely.

Although scientific men such as Kondakov and Lebedev, working under the old regime, made considerable contributions to the early study of rubber, it was not until after the Revolution that this study developed enormously and led to the production of synthetic rubber on a large scale from 1931 onwards. To-day the Soviet Union is probably the largest producer of synthetic rubber in the world, and 80 per cent of her requirements are now satisfied by the synthetic product. In addition, the rubber problem is being solved by the rapid development of the natural rubber-yielding plants Kok-Sagyz and Tau-Sagyz.

Dr. M. Ruhemann dealt with low-temperature research and development. He spoke in particular about the separation of natural and industrial gases, which necessitates the use of low temperatures and refrigerating machinery. The studies of Soviet scientific workers on the phase equilibria of different gaseous mixtures and of the solid-liquid mixtures of several binary and ternary systems are now well known. These findings were applied to coke-oven gas, and important results were soon obtained, such as the extraction of hydrogen of 97 per cent purity and the development of a new method of obtaining krypton. As a result of this scientific research, the Soviet Union now has a larger gas separation industry than any other country in the world, and this is of great importance for the heavy chemical industry.

The afternoon session was opened by Prof. J. B. S. Haldane, who spoke on the biological sciences in the U.S.S.R. In biochemistry, work has been done on the way in which a protein 'gets itself copied', and the emphasis has been on the study of processes rather than on the isolation of substances. In sheep genetics the Soviet Union is well ahead, and the beginnings of a chromosome map for sheep are now visible. New species of plants have been produced such as an octoploid wheat, and the great work of Vavilov on the systematics of cultivated plants has led to the development of types suitable for many parts of the vast territory.

Umanski's discovery that cancer tissue will act as an organizer is very important, and work is proceeding on the study of the conditions necessary for tissue to be capable of being organized. In medical techniques several advances have been made. The transfusion of cadaver blood is a regular procedure now, and it has been found that it is more effective than blood from living donors, although the reason for this is not yet known. The grafting of tissues from corpses was based on the idea that the distinction between life and death and between different organisms is not so fundamental as has been thought. By the use of such processes, Filatov and his assistants have probably restored sight to more people than all other surgeons in the world put together.

Soviet biology is linked not only with agriculture, but also with the development of fishing, hunting, the timber industry, and very closely with medicine. Nevertheless, it does much work of fundamental importance which is altering our theoretical approach to many biological problems.

Mr. J. L. Fyfe made a contribution on the genetics controversy in the U.S.S.R. In his opinion the clash between the geneticists and Lysenko, a physiologist, arose because of the close relation between science and technical needs. Vernalization is the opposite of plant-breeding in the sense that it is designed to produce improved forms of crops by treatment, not to select them by testing. The special importance of vernalization in the Soviet Union is its speed as compared with plant-breeding. In 1931 Stalin said that the Soviet Union was fifty or a hundred years behind the advanced countries, and he gave the country ten years to make up leeway. Prejudices have obscured the issues, and this controversy has developed in a period of strong anti-Soviet propaganda. Mr. Fyfe went on to discuss the relation between genetics and the ideas of Lysenko. These ideas are in many ways contradictory to the basic postulates of genetics, but it is significant that recent developments in genetics itself are doing very much the same thing. Genetics is thus approaching a crisis, and the work and ideas of Lysenko are contributing to this developing crisis. The crying need, however, is for careful experimental work to test the theories of Lysenko, for it would be as foolish to set him up as an infallible prophet as it is to dismiss his work lightly.

Mrs. Beatrice King spoke on science in Soviet school education, which, she said, can only be understood in its social and economic setting. In the struggle of an economically backward country to transform itself in a few years into an advanced one through the building of a socialist economy, science has been of prime importance. In education, also, the Soviet Union has passed through a period of intense struggle to become an advanced country and to develop among the people the scientific outlook which is essential for the building of socialism.

In school the approach is historical and international, and science is directly linked with social and economic problems so that children learn at an early stage to think scientifically and not to regard science as a separate subject. All children study scientific subjects experimentally as well as theoretically, but there is no specialization in ordinary schools. The text-books which are used in schools and in universities are generally the work of several writers and are always tried out for a year before being finally approved.

Outside school, science plays a large part in the lives of the children. Science and scientific discoveries bulk largely in the literature of children of all ages, while their plays and films often have scientific subjects. The children's Pioneer Palaces always have laboratories, and school science and exploration clubs flourish, while excursions to the country and to museums and regional-study holidays are attended by millions of children every year.

Dr. M. Ruhemann spoke on the scientific worker in Soviet society. Soviet men of science have closer contact with other strata of the population than is the case in Western countries, and they react to the pressure of public opinion from a people which has learned to respect science and to expect a lot from it. In most cases students receive a stipend from the State during their five-year course. The best students can proceed to do research work with increased stipends and are entitled to all the help that their seniors can give them. As a member of the same trade union as all other employees in the institution, whether technical, scientific or office workers, the man of science becomes bound up with the life of the institute. The intense Soviet life around, the unlimited scope for solving practical problems, and, finally, the basic Marxist conception of science as the foundation of technique and of the development of the productive forces of society make the scientific worker a conscious and enthusiastic citizen.

The whole symposium was attended by about 250 people, and Marx House is to be congratulated on the organization of such a successful set of meetings. These symposia constitute a valuable contribution to Anglo-Soviet unity and understanding.

THE SCIENTIFIC WORK OF ELIE METCHNIKOFF

By DR. G. F. PETRIE
Lister Institute

THE heightened interest in the cultural and intellectual activities of the U.S.S.R. has stimulated a desire to know more about the work of outstanding Russian men of science who belong to the recent past, and thus the anniversary of the birth of Metchnikoff on May 16, 1845, is a fitting time to survey his achievements and to indicate the significance at the present day of his fundamental work on the role of phagocytosis in inflammation and immunity.

Metchnikoff's training as a zoologist was of the greatest value to him throughout his life in guiding his researches, and indeed in consequence of it he was led to the central point of his theory of immunity, for during his stay at Messina in 1882 he made his observations on the mobile cells of a transparent starfish larva and conceived the idea that similar cells might serve to defend the organism against intruding particles whether these were living or non-living. A simple experiment carried out on the spot went far towards establishing the proof. As he himself wrote: "A zoologist until then, I suddenly became a pathologist." During the next twenty-five years the theory was extended by Metchnikoff and his pupils and by numerous workers in many parts of the world to include bacterial infections such as anthrax and erysipelas, with the result that ample evidence of the importance of phagocytosis as a means of disposal of intrusive bacterial elements was forthcoming.

Metchnikoff was fortunate in his choice of scientific associates and of the milieu in which his life-work was done. On his first visit to Pasteur in 1887 he was kindly received and was offered a laboratory in the then newly built Institute in the Rue Dutot, whereas, soon afterwards, Koch in Berlin and Emmerich in Munich gave him such a cool reception that he decided to accept Pasteur's offer, and thus in October 1888 he entered the most fruitful period of his career, which lasted until his death in 1916 at the age of seventy-one.

The controversies on the rival doctrines of immunity upheld by the French and the German schools—which, on one side at least, gave the impression of national partisanship—are now of merely historical interest. The humoral theory to which the German workers obstinately clung was based on the direct bactericidal action of the blood-serum of normal and, in particular, of immunized animals. The view now held is that active phagocytosis depends upon sensitization of the bacteria by bacteriotropic substances that are present in normal and immune sera. The two points of view are thus by no means mutually hostile ; they are indeed complementary and their relative importance varies with the particular instance of an infective process that is chosen for illustration. After Metchnikoff's death, Aschoff and other workers systematized the cellular theory of immunity by defining the types of cells scattered throughout the tissues and organs of the body that are capable of functioning as phagocytes ; these form the so-called reticulo-endothelial system of cells. This scheme of classification has conduced to precision and convenience of description. Recent studies of phagocytosis have been numerous and have been directed towards elucidating the finer mechanisms of the process as revealed by physical and physico-chemical methods. The romantic attribution to the phagocytes of purposeful activities as defenders of the citadel of life against bacterial invaders, which so impressed the popular mind in the last decades of the nineteenth century, has given place to more prosaic interpretations. Experimental work has thrown light on such problems as the part played by the nature of the surface of the particles exposed to phagocytosis ; the influence of the *p*H of the surrounding medium upon the exposed particles and upon the phagocytes ; the influence of temperature, of surface forces, and of the viscosity of the cell protoplasm upon the intake of particles ; and the differences that are observed in the functional activity of leucocytes when these are collected from healthy and diseased subjects.

Metchnikoff's researches included studies on the comparative pathology of inflammation, a process in which phagocytosis is one of the chief manifestations. His observations on chemotaxis and on intracellular digestion of bacteria engulfed by the phagocytes have not been disturbed by the newer knowledge. There still remains, however, for solution the refractory problem of the deviations from the normal of the biochemical activities within the local phagocytes and fixed tissue cells ; these changes must be assumed to vary both in quality and degree throughout the phases of the inflammatory process until the lesion has healed.

The general interest aroused by his work on the transmission of syphilis to chimpanzees and on the prophylaxis of the experimental disease by the inunction of mercurial ointment is still remembered. Metchnikoff had a passion for probing into the mysteries of life and death, as is shown by his own mental reaction to his approaching dissolution, but it would seem that in his views on the production of senile changes in the tissues caused, as he thought, by intoxication from harmful intestinal bacteria, his imaginative powers outran his judgment ; the habit of drinking sour milk as a preventive measure against ill-health and premature old age has now disappeared. Nevertheless, his work has encouraged the important study of the physiology and pathology of senescence, and within recent years this subject has engaged the attention of an enthusiastic group of scientific workers in the United States and also in Great Britain.

Metchnikoff was international in outlook both as a man of science and as a humanist, and here it is worth quoting a sentence from the warmly expressed tribute of Emile Roux, his friend and colleague, on the occasion of Metchnikoff's seventieth birthday. "Resté Russe de nationalité, vous êtes devenu Français par votre choix et vous avez contracté avec l'Institut Pasteur une alliance franco-russe, longtemps avant que les diplomates en aient eu l'idée."

Is it, perhaps, too fanciful to believe that the far-reaching speculations of Metchnikoff were influenced by the early impressions which he formed when as a boy he viewed with the eyes of a born naturalist the boundless steppes that surrounded his village home near Kharkoff ? He can never lose his place among the company of the pioneers of experimental medicine.

Dr. B. M. Griffiths

DR. B. MILLARD GRIFFITHS, who died on March 25, was born at Kidderminster in 1887, and studied at the University of Birmingham during the years 1905–8 ; he took the D.Sc. degree of that University in 1923. Towards the end of the War of 1914–18 he was assistant to Prof. Yapp at Belfast, but in October of 1920 he was appointed lecturer at Newcastle and afterwards, in 1924, became reader in charge of the new botanical laboratories established at Durham, which he placed upon a secure footing.

His early work concerned the giant bacteria belonging to the genus Hillhousia and was carried out in conjunction with G. T. West, but most of his scientific investigations related to the Algæ. Already in 1912 he published a paper on the Algæ of Stanklin Pool and in 1915 a morphological study of Glaucocystis, while afterwards he turned his attention chiefly to planktonic and limnological studies. We owe to him a considerable number of data on the phytoplankton of the lowland pools of Britain contained in a number of papers published in the Linnean Society's Journal.

He took some part in the foundation of the Freshwater Biological Association and for several years represented the University of Durham on its Council. During the later years of his life he suffered much from ill-health, and this no doubt contributed materially to reduce his output of scientific work, which showed considerable promise.

F. E. FRITSCH.

NEWS and VIEWS

Grassland Research in Great Britain

Sir George Stapledon, C.B.E., F.R.S.

The appointment of Sir George Stapledon as the director of the Ministry of Agriculture Grassland Improvement Station, Dodwell, marks a break in a long period of pioneer service which may be said to have revolutionized the current methods of grassland management. After holding the posts of professor at Cirencester and adviser in agricultural botany at Aberystwyth, Sir George became the first director of the official Seed Testing Station when it was founded by the Food Production Department of the Ministry of Agriculture during the War of 1914–18. Thence he proceeded to the chair of agricultural botany at Aberystwyth and also became director of the Welsh Plant Breeding Station when it was founded in 1919. Gathering round him a band of enthusiastic and patient research assistants, he began the long series of experiments which have made his work famous the world over.

So early as 1913 Sir George was interested in pasture problems, such as drought resistance, and the response of grassland species under manuring, and in 1916 he collaborated with his present successor T. J. Jenkin in investigations on indigenous species in relation to habitat and sown species. For the next twenty-five years his attention was devoted to the various ways in which the grasslands of Great Britain could be improved and better use made of the great acreage of unprofitable and neglected pastures up and down Great Britain. The importance of varieties and strains was fully recognized, and geneticists and plant breeders on his staff concentrated their attention on the production of the special types of the herbage plants needed for specific purposes. The labour involved was immense, and only by most skilful organization has it been possible to carry through the work without confusion or delay, and to apply the results to agricultural practice. Varieties of grasses and clovers have been bred for earliness or lateness, for leaf or stem production, for spreading or erect types, to provide seed to meet different requirements.

Parallel with the plant-breeding work, problems of management were investigated, particularly in relation to the effects of grazing, and the most amazing and valuable results were obtained. But all the time Sir George was working towards his main object of obtaining recognition from the Government and farmers alike that poor or derelict pasture could be so improved as to become an important asset instead of a liability. Much preliminary critical work was carried out, the importance of buried and viable seeds in the soil being early recognized. Then in 1933 the Station acquired Cahn Hill, whereon large-scale hill experiments could be made in order to develop methods whereby improvements could be made and to determine their economic value. Much progress has been made, both on the hill pastures and in connexion with ley farming, in which poor permanent pasture is improved by ploughing up and reseeding. Sir George Stapledon's new appointment will provide an excellent opportunity to demonstrate the value of his ideas, backed by wide experience, and the venture will be followed with great interest by all who have the interests of agriculture at heart.

Dr. T. J. Jenkin

Dr. T. J. Jenkin, who succeeds Sir George Stapledon at Aberystwyth as professor of agriculture and as director of the Plant Breeding Station, has been associated with the Station from its very early days, and prior to that was adviser in agricultural botany at the University College of North Wales, Bangor. At this time he also worked on seed testing and collaborated with Sir George Stapledon. His early work at Aberystwyth included rust resistance trials with wheat, but his attention was soon concentrated on the genetics and breeding of grasses, of which work he was in charge. For years he has devoted himself to the varied aspects of grass improvement, including the problems correlated with self- and cross-fertilization in the more economic species, carrying on comprehensive experiments in connexion with the artificial hybridization of grasses. His work on inter-specific and inter-generic crosses with the grasses opens up many possibilities for the future of grassland improvement.

The valuable results obtained during the comparatively short space of a quarter of a century are eloquent of painstaking and accurate concentration on a multiplicity of details, involving great personal sacrifices of time and leisure. The appointment of Dr. Jenkin as successor to Sir George Stapledon ensures that the best traditions of the Plant Breeding Station will be carried on by one who has himself done much to build up the esteem with which the work of the Station is regarded.

Agricultural Advisers in Washington and London

The growing importance of agriculture, both in national and in international affairs, has in recent years necessitated certain changes in diplomatic and consular representatives. Denmark, Norway, Sweden and Holland have long had agricultural councillors attached to their consulates in London ; men of high distinction such as Mr. Harald Faber, Mr. van Rijn, Mr. I. Bagge (to mention only past officers) and others whose pre-eminence in their subject caused them to be greatly respected by experts in Great Britain. The United States has now appointed an agricultural adviser, Mr. Loyd V. Steere, who has already had some years of service in Berlin, so that he is thoroughly familiar not only with American but also with Continental conditions. Mr. Steere will be cordially welcomed by British agriculturists.

The British Government has now decided to appoint an agricultural expert to its Embassy at Washington and has selected Prof. Scott Watson for the post. The choice will give universal satisfaction. Prof. Scott Watson has an unusually wide knowledge of the subject and of the persons concerned with it. He holds the Sibthorpian chair of rural economy in the University of Oxford, is a member of the Agricultural Research Council and the Agricultural Improvement Council ; he is also editor of the Royal Agricultural Society's publications, and is a well-known broadcaster.

Scientific Direction of War

Recent correspondence in the Press on the direction of war strategy, to which reference is made in the leading article on p. 531 of this issue of Nature, has had a sequel in the form of a discussion in the House of Lords on May 5. Lord Denman directed attention to the White Paper on Organization for

Joint Planning recently issued, and said there is a considerable amount of dissatisfaction among technical and engineer officers regarding methods of applying equipment to the Army. "We have men of great scientific ability, great technical experts, good factories and workshops, and skilled craftsmen and mechanics, but we need to make sure that they are being utilized to the best advantage." There should be a chain of technical responsibility from the Army Council down to the units in the field. Viscount Swinton also emphasized that we have the men of ability needed in the various fields, but found fault with the present system of utilizing them. Lord Milne said that the "great necessity at the present moment is a scheme to link together our great advantages in technical science with our requirements in military strategy".

Lord Hankey, who has until recently been much concerned with the co-ordination of resources of man-power in different fields, pointed out that the White Paper shows that great advances have been made at least in the lower stages, in the provision for collaboration, but there is room for further improvement, particularly at the ministerial stage. He expressed the hope that it would be possible to add a scientific staff to the Joint General Staff. "Each of the Service Departments is already using scientists, and has found them of great value for operational and other purposes. It is obvious that they should also be brought into the central control of the war." This reminds one of the attitude taken by Sir Henry Tizard in his address at the annual luncheon of the Parliamentary and Science Committee (see NATURE, Feb. 7, p. 164). He divided the scientific effort in relation to the War into two portions: the tactical and the strategical. With regard to the former, he said that in Great Britain we have nothing to fear from any nation; but the latter is not nearly so sound. The remedy, he said, is "to have scientists working side by side and in the closest collaboration with those who have the administrative and executive responsibility". The weight of opinion, scientific and lay, is clearly on the side of increased participation of science in the strategy of the War.

School Medical Service in War-time

IN a Chadwick Lecture delivered on May 12, Dr. J. Alison Glover, late senior medical officer, Board of Education, discussed the school medical service in war-time. In the thirty-one years between the inauguration of the school medical service and the outbreak of the present War the service passed from ascertainment and treatment to prevention, and is entering into a fourth phase, the search for "positive health", the appreciation "that it is the legislator's task to frame a society which shall make the good life possible" and so enable every child to reach the highest degree of health and development of which he is inherently capable. These phases are well shown in the changing outlook on nutrition, from the ascertainment and treatment of malnutrition to the striving after optimum nutrition. In this period of thirty-one years, the British school-child has undergone a wonderful metamorphosis for which, though many other factors have had a share, the school medical service has been largely responsible. The school-child of 1939 was bigger, more resistant to disease, cleaner and in every way fitter to stand the strain of total war than his predecessor of 1908.

The present health of the school-child after two and a half years of war is shown to be well maintained whether it be judged by clinical assessment of nutrition, average measurements of growth, the incidence of infectious and catarrhal diseases, the incidence of neurosis or the general impression of medical men, nurses or teachers closest in touch with school-children. Much vigilance is, however, necessary. The difficulties which the service encountered from evacuation naturally differed in the reception and evacuation areas. They were increased by the constant ebb and flow of the ceaseless 'drift-back', by the interruptions of alerts, by shelter life, appropriation of schools for other purposes, and by the calling up for service with the Forces of medical men, dentists and nurses. The great development of the provision of meals and milk, the intensive campaign for immunization, the conversion of the camps provided by the National Camps Corporation into residential schools, and the great development of the provision for children under five years were also described. Despite some inevitable curtailment the service has continued to render efficient service.

The Association of Scientific Workers

THE twenty-fifth annual council meeting of the Association of Scientific Workers was held during May 2–3 at the London School of Hygiene under the chairmanship of the president, Mr. R. A. Watson Watt, F.R.S. About two hundred delegates, representing the eighty-four branches into which the membership of almost six thousand is divided, attended the Council. In his opening address Mr. Watson Watt spoke of the remarkable growth of the Association especially since its registration as a trade union, and its affiliation to the T.U.C. Referring to the Conference on "Science and the War Effort" convened by the Association in January last, he said that in spite of the success of that Conference it is necessary to persist if the criticisms made then of the misuse of science in the national effort are to result in practical action.

If any fears have been felt that the remarkable growth of the Association in the trade union field was likely to have diminished its concern to maintain the highest scientific standards, these were set at rest by a number of forceful speeches insisting that the two sides of the Association's work must proceed hand in hand, and resolutions confirming this attitude were carried by an overwhelming majority. Reports were given of the successful action taken by the Association to maintain standards of payment and working conditions in industry, and of the activities of committees dealing with science education, medical services, agriculture, and the proper use of refugee scientific workers. A report was also given of the activities of branches in the work of building up an appreciation of science and scientific method among the general public.

Academy of Sciences of the U.S.S.R.

PROF. V. KOMAROV has been re-elected president of the Academy of Sciences of the U.S.S.R.

At the concluding session of the general meeting of the Academy at Sverdlovsk on May 8, the following were elected honorary members: Prof. W. B. Cannon, George Higginson professor of physiology at Harvard Medical School; Sir Henry Dale, president of the Royal Society; Prof. J. B. S. Haldane, Weldon professor of biometry at University College, London; Prof. Ernest O. Lawrence, director of the Radiation Laboratory, University of California; and Prof. Gilbert Newton Lewis, professor of chemistry and dean of the College of Chemistry, University of California.

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

The Problem of the Autonomy of Life

Prof. F. G. Donnan's review in Nature of April 11 of my book "Science versus Materialism" embodies a few statements about order, organization and energy which ought not to pass without a challenge. He speaks, for example, of "the potency for producing order residing in the disequilibrium between the 'hot' radiation of the sun's photosphere and the relatively cool surface of this planet". Can a scientific man really believe that the difference in temperature between two surfaces (for this is all this statement amounts to) has a potency for producing order ? The remark reads like a parody of present-day fashionable philosophies. Again, Prof. Donnan speaks of the "sun's enormous store of 'organized' energy", and one is bound to ask what his criterion of organization is, and for what reason he considers the energy in the sun to be more organized than energy elsewhere ? Later he speaks of "this disequilibrium (and consequent potency for producing order)". This remark is made with special reference to "the part played by the electro-magnetic field and electro-magnetic radiation". So Prof. Donnan really does seem to believe that disequilibrium can by itself produce order, and that electro-magnetic phenomena have special virtues and accomplishments, such as powers of organization and orderliness.

The truth is, of course, that mere difference in temperature, mere radiation, mere disequilibrium, mere electro-magnetic fields, may be described as the cause of *changes*. Such changes may be ordered if there is something to guide the particles taking part in the change, but they will not be ordered if there is nothing to provide guidance, selection, control, discrimination. When we observe order or organization we have, therefore, to seek for two combined causes : the first is the source of energy, which is usually easy to find, the second is the source of the discrimination. This presents a formidable problem in science. It does so, for example, when we seek to understand the structure of living substance. It is poor science to evade this problem as Prof. Donnan wishes to do.

The *reductio ad absurdum* of Prof. Donnan's view of the potency of temperature differences and radiation would be the assertion that a number of nuts and bolts, connecting rods, piston rings, and other machine parts, would, by nothing more than sufficiently violent kicking, become a complete motor-car, and that this would not happen by chance once in a way, but as often as similar living forms are to be found.

Reginald O. Kapp.

University College,
London.

In his extremely interesting review in Nature of April 11 of "Science versus Materialism" by Prof. Kapp, Prof. F. G. Donnan seems to be playing into the hands of the metaphysicians when he describes radiant energy as a "non-material entity". From his opening paragraph, Prof. Donnan would appear to accept as a definition of 'materialist' one who regards all phenomena, whether pertaining to living or non-living things, as solely explainable in terms of "the existing concepts and laws of physics and chemistry". Certainly his rebuke of Prof. Kapp for suggesting that a non-material something else supports the assumption of a "doubly determined" pattern of life, is consistent with such a definition.

The only logical conclusion to be drawn from the findings of modern physicists is, in my opinion, that electro-magnetic radiations are, *au fond*, just as material as atoms. Physicists used to define matter as "that which affects the senses" ; light, for them, was an "imponderable". But a light-wave acts on sense-organs as truly as a sound-wave or a kick on the shin. Either an electro-magnetic wave-train is of a material nature with properties investigable only by physico-chemical means, or it is not. If, as Prof. Donnan seems to imply, light radiation is 'non-material', what concept are we to form of it ? There is only one antonym to the word 'material' that does not involve tautology, and that is 'spiritual', and to state that an entity is not of a material nature is to state that it is of a spiritual nature.

May I mention some findings of recent physicists that appear to me to militate against excluding radiations from the sphere of materiality ?

(1) The fundamentals of matter (protons and electrons) behave, according to circumstances, as waves or particles ; but the fundamentals of radiations (photons) likewise have both particulate and undulatory characteristics.

(2) Energy is transferable from atoms to radiations and from radiations to atoms.

(3) Mass and radiation are mutually convertible ; thus, the total mass of the separate components of an atomic nucleus is not equal to the mass of the nucleus, but to that mass *plus* the 'energy of binding'. Again, in the hot interiors of the stars matter is steadily being transmuted to electro-magnetic radiations, and, according to Millikan, there is probably occurring in inter-galactic space a complementary synthesis of radiations into matter.

(4) When an electron collides with a photon, the former moves off in one direction with changed velocity ; the photon proceeds in another direction with lower energy (longer wave-length and decreased frequency) but with the same velocity. Despite the modification of each entity, the combined momenta remain constant.

(5) One piece of matter can press on another ; but radiations likewise exercise pressure on matter.

(6) Atoms have weight, but so have radiations, a weight "as real", says Sir James Jeans, "as a ton of coal". Like the apple, radiations are influenced by a gravitational field, and are "attracted" by a mass of matter.

These examples, which are platitudes to Prof. Donnan, are only brought forward to support my contention that an 'immaterial' entity cannot act upon, or be acted upon by, a 'material' entity, and neither can be begotten of the other. Finally, the very expression 'immaterial entity' is surely a contradiction in terms. If it is not, some new definition of 'non-material' that side-steps 'spiritual' is required.

Charles M. Beadnell.

Hollywood,
Egham Hill,
Egham,
Surrey.

MY expression "potency for producing order" means *potential availability for the occurrence of greater order* (*that is, decrease of entropy*) *in another system.* It is no part of my business to enlighten Prof. Kapp on the principles of physical science, but I may perhaps help him by quoting a passage from the writings of a world-famous physicist[1]. "In individual sections of the universe, or in definite material systems, the movement may well be towards a higher degree of order, which is made possible because an adequate compensation occurs in some other systems. Now, according to what the physicist calls 'order', the heat stored up in the sun represents a fabulous provision for order, in so far as this heat has not yet been distributed equally over the whole universe (though its definite tendency is towards that dispersion), but is for the time being concentrated within a relatively small portion of space. The radiation of heat from the sun, of which a small portion reaches us, is the compensating process making possible the manifold forms of life and movement on the earth, which frequently present the features of increasing order."

I must apologize to Prof. Schrödinger for having attributed the expression "organized energy" to him. What he meant was, of course, that the "hot" sun and the "cool" earth represent a *non-equilibrium* distribution of energy, which makes possible the occurrence under suitable conditions of an increase of order (diminution of entropy) on the surface of our planet. It is, of course, quite true, as indicated by my expressions "potency", "potential availability", and Prof. Schrödinger's expressions "making possible", "made possible", that the purely general thermodynamic argument provides only a *conditio sine qua non*, that is, a necessary but not a necessary and sufficient condition. It is this gap which affords a loophole for the metaphysicians (including metaphysically minded engineers), to insert their "entelechies" and "specifications", which are obviously nothing else than words inserted into the description for the purpose of satisfying the personal wish for a mystical element of "causality".

Science, as is seen in the work of the photochemists, biochemists and physiologists, does not proceed in this manner, but endeavours to fill the gap between necessary and sufficient by patient and detailed experimental investigation. I think it would do Prof. Kapp a great deal of good if he could spend some of his spare time in the study of photochemistry and photosynthesis. He would be surprised to find that the relatively high-frequency photons which enter the green leaf do not "kick" the "nuts and bolts" about after the fashion of the mad engineer depicted in his letter. That dramatic scene provides us indeed with a very revealing picture of Prof. Kapp's conceptual "chaos". On the contrary, he would find that the available energy of the "non-equilibrium" photons is largely utilized, by means of the leaf pigments and an enzymatic system, in producing a greater degree of order, not of disorder.

Finally, let me say, as I briefly indicated in my review, that I do not wish to deny that biological science may or will require for its more highly developed autonomous description concepts, methods of thought, and mathematical techniques which are unknown (or at least very unfamiliar and unusual) in present-day physics and chemistry. It may be necessary, for example, to distinguish between the biological concept of 'organization' and the physical concept of 'order', perhaps defining the former as a capability for producing order *for an end*. Needless to say, the teleological or finalistic element in such a definition has been anathema in physical science since the days of the Renaissance and the breakaway from medieval Aristotelian scholasticism. But an autonomous description of biological phenomena amounts to the assumption that such a description will be different in some respects in type from that hitherto found suitable for physical science. If so, it will require an appropriate mathematical technique or a method of symbolic logic involving some sort of 'dimensional' extension in its system of relationships. Its system of causation will differ from the probability-distributions of modern quantum theory, perhaps by a suitable modification of the latter by means of Volterra functionals of the historical type.

I do not think that Admiral Beadnell need have any fear that my use of the adjective 'non-material', *as applied to radiation*, will be a source of any comfort to the 'metaphysicians', for, in the sense in which I used it, non-material means 'not having the same properties as matter', but at the same time something quite as real. He is quite right, however, in pointing out that this use of the adjective non-material is inconsistent with the use of the same adjective as applied to Prof. Kapp's "specification", where it means unreal, in the sense of being derived *a priori* from the dialectic of metaphysical 'idealism'.

The complementary aspects of the descriptions, namely, 'wave-like' and 'particle-like', of the behaviour of both radiation and matter in different experimental conditions were very puzzling at one time, but I think I am correct in stating that modern quantum and quantum-statistical theory has found a consistent method of predicting the macroscopic results of all such experiments without involving the assumption that matter and radiation are synonymous terms. I think that if Admiral Beadnell will refer to Heitler's recent book on the quantum theory of radiation, he will obtain a definite answer to his question such as I am not competent to give. I wish to thank him for his friendly comment and his kindly reference to my review of Prof. Kapp's book.

F. G. DONNAN.

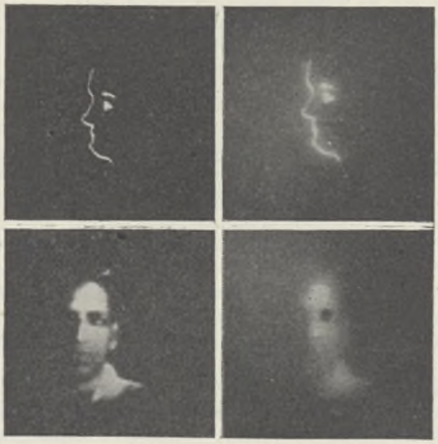
The Athenaeum,
London, S.W.1.

[1] "Science and the Human Temperament", by E. Schrödinger. Translated by James Murphy. (London, George Allen and Unwin. Ltd., 1935.) The passage quoted occurs on pp 39 and 40.

Optical Images formed by Conical Refraction

A PLATE of biaxial crystal cut approximately normal to the axis of single-ray velocity has the remarkable property of forming optical images of an illuminated object held in front of it. This effect was first observed with aragonite[1] but is exhibited in a much more striking fashion by a plate of naphthalene prepared for the exhibition of conical refraction as described in a recent note[2]. The accompanying reproduction illustrates this phenomenon. 1 and 3 reproduce objects held in front of the crystal, while 2 and 4 are the corresponding images formed in the rear of the crystal and received directly on a photographic plate. The image recorded is in every case erect and of unit magnification. The distances of the object and of the image from the crystal faces may be independently varied from zero up to large values.

We have investigated the explanation of this effect, using a point source as the object, and find that in every case the light reaching the image-point diverges behind it in the form of a hollow cone of rays, the angle of divergence depending on the distances of the object and of the image from the crystal faces. The image formation is thus due to a kind of generalized 'external' conical refraction which can scarcely be reconciled with the ordinary ideas of geometrical optics. Our experiences show clearly that the usual explanations of conical refraction do not go deep enough into the physical aspects of the problem.



OPTICAL IMAGES FORMED BY A NAPHTHALENE CRYSTAL.

C. V. RAMAN.
T. M. K. NEDUNGADI.

Department of Physics,
Indian Institute of Science,
Bangalore.
March 5.

[1] Raman, C. V., NATURE, 107, 747 (1921): *Phil. Mag.*, 43, 510 (1922).
[2] Raman, C. V., *et al.*, NATURE, 147, 268 (1941).

Colour Measurement

MR. GUILD's letter[1] makes it clear that the recent conflict in views on colour measurement arises by his adopting an interpretation of the role of the C.I.E. colorimetric system which puts it outside purely physical discussion. The explanation he suggests does not, however, apply, as I have not been concerned with the public and practical aspect to which he refers. As was clearly stated[2], my remarks referred to the purely physical analysis of the phenomenon of colour, and measurement of the quantities following from such analysis: the C.I.E. system was therein referred to for what fundamentally, apart from all implication and interpretation, it actually is, namely, a conventional schematization of physical fact, having reference to certain conditions of observation, based, of course, upon averaged data but nevertheless representative in such conditions of a possible *real* observer (cf. the analogous purpose served by Listing's typical schematic eye in ophthalmology). In this sense the system forms in general a representative first-order theory. Such use of the system accords with normal physical practice, for no suggestion of compromise in form, or simplification of the phenomenon has hitherto been implied in the reduction of physical data to refer to the C.I.E. normal observer.

Mr. Guild makes no reference to this aspect of the question, but he makes it clear that, in his interpretation, the C.I.E. colorimetric system is not subject to the limitations affecting the physical theory upon which it is based and that it exists absolutely and purely by virtue of definition. A physical phenomenon can, however, only be defined by relation to the conditions in which it is observed, and the existing physical knowledge of the time: the C.I.E. quantities which Guild postulates are, therefore, in general fictitious, and the C.I.E. standard observer in this extended sense, therefore, is artificial and lacking properties relating to the important physical phenomena connected with the variation of such conditions as field size. For some practical purposes this may suffice, but the theory cannot be regarded as complete while such phenomena remain demanding explanation.

Measurement on the basis of such an interpretation is clearly not measurement of physically significant quantities, and considerations involving such an interpretation are, therefore, beyond the scope of the present discussions. My statements on the subject from the point of view of the development of colour physics remain unaffected by the statements made on such other grounds in the recent correspondence.

It is, of course, possible to maintain views on interpretation, compromise and simplification for ordinary purposes, and Mr. Guild's promised statement will be awaited with interest.

J. W. PERRY.

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[1] NATURE, 149, 442 (1942).
[2] NATURE, 149, 76, 247 (1942); 148, 961 (1941).

Periodicity of Refection in the Wild Rabbit

SINCE my previous communication on this subject[1] various fresh data have thrown new light on the coprophagy or refection rhythm in wild rabbits. Taylor[2] reported, that of a number of wild rabbits shot and examined for the presence in the stomach of soft fæcal pellets such as are re-ingested immediately, those shot in the evening contained such pellets; those shot in the morning did not. He suggested, therefore, that the rhythm in wild rabbits was the reverse of that found in domestic rabbits; the resting period of the former being during the day, naturally this would be the time when soft or 'night' pellets are produced and swallowed.

Since then I have taken careful note of the stomach contents every time a wild rabbit, which was killed at a known hour of day, came into my hands. I have also included records in which the time of death could be narrowed down to four or five hours. Recently I was able to examine fairly extensive material from a large area of woodland in Gloucestershire and this constitutes the greater part of the data upon which the accompanying table was based.

The criterion used was simply the presence or absence of soft pellets in the stomach. In 135 of the rabbits examined a note was also kept of the contents of the rectum; in only 4 cases did it contain soft fæcal pellets, whereas in 19 cases they were found in the stomach. It is clear from this that the process of formation and evacuation of soft fæcal pellets takes a comparative short time and is evidently not a process which is going on continually during the day resting period of the wild rabbit. This is what would be expected, if, as Eden[3] maintains, the production of dry fæcal pellets goes on most of the time, interrupted at certain points by a rapid emptying of the deeper part of the cæcum and production of soft pellets.

Period (G.M.T.)	No. of rabbits examined	Per cent stomachs with pellets
21 — 2 hr.	12	33
2 — 6	62	0
6 — 11	30	86
11 — 14	17	88
14 — 16	21	86
16 — 19	9	45
19 — 21	41	5
Total ...	192	

The accompanying table summarizes data from 192 rabbits. The periods are unequal because it was difficult, when collecting field data at other people's convenience, to narrow down the time of death to within the same range of time all through the twenty-four hours. The number of stomachs containing soft pellets is expressed as a percentage of the total for each period.

It is clear that at this time of the year (March 9–12) there are two periods during the twenty-four hours when refection of fæces takes place. The main period is, as Taylor suggested, during the day from 6 a.m. until 4 p.m., though it is not quite accurate to say that soft pellets are not found during the morning: it would be more accurate to substitute "late night and early morning". From 4 until 7 p.m. the rate of occurrence falls to 45 per cent and from 7 until 9 p.m. it is only 5 per cent. This drop corresponds with the normal commencement of feeding at this season. From 9 p.m. until 2 a.m. there is a smaller peak, and then again, when late night and early morning feeding commences, there is a drop right down to 0 per cent. In practically all rabbits examined at this time the stomach was crammed with fresh food.

These data are confirmed by activity records made at an experimental rabbit warren. The area was wired round with netting: the rabbits went out to feed through gates which operated mercury switches and recorded the time. Through March feeding activity showed peaks at dusk and just before and after dawn.

The apparent discrepancy between my previous observations and the observations given by Taylor[2] is explained by the fact that the morning occurrences of refection observed by me would come just at the beginning of the large day-time peak: rabbits shot during the early morning activity period would be earlier than this. The lack of observations of evening refection is probably accounted for by the process taking place inside the warrens.

These results, of course, only apply to a season when day and night are equal. In summer, when the shorter nights give less feeding time, it is possible that the rhythm may change.

H. N. SOUTHERN.

Bureau of Animal Population,
University Museum,
Oxford.
March 31.

[1] Southern, H. N., NATURE, 145, 262 (1940).
[2] Taylor, E. L., *Vet. Rec.*, 52, 259–62.
[3] Eden, A., NATURE, 145, 628–9 (1940).

A Substitute for Glycerine as a Mounting Medium

FIFTY per cent glycerine which is widely used as a temporary mounting medium for sections of plant tissues is now difficult to get. Instead, a nearly saturated solution of calcium chloride can be tried. Put excess of commercial calcium chloride in tap water, remove the slight amount of chalk with hydrochloric acid, let any bits settle and filter if necessary. This solution is rather similar to 50 per cent glycerine in viscosity, refractive index and, of course, will not dry up. At pre-war rates it is a good deal cheaper than 50 per cent glycerine. It can be used in just the same way as glycerine with such stains as iodine, Sudan III, alcoholic phloroglucin (but not alkalis or sulphates). If the bulk of the calcium chloride is removed by washing the section in water or alcohol for a moment, it can be stained and dehydrated in the ordinary way.

T. M. HARRIS.

Botany Department,
University of Reading.
May 2.

Simplification of Musical Notation

JEANS's great work on music is difficult for the ordinary physicist, if he knows nothing of music, and for the musician, not readily understandable, if he be unsympathetic to physics. There seems a moral to be drawn from it, however, that has been missed. It is, how can we make music simpler so that more people can play, anyhow to start with, the basic instrument—the piano.

I wonder if I shall awaken a chord in the youth of many when I say I tried like others when young, but found it just too difficult, and its difficulty lies in its notation. I maintain, in that all have been taught to read thoughts from printed paper, by virtue of conjuring up sounds to the brain as speech, so it should be simple to devise a method by which we could hit the correct notes indicated on a piece of written music with the facility we do the typewriter. The reason we cannot do this is that there is a conspiracy against us to make it difficult, and it is wrapped up with sharps and flats.

I will not go into the details why *A* sharp and *B* flat are not theoretically the same note, but due to what is known as 'equal temperament', they are in fact on the piano actually the same note. What is the point of making such a fuss to discriminate between the two, when all that can be struck is the one note?

Then comes the arch-conspiracy of writing in separate keys, when nothing you see on the paper is what you think it is. Who would ever have learnt to read an ordinary book if at the start of a chapter it was announced that it was a sad story and in a minor key, whereupon most of the letters of the alphabet were changed about, and then to find in the next chapter, when things brighten up a bit, that the letters have changed again in an entirely different way. Nobody but a thought-reader could have persevered, yet so it is with music; no one but a musician goes on with it. But the ordinary man reads his book with enjoyment, though not a student: so should an ordinary man enjoy playing the piano even if he be not a musician.

The first thing I plead for is that all music be written in a straightforward honest way, as if it were in the key of *C*, with all accidentals inserted. You could at least read it. You would find out later it was not in that key, but would that matter, as you would be playing it in the key desired and what more do you want? If we could get as far as that, it would be something, but I go further. I contend there are only twelve notes in an octave on the piano. All you want to know is which of the twelve to hit and in which octave. Surely not a very difficult problem in notation.

Here is really where a little organized common sense—sometimes called science—might bring great joy to millions. Surely such a thing is worth while trying and not beneath our dignity, but do not expect help from musicians; they revel in the mysticism of their trade union.

Brabazon of Tara.

70 Pall Mall,
S.W.1.

Quality Control in Manufacture

The note in Nature of April 11, p. 408, on "Quality Control in Manufacture", repeats an error made in the article on which the note is based. Prof. R. A. Fisher has made many notable contributions to statistical theory and practice, and his elegant analysis of variance may possibly be considered the outstanding contribution of the century, but I think he would be the last to agree with the statement made in the opening phrases of the second sentence of the note. The theoretical foundations on which the control charts for averages of samples is based have been long known, and those for control charts for measures of variability have been laid by the work of British statisticians other than Prof. Fisher.

Apart from this error, I think that by not referring to the British Standards Institution publication of 1935 on this subject, the notes may leave the impression that the technique is only just receiving attention in Great Britain after many years practice in the United States. Dr. W. A. Shewhart's visit to England in 1932 focused attention on the work proceeding at that time in some British industrial organizations and stimulated interest in it. The formation of the British Standards Institution Committee in 1933, which led to the publication of B.S.S. 600 (1935) and the formation of the Industrial and Agricultural Section of the Royal Statistical Society, were some of the results of the increased interest in the subject.

The interested reader will find on close examination that the use of statistical methods has been growing simultaneously in Great Britain and the United States, and that the development has differed in detail but not in principle. A careful study of the two documents to which reference is made (B.S. 600 *R*: 1942 and B.S.1008 : 1942) will reveal this.

Bernard P. Dudding.

Research Laboratories,
General Electric Company, Ltd.,
Wembley.

Education for Culture and Citizenship

The conflict between subjective and objective biological teaching, referred to in the leading article on "Education for Culture and Citizenship"[1] and by Mr. L. J. F. Brimble[2] need not arise when the subjects of a school curriculum are more closely related, so that matters undesirable to teach from one angle can be taught from another. Such closer relationship could be obtained were education regarded as the fitting of man for his environment.

The subjects of the school curriculum would then fall into two groups: (1) man in relation to environment (the humanities), and (2) environment in relation to man (the sciences). Each group would dovetail into the other, and each subject be taught as part of a related whole, to the relief of overcrowded curricula. Environment for juniors would, of course, be the vicinity of the school, and syllabuses be based on its natural features and human activities. Even great cities provide a surprising amount of material for biological study and for that training in habits of observation and inquiry which is the root of true education. As the students get older, environment would broaden out to the whole world, and travel and research begin to play their part in education.

T. S. Dymond.

14 Albany Road,
St. Leonards-on-Sea.
April 28.

[1] Nature, 149, 447 (April 25, 1942).
[2] Nature, 149, 457 (April 25, 1942).

First Publication of the Geological Society

In reply to Mrs. Eyles's query[1], there is no reason to doubt that the pamphlet "Geological Inquiries" was issued in 1808, which is the date inscribed by Horner on his copy now in the library of the Sedgwick Museum. That it was published before the first volume of *Transactions of the Geological Society* is clear from the following extract from the Preface (*Transactions*, 1, June 28, 1811, p. v): "shortly after their establishment [Nov. 13, 1807] they [the founders of the Geological Society] drew up and distributed a series of inquiries."

L. Hawkes.

1 Chaucer Road,
Cambridge.

[1] Nature. 149, 442 (1942).

FLOODS OF SEPTEMBER 1938 IN NEW ENGLAND

THE hurricane which visited New England in September 1938 is rather artlessly described in a massive volume of 562 pp. as "the greatest catastrophe since settlement by the white man"*. The loss of life was very heavy and the material damage by flood, wind and wave exceeded three hundred million dollars. The greater part of the damage was caused by flooding of the rivers resulting from heavy rain, and coming so soon after the great floods of March 1936 it caused much alarm. The U.S. Geological Survey has accordingly collected all the available information about rainfall and river-levels as a basis for the design of protective measures for the future.

The antecedent conditions were unfavourable but not in themselves dangerous. In the preceding months rainfall had been above normal, and by September 11 there was an accumulated surplus of moisture in the ground. Heavy rain during September 12–16 added to this, but though the rivers ran bank high there was no flooding. On September 16 there was even some improvement, but from September 17 onwards the weather was consistently unfavourable. On September 19 a trough of low pressure lay over New England in which moist tropical air moved northwards, giving falls exceeding 5 in. in twenty-four hours. Meanwhile a tropical hurricane was moving rapidly northwards near the coast. As a rule these hurricanes keep well to the east, but this one was diverted into the open trough of low pressure, and on September 21 moved rapidly inland towards the Canadian border. On the eastern side of the centre the winds reached hurricane force, doing widespread damage, and the rainfall was torrential, but with the passage of the centre the rain ceased abruptly. In the twenty-four hours ending at 6 p.m. on September 21, 6 in. or more fell over 1,020 square miles, and floods which, though severe, might have been manageable, burst all bounds.

Rainfall charts are given day by day and again for every twelve hours, but since the effect of flood rains is largely cumulative, greatest interest centres in the map for the whole period September 17–21. The distribution is remarkable, for while there was a rainfall of 6–10 in. in these five days over a very wide area, the greatest amounts of 10 in. to more than 17 in. were confined to a comparatively narrow belt along the hurricane track northwards from Long Island, comprised mainly within the basins of the Connecticut, Merrimack and Thames Rivers. Over an area of 100 square miles in Connecticut and central Massachusetts the rainfall exceeded 16 in., equivalent to the total average rainfall in London from January to September inclusive. On the eastern side of this belt the rainfall diminished almost abruptly, so that the coast of Massachusetts received only a few inches, but on the western side the decrease was more gradual and flooding extended for some distance with decreasing severity. In many places on the smaller streams in the central belt the crest of the flood reached levels several feet higher than any previously recorded. The tables of flood height and discharge which make up a great part of the book show instances of discharges which were only a few cubic feet per second per square mile of drainage area on September 18 and 100 cub. ft. on the morning of September 21, but had risen to 400 or 500 cub. ft. a few hours later. On the larger rivers the rise was naturally slower as various tributaries came in at different stages, but the cumulative effect was as great. Under the pressure of the water, dams and bridges gave way and the rivers spread over their flood plains, destroying roads, railways and houses; the damage is vividly shown by a fine series of photographs.

The coasts naturally did not suffer from river flooding, but they were swept by a great storm wave, which in the eastern areas coincided with the normal time of high tide and rose to heights of 10 ft. and, where the waters were heaped up in narrow channels, more than 17 ft. above the average level of high water; New York's holiday coast was devastated, scores of houses being completely demolished.

The flood problem of rivers in populous country is one of great complexity. To enable the waters to flow away freely and naturally, the flood plain should be kept unobstructed, but the life of the towns and villages depends on the river, and encroachments are hard to avoid, while it is to these low-lying settlements that the danger is greatest. Reservoirs, whether constructed specially for the purpose of controlling flood water or for other purposes, play a useful part in minimizing the rise, but if the river sweeps away the obstructing barrier and empties the reservoir, the sudden influx of stored water may add to the catastrophe; in fact, many of the curves of flood height show a double crest due to this cause. The volume of flood water depends on the absorption of the ground as well as on the rainfall; the great flood of March 1936 was magnified by the melting of the snow and by the imperviousness of the ground, which threw practically the whole of the rain-water into the rivers; by contrast in September 1938 the ground, in spite of its previous soaking, managed to absorb a good deal of the earlier rainfall, though it could not cope with the torrential downpour of the last day.

Hurricanes have visited New England before, and will doubtless do so again, but this detailed record compiled by the U.S. Geological Survey will at least provide American engineers with the data for plans to minimize, though they are unlikely to be able entirely to avert, the effects of future visitations.

C. E. P. BROOKS.

* Hurricane Floods of September 1938. U.S. Geological Survey Water-Supply Paper 867, 1940.

BIOGEOGRAPHIC DIVISION OF THE INDO-AUSTRALIAN ARCHIPELAGO

ON April 16 and 30 a discussion was held by the Linnean Society under the chairmanship of the president, Dr. E. S. Russell, on "the biogeographic division of the Indo-Australian Archipelago, with criticism of the Wallace and Weber lines and of any other dividing lines, and with an attempt to obtain uniformity in the names used for the divisions". The following papers were contributed: Mr. J. B. Scrivenor, "Geological and climatic factors affecting the distribution of life in the Indo-Australian Archipelago"; Mr. I. H. Burkill, "A historic account of the divisions which have been proposed"; Dr.

Malcolm A. Smith, "The divisions as indicated by Vertebrata"; Dr. A. S. Corbet, "The divisions as indicated by the Insecta"; Mr. H. K. Airy Shaw, "Some general considerations from the botanic standpoint"; Dr. P. W. Richards, "On the ecological segregation of the Indo-Malayan and Australian elements in the vegetation of Borneo"; Dr. F. E. Zeuner, "The divisions as indicated by the distribution of insects in relation to geology".

The object of the discussion, in so far as it aimed at uniformity in principle, can be said to have been attained because there was a general opinion that division into biogeographical sub-regions was preferable to divisions by lines such as the Wallace and Weber lines, but no agreement was reached as to what those sub-regions should be. At the same time it was held that the Wallace and Weber lines retained some importance, but that the Wallace line as drawn by him to pass from the northern end of the Macassar Strait to the east of the Philippines should be modified so as to pass along the deep channel between Mindoro and the small islands off the northern end of Palawan. The southern termination of the Wallace line between Bali and Lombok has been criticized as unimportant by Dutch zoologists, none of whom, through the unfortunate force of existing circumstances, could take part in the discussion. It was also agreed that at the height of the Pleistocene glaciation the Sunda and Sahul shelves were dry land but that there is no precise knowledge yet how far the sea rose above its present level when the ice melted. The discussion was partly directed to considering the validity of Wegener's theory of continental drift as applied to the particular hypothesis that the Australian continental block with New Guinea as a spear-head has broken through what was once a continuous chain of islands now represented by the islands of the Banda Arc and the Bismarck Archipelago. An inquiry as to the general opinion of geologists about continental drift elicited a reply that the theory explains so much that there is a feeling that it must be true but that as yet there is nothing that can be called proof of it. It was agreed that the Indo-Australian Archipelago consists of two comparatively stable areas, the Sunda and Sahul shelves, with a very unstable area, sometimes called 'Wallacea' in between, where mountain-building is now in progress and where islands with rugged contours alternate with areas of deep sea. The Wallace line roughly follows the edge of the Sunda shelf and the Weber line that of the Sahul shelf; but the latter is drawn so as to pass on the west of the Kai Islands and on the west of Halmahera, whereas the edge of the Sahul shelf is to the east of those islands.

Mr. Burkill gave an interesting survey of proposed zoological and botanical divisions, the former following vertical and the latter horizontal lines. He mentioned doubts expressed by Wallace himself about his line and especially about the position of Celebes with regard to it, which he said ("Island Life", 1895 ed., p. 462) might perhaps with equal propriety be left out of both the Oriental and Australian regions. Weber's line was the result of studying the distribution of freshwater fish, but had been slightly modified by Pelseneer and Merrill, while Lydekker would have placed Halmahera west of it.

The unstable 'Wallacea' is a broad transition belt in which a mixture of fauna and flora occurs. Dr. Malcolm Smith emphasized the evidence given by the re-establishment of life on Krakatau after the 1883 eruption of the ease with which organisms, large and small, could have travelled by water and air from the continental areas to the islands in this belt. He said that while the Sunda vertebrate fauna is very like that of Asia, that of New Guinea is not so similar to that of Australia because climatic and geographical conditions differ to a greater extent.

Mr. Airy Shaw said that lowland and mountain floras in the Indo-Australian Archipelago may have quite different affinities with the floras of adjacent regions. Speaking of the floras within the Archipelago, he said that the lowland floras of Sumatra, the Malay Peninsula, Borneo and the Philippines are much the same, but that of Java differs from them. The mountain floras of Sumatra, Java and the Lesser Sunda Islands resemble each other but differ from the mountain flora of Borneo. Dr. Richards, as a result of his work in Borneo, thought that the Australian element has only been able to penetrate into the Archipelago where the soil is poor, and he thought that the Wallace line only holds good at all in so far as it agrees with the divisions of climatic and physical factors.

Dr. Corbet and Dr. Zeuner both dwelt on the importance of butterflies in connexion with the discussion and described the distribution of certain genera. The former proposed a division into sub-regions which he named the Malaysian, the Philippine, the Celebes, the Moluccas and New Guinea, and the Lesser Sunda Islands sub-regions. These differed from Dr. Malcolm Smith's proposal of Malaysian, Philippine, Indo-Chinese, Papuan, Austro-oriental and Australian sub-regions. Dr. Zeuner thought that the Wallace and Weber lines could not be defined biologically and that the Australian continental block is approaching Asia.

In a general discussion which followed the last paper read, Mr. Norman cited the evidence of the distribution of freshwater eels as bearing on the earlier relations of land and sea in this area. The importance of co-operation between biologists and geologists was mentioned, but one speaker pointed out that neither must rely on the other too much for proof of their theories but must rely chiefly on their own efforts.

J. B. Scrivenor.

CARNEGIE INSTITUTION OF WASHINGTON

The Year Book of the Carnegie Institution of Washington No. 40 covers the year July 1, 1940–June 30, 1941, and includes the report of the president as well as the reports of departmental activities and co-operative studies.

In his report, the president refers to the retarding of the attack on many problems on the border line between physics and biology, to implement which the construction of a large cyclotron has commenced, as well as on the new approach to human genetics, but emphasizes the responsibility of such an organization as the Carnegie Institution for preserving intact some of the more important threads of fundamental scientific research, now almost completely stopped all over the world. With regard to defence activities, nearly all the research in the Department of Terrestrial Magnetism was on Government problems, and the number of men employed in that laboratory had been more than doubled. Important work was also proceeding in the Geophysical Laboratory, the Mount Wilson Observatory and the Nutrition Laboratory.

To secure the proper integration of the combined research effort in the United States, Mr. Roosevelt has created the Office of Scientific Research and Development as a part of the Office for Emergency Management, and the president of the Carnegie Institution is the director of this Office, and many of the staff are members of its organization. The president points out that the close connexion of the Institution with the defence research effort has led to much closer contact between members of its staff and outstanding scientific men of the country, which should be of great benefit when the full normal programme is renewed.

Despite the preoccupation of most of the staff of the Department of Terrestrial Magnetism with defence research, progress has been made with its fundamental programme, and it is anticipated that the cyclotron will shortly be completed. The studies of the electrical and chemical conditions of the air at great heights are also progressing, as well as the co-ordination of magnetic, solar and upper air studies relating particularly to problems of radio transmission. Further progress in studies on photosynthesis is reported from the Division of Plant Biology, where recent research relating to the chemical mechanism of the photosynthetic process has necessitated revision of the old hypotheses in regard to the chemical interaction involved.

In the development of co-operation between the Department of Genetics and the Long Island Biological Association, a symposium at Cold Spring Harbor on the subject of the gene and the chromosome attracted a large group of scientific workers. Plans for the continuation of such co-operation are being formulated.

In the Nutrition Laboratory progress has been made in the development of instrumental technique and in co-operative studies of carbohydrate metabolism with reference to diabetes.

Interesting results have been obtained in the Geophysical Laboratory with the equipment for studying silicate minerals in the presence of water at high temperatures and pressures, such as prevail deep within the earth. The apparatus used is essentially an electric furnace within a strong closed chamber in which materials can be exposed to the action of steam at pressures of several thousand pounds and at temperatures far above a red heat. Other work has been concerned with the properties of solutions under high pressures.

FORTHCOMING EVENTS

Monday, May 18

ROYAL GEOGRAPHICAL SOCIETY (at Kensington Gore, London, S.W.7), at 5 p.m.—Sir Henry Craw: "The Burma Road".

Tuesday, May 19

IRON AND STEEL INSTITUTE (joint meeting with the Sheffield Society of Engineers and Metallurgists, the Sheffield Metallurgical Association and the Refractories Association of Great Britain) (at the Royal Victoria Station Hotel, Sheffield), at 5.30 p.m.—Discussion on "Open-Hearth Furnace Refractories": (*a*) "Dolomite Bricks", (*b*) "Open-Hearth Roofs, including Temperature Control". (Chairman: Dr. W. H. Hatfield, F.R.S.)

Wednesday, May 20

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London, W.C.2), at 1.45 p.m.—Prof. H. D. Kay: "The Future of the Milk Industry".

INSTITUTE OF PHYSICS (ELECTRONICS GROUP) (at the Royal Institution, 21 Albemarle Street, London, W.1), at 2.30 p.m.—Discussion on "Amplifiers for Measurement and Control" (to be opened by Mr. C. A. A. Wass).

ROYAL METEOROLOGICAL SOCIETY (joint meeting with the Physical Society) (in the Physics Department of the Imperial College, Imperial Institute Road, London, S.W.7), at 5 p.m.—Discussion on "Emission and Absorption of Radiation in the Atmosphere" (to be opened by Dr. T. G. Cowling).

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

JUNIOR ASSISTANT (MALE OR FEMALE) TO THE PUBLIC ANALYST—The Public Analyst, Parker Lane, Burnley (May 20).

HEADMASTER OF THE EASTBOURNE TECHNICAL SCHOOL—The Education Officer, Technical Institute, Eastbourne (May 23).

ASSISTANT LECTURER IN AGRICULTURAL BACTERIOLOGY—The Registrar, The University, Leeds 2 (May 29).

UNIVERSITY CHAIR OF BIOCHEMISTRY tenable at St. Thomas's Hospital Medical School—The Academic Registrar, University of London, Richmond College, Richmond, Surrey (June 8).

INSTRUCTOR IN ELECTRICAL ENGINEERING at the East Ham Technical College—The Secretary for Education, Education Office, Town Hall Annexe, Barking Road, East Ham, London, E.6.

SENIOR LABORATORY ASSISTANT—Mr. R. W. Stott, Rugby School Science Laboratory, Barby Road, Rugby.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

John Innes Horticultural Institution. Thirty-second Annual Report for the Year 1941. Pp. 14. (London: John Innes Horticultural Institution.) [274

Brompton Hospital Reports: a Collection of Papers recently published from the Hospital. Vol. 10, 1941. Pp. vii+127+29 plates. (London: Brompton Hospital.) 5*s*. [284

Carnegie United Kingdom Trust. Twenty-eighth Annual Report, 1941. Pp. 16. (Dunfermline: Carnegie United Kingdom Trust.) [284

Other Countries

U.S. Department of Agriculture. Miscellaneous Publication No. 439: The Fruitflies of the Genus Anastrepha. By Alan Stone. Pp. 112+23 plates. (Washington, D.C.: Government Printing Office.) 40 cents. [224

Imperial Council of Agricultural Research. Miscellaneous Bulletin No. 54: A Further Survey of some Important Breeds of Cattle and Buffaloes in India. By F. Ware. Pp. iii+16+21 plates. (Delhi: Manager of Publications.) 1.4 rupees; 2*s*. [224

Forest Research Institute, Dehra Dun. Indian Forest Leaflet No. 10 (Utilisation): A Preliminary Note on the Use of Prolamins as Adhesives. By D. Narayanamurti and V. Ranganathan. Pp. ii+4. (Dehra Dun: Forest Research Institute.) [234

Indian Forest Records (New Series). Botany, Vol. 3, No. 1: The Flora of the Aka Hills. By Dr. K. Biswas. Pp. 62. 2.2 rupees; 6*s*. 6*d*. Botany, Vol. 3, No. 4: A Short Account of the Geology and Flora of the Hill Zamindaries in Kalahandi State. By H. F. Mooney. Pp. 131–143+4 plates. 14 annas; 1*s*. 3*d*. Botany, Vol. 3, No. 5: New Indian and Burmese Species. By Dr. N. L. Bor. Pp. 144–150+4 plates. 10 annas; 1*s*. Entomology, Vol. 4, No. 2: A Guide to the Control of Termites for Forest Officers. By C. F. C. Beeson. Pp. 44–90. 1.2 rupees; 1*s*. 9*d*. (Delhi: Manager of Publications.) [234

Forest Bulletin No. 94: Specification for the Inspection and Passing of Helves and Hammer Handles. By V. D. Limaye. Pp. ii+7. 4 annas; 1*s*. 3*d*. Forest Bulletin No. 95: Stacking Timber for Air Seasoning. By M. A. Rehman. Pp. ii+9+1 plate. 3 annas; 4*d*. Forest Bulletin No. 96: Drying of Wood Fuel of *Shorea robusta* (*Sal*), *Eugenia jambolana* (*Jaman*), *Machilus duthiei* (*Kaula*). By M. A. Rehman. Pp. ii+8+1 plate. 4 annas; 5*d*. Forest Bulletin No. 97: Experiments on the Air-seasoning and Notes on the Passing of *Sal* Sleepers. By M. A. Rehman. Pp. iv+25. 7 annas; 8*d*. Forest Bulletin No. 99: Properties, Preparation and Testing of Helve and Tool Handle Timbers. By V. D. Limaye. Pp. ii+13+3 plates. 8 annas; 9*d*. (Delhi: Manager of Publications.) [234

U.S. Department of Agriculture. Circular No. 626: Control of the Locust Borer. By Ralph C. Hall. Pp. 20. (Washington, D.C.: Government Printing Office.) 5 cents. [234

Report and Accounts of the National Botanic Gardens of South Africa, Kirstenbosch, Newlands, Cape (and the Karoo Garden, Whitehill, near Matjesfontein) for the Year ending 31st December 1941. Pp. 12. (Kirstenbosch: National Botanic Gardens of South Africa.) [244

U.S. Office of Education: Federal Security Agency. Bulletin 1941, No. 2: Education of Teachers; Selected Bibliography, October 1, 1935, to January 1, 1941. By Benjamin W. Frazier. Pp. vi+60. 10 cents. Bulletin 1941, No. 10: Inter-American Friendship through the Schools. By Prof. Verna A. Carley. Pp. vi+61. 15 cents. (Washington, D.C.: Government Printing Office.) [244

Pennsylvania State College: School of Agriculture, Agricultural Experiment Station. Bulletin 415: The Minimum Base Value of Heat Production in Animals; a Research in the Energy Metabolism of Cattle. Pp. 26. (State College, Pa.: Pennsylvania State College.) [244

Bell Telephone Laboratories: a Bell System Company. Pp. 32. (New York: Bell Telephone Laboratories, Inc.) [274