studied along two meridians, and the measurements will include water velocities determined electromagnetically, and the heat exchange between sea and air, as well as the customary temperature, salinity and other standard measurements. About forty new stations will be set up, equipped with tide gauges and non-tidal long-wave recorders, on many islands and on some continental coasts. The shifting boundary between temperate and arctic waters, and the warming of the Arctic, will be studied. Continuous echo sounding, registration of magnetic intensity by towed instruments, collection of plankton by towed nets, radiocarbon sampling of the deeper waters, measurement of temperature gradients in sediments, collection of long sediment cores, and seismic reflexion observations will be among the activities of some of the oceanographical ships; these will also be available, so far as possible, as moving 'stations' for other types of geophysical observation.

Seismic and Gravity Measurements

The Geophysical Year will provide opportunity for seismic recording and gravity measurements to be made at many antarctic and island sites not ordinarily accessible or available, and it is expected that many expeditions will include such work in their programme.

The Rocket Programme

Rockets provide the most important new technical feature that distinguishes the Geophysical Year from the second Polar Year. They will enable the atmosphere to be explored over a much increased range of height in various ways, and may considerably extend our understanding of upper atmospheric processes and our knowledge of solar phenomena that affect the earth. The technical advances that are involved concern not only the rockets themselves, but also the measuring devices they carry. The measurement of atmospheric properties by instruments travelling at high speed presents difficult problems. During the past decade American scientists have made remarkable progress towards their solution, and the tide of invention in this field continues to flow strongly.

In most of the upper-atmospheric rocket researches thus far made, large and very expensive rockets have been used, launched from a desert site in New Mexico, with costly ground installations. The smaller rockets of this type can be, and have been, launched also from specially fitted ships. Recently, however, a much cheaper method of rocket exploration has been developed by Van Allen and his colleagues. The rocket is carried up to a considerable height by a large balloon, and launched at a predetermined pressure-level. The launching heights have ranged up to 27 km., and the heights attained have at times exceeded 100 km. The load that can be carried up to about 100 km. is 15 kgm., which permits a wide variety of researches, such as those on cosmic rays, ozone, pressure, density and temperature, the solar spectrum, the sky brightness and airglow, geomagnetism, auroral particles, and ionospheric physics. The combined rocket–balloon system is called a 'rockoon'. Investigations are in progress into the vertical launching of rockets from aircraft, and if successful may contribute to the Geophysical Year programme.

The American National Committee for the Geophysical Year plans to fire approximately thirty-six large rockets ('Aerobees') and about a hundred rockoons, distributed throughout the period, and also geographically, from the Arctic to the Antarctic. Many of the above researches, if not all, will be included in the programme. The French National Committee plans to launch twelve of the large French rockets ('Véronique') from the Sahara, in pairs, at intervals; their instruments are expected to measure pressure and density, ionization, solar radiations, and particle masses (by mass-spectrograph). It is greatly hoped that other nations will also contribute to the rocket programme.

Problems of Organization and Finance

The achievement of the Geophysical Year will depend on the effort and funds devoted to it by the different participating nations. Naturally, their contributions will be unequal in magnitude and kind; help will be afforded by some nations to other nation-partners in the enterprise, by provision of instruments, training of observers, reduction of observations and in other ways. The unprecedented volume of observations that will accrue will present problems of collection and discussion for which detailed plans are not yet made. Many important points as to methods and recording of observations, and standardization and calibration of instruments, await settlement. Some important nations have still not associated themselves with the Geophysical Year. Thus there remains much scope for effort and thought in order to render the enterprise as successful as possible. But the stage already reached, more than two years before the Year begins, is good ground for confidence that the scheme will far surpass every previous co-operative scientific effort of its kind, and that it will lead to notable advances in knowledge of importance and interest to mankind. When the Geophysical Year ends, the level of activity in geophysical observation will necessarily drop rapidly and considerably; but past experience indicates that the subsequent level will still mark a distinct rise above the present level; thus it will afford a higher stage from which at some later epoch another International Geophysical Year can mount to yet greater heights and intensity.

A PATTERN FOR INDUSTRIAL RESEARCH

IN 1953, seven senior executives of the United Steel Companies, Ltd., were invited to lecture to engineering undergraduates in the University of Cambridge on various aspects of industrial management. The lectures have now been presented in book form*, and among them is a valuable contribution to contemporary thinking about the organization and application of scientific research in industry by Dr. J. H. Chesters, assistant director of research to the Company.

The research worker in industry spends a good deal of time on development work that adds little to scientific knowledge; on the other hand, his best achievements are often based on fundamental data which he himself has collected or been able to appreciate and apply.

* Industrial Management: a Course of Lectures given at Cambridge University for the Faculty Board of Engineering. Pp. 124. (Sheffield: United Steel Companies, Ltd., 1954.)

The usefulness of a research department depends primarily on the originality, initiative and effort of the staff; but the framework within which research workers function greatly influences the results.

The research department may vary from one man to giant organizations, such as Bell Telephones, which must be considered as plants in themselves and indeed, in the United States, are registered as separate companies. In Great Britain there is wide variation (0·4–5·3 per cent) in the research and development costs expressed as a percentage of turnover in different industrial groups. In the scientific instrument and light electrical engineering industries the figure is more than 5 per cent, in chemicals 2·4 per cent, whereas for the ferrous industry and for food, drink and tobacco it is only 0·4 per cent. In general, the older the industry the less is its present investment in research. One reason for this is that iron and glass can be made, and indeed have been made, without any precise scientific knowledge; but radio sets would not even have been thought of unless a great deal of fundamental research had been done.

A research unit consisting of a university graduate backed up by two assistants can be run for an average expenditure of £3,000 per annum. In the United States, industrial research activities account for less than a half per cent of the cost of goods and services of the undertaking.

Research in the United Steel Companies costs approximately a half per cent of all sales. There is a total staff of almost two hundred, who study all the major aspects of iron- and steel-making in metallurgy, engineering, physics, chemistry, mathematics and geology.

The possession of a first- or second-class honours degree is by no means the sole criterion in the choice of an industrial research worker. The ability to work in a team has long been recognized as equally vital, the isolated research worker being now something of a curiosity. The old vertical-type team consisted of a section head with his senior and junior assistants. The new type team—which is of a horizontal character and requires the fullest co-operation between different section leaders and their staffs—calls for an even higher conception of team-work.

The efficient use of specialists demands that they be supported by other workers who do not require to be as highly qualified. In the United Steel Companies about a hundred university graduates and men with equivalent qualifications are backed up by more than a hundred other members of staff, many of whom left school when they were sixteen, but have since acquired considerable skill in some particular field of activity. The old idea of 'lab. boys', who often finished in blind-alley jobs, is rapidly dying out.

The senior staff, too, are encouraged to continue their studies and to join appropriate scientific or technical societies. By so doing they not only increase their background of knowledge, but also get the opportunity of 'sparking' their minds on those of workers in other fields.

Considerable experience now exists on the building of research departments, and such elementary mistakes as putting dirty and clean work adjacent to one another, or heavy machinery near equipment requiring freedom from vibration, rarely occur. Where a new laboratory replaces an old one certain new problems arise, notably the clash between the desire to have a smart modern laboratory and to do work that can be far more efficiently carried out if a certain amount of mess is permissible. The best, though still imperfect, answer would seem to be the segregation of 'dirty' activities in either a separate block or outbuilding.

Another risk with new and impressive laboratories is that the worker is less inclined to use the 'string and sealing wax' technique. Unless encouragement is given to start with rough equipment there is a tendency for the research man not to start his experiments at all until he has designed what he considers to be a good-looking piece of equipment. Far quicker results would be obtained and much money saved if at least early work is done with a crude assembly, and this only converted to an engineering job where accuracy or long-term use demands.

The jobs tackled in an industrial research department can be conveniently divided into those which arise internally and those arising from external demand. The latter may come direct from the plants or arise from long-term policy laid down by high-level management or the numerous technical committees that form so valuable a part of large-scale industry.

External demand is not, of course, limited to the works; it includes the demand by customers for materials to meet more arduous service conditions or for the solution to a problem that is difficult to solve by engineering means. An example of the latter was the joining of austenitic and ferritic tubes, the different coefficients of expansion of which would affect the tightness of a bolted joint, or the stresses in a plain butt weld in conditions of fluctuating temperature. An appreciation of the desirable characteristics of such a joint in service and the potentialities of an extrusion press in producing the necessary conditions for making a pressure weld enabled a tubular transition piece to be evolved which consisted of a ferritic tube gradually tapering to zero thickness inside an austenitic tube increasing at the same rate from zero to the full tube thickness.

At least a third of the solution to a problem lies in stating it correctly; research work often suffers because the true nature of the problem is not appreciated before the work began. A close examination at the start may even show that the problem does not really exist, is trivial, or such that a solution would yield little benefit. In the United Steel Companies all major items of work in the research department are covered by means of investigation sheets, which state in a few paragraphs the nature of the problem, the method by which it is to be tackled, and a list of the plants expected to benefit if a useful conclusion is reached.

Most research departments carry more investigations than they are really capable of handling. This leads to double dissatisfaction, the user being depressed because his problem gets little attention, and the research worker annoyed because he is perpetually asked to report on investigations on which he has done no work for some time. A rough rule is that the number of investigations in a section should not exceed that of the staff.

It is a tradition with research workers that they commence an investigation by searching the literature. The industrial worker rarely has time to do so at all fully, but can be greatly aided by an information section which keeps him continually informed of developments in his field, and can cover a far wider range of literature than he can ever hope to do by his own specialized reading.

Speed is frequently vital in industrial research. There are occasions when, to be of value, information must be provided within a day. If the research organization is sufficiently flexible, such demands can sometimes be met. The research department was once asked at 9 a.m. whether the collapse of a new steel furnace roof was due to poor brick quality or to operating procedure. The roof had to be replaced that night, and any answer after 5 p.m. could not affect policy for the next furnace campaign. By switching all the staff of the refractories section to the problem, all the standard properties of the suspect-bricks were determined and a report issued over the telephone at 5 o'clock to the effect that there was nothing wrong with them and that the same quality should therefore be employed in the new furnace. The subsequent behaviour of the furnace showed this to be the right decision.

The object of research should be the provision of genuinely new information in which is included quantitative research hitherto only understood qualitatively. The results obtained may at first prove unpalatable, because they conflict with previous assumptions.

From the practical point of view, a result opposite to that anticipated frequently proves to be of value. As an example may be cited war-time troubles with induction furnace linings, due to the loss of the previously used Austrian and Greek magnesite. At the time and on an apparently sound theoretical basis, it was believed that the ultimate test for induction furnace lining materials was their ability to withstand high temperatures without shrinkage—shrinkage cracks being thought to lead to metal penetration and a consequent strike to the high-voltage water-cooled coil. This hypothesis was overthrown by the results of laboratory tests on a wide range of linings, which showed that the satisfactory ones frequently had a high shrinkage when heated to 1,600° C., while those that failed mostly showed a low shrinkage.

A large proportion of the more important developments arise from accidental observations. This was seen in the metallurgical field by work on boron, which was added among other materials to 0·5 per cent molybdenum steel to prevent the cracking of steam pipes. It was noted that the boron–molybdenum steel had twice the proof stress of mild steel and yet possessed similar weldability. Realizing that such a steel would be of great value in reducing the weight of engines and structures, its properties were thoroughly investigated and this led to a valuable contribution in aircraft gas turbine design, and the provision of light-weight structures generally.

Assessment of a job frequently indicates that an efficient attack requires the cutting across of section boundaries. Development of a new-type furnace, for example, may demand co-operation with those concerned with such primary aspects as flow pattern and combustion on one hand, and design and development engineers on the other, the latter putting an engineering interpretation on what may have started as a rough sketch.

It is often assumed that such co-operation should be easy with scientific workers, since they are solely concerned with the discovery of truth. In actual fact, they are just as liable to be upset if credit goes elsewhere for work they have done. The techniques for ensuring that credit in team-work is given where it is due are still very much in the evolutionary stage. One method is the symposium, in which the various contributors are given a place that is at least roughly related both qualitatively and quantitatively to their own contribution to the work.

Industrial research departments can be classed into those which like to keep everything secret and those which are willing to talk of almost all the work they have in hand. It is the latter approach which will ultimately survive, since the willingness to give generously of information without guarantee of return seems essential to healthy development.

Good reports of research are essential, since they are the foundation of future work; the research worker must be prepared to finish his report with clear and concise conclusions and recommendations. Most young research workers, and some older ones, object to writing a report until the work has reached a stage where they feel they can give a full answer to the problem. The result is that the practical man is starved of information for long periods, while the research worker frequently gets so involved in his deliberations that he ceases to see the problem at all clearly. The right answer to this difficulty would appear to be the issue of interim reports. Sometimes it is desirable to follow the series with a summary report in which the chaff can conveniently be separated from the wheat. Moreover, if the research worker is incapable of putting his discoveries into simple language, it may well be because he does not really understand what he has found out.

On costs the research director should be given a reasonably free hand. "How do you *know* that research really pays ?" is by no means an easy question to answer, particularly where research is mainly concerned with the improvement of a product. Where it deals equally with production processes, however, it is frequently possible to show that the savings associated with quite a small number of investigations are of such a high order as to leave no doubt whatever regarding the overall economics of the research department.

The research director's attitude to patents will be greatly influenced by the type of work done in his department, and also the general policy of the company. Some firms publish little, but take out many patents; others have few patents but publish almost everything. It is often doubtful whether the benefits gained are not more than offset by the trouble and expense involved.

There is still much to be learned about the technique of applying scientific ideas in industry. The major problems are more often psychological than technical, and the ability to tackle them depends more on the personality of the individuals concerned than on their academic achievements. Wherever possible, those likely to use the results should be in touch with the research work as it proceeds, starting sometimes to apply to new ideas before any report is issued.

It is frequently found that the economics of a procedure suggested by research can only be assessed on the plant itself. This means that large-scale trials must be organized and data collected which will enable costing to be done. Where the industry is of a type that owes its origin to scientific research, like chemicals or electronics, such trials present few psychological difficulties.

In the older industries the position is very different, there being a conscious or unconscious struggle between the craft of the 'witch-doctors' and the new ideas of the 'backroom boys'. Between these extremes lies a wide field for diplomacy, the need of the scientific worker for more precise information on plant performance being balanced against the extra worries which such trials place on works staff

Sometimes the application of a new idea or device is delayed because of a natural desire on the part of production executives to see whether it operates successfully elsewhere before committing themselves to major expenditure. In such cases, trials on small units can often speed application to larger units. A good example of this was the application of a metallic recuperator to reheating furnaces. A new design, developed abroad, was felt to be promising, but lack of previous experience caused hesitancy in applying it on new soaking pit furnaces. The construction and exhaustive testing of a small recuperator attached to a works' furnace gave results which were sufficiently promising to lead to large-scale applications both in the United Steel Companies and in other industries.

OBITUARIES

Miss M. S. Johnston

MISS MARY SOPHIA JOHNSTON, second daughter of the Rev. W. A. Johnston, rector of Acrise, Kent, was born at Folkestone on October 29, 1875, but spent the greater part of her life first at Wimbledon and then at Kew, Surrey. She became keenly interested in geology as a girl and very soon established her position among the amateurs in days when women geologists were few. Her interests lay mostly in stratigraphical and physical geology, and it was on an aspect of these that she wrote her best-known paper (with the late Miss M. C. Crosfield) on "The Ballstone and Associated Beds in the Wenlock Limestone of Shropshire".

Until age somewhat curbed her strenuous activities, Miss Johnston was a constant and energetic participant in the field meetings of the Geologists' Association (which she joined in 1898), while she had field experience of foreign geology at several meetings of the International Geological Congress, at the Toronto meeting of the British Association, and by travel in Egypt. On all these occasions she collected assiduously. Thus she built up a remarkable collection, which was always at the use of students and which she presented ultimately to the nation and to various universities. She wrote on some of her observations abroad, and also lectured extensively about them.

Miss Johnston had a life-long interest in archæology and heraldry, and compiled historical pamphlets on Richmond (Surrey) and Kew.

She was proud of being one of the first, small group of distinguished women elected as Fellows of the Geological Society of London in 1919. She served as an officer of the Geologists' Association for twenty-one years (and was made an honorary member in 1939), on the Council of the Palæontographical Society, and as treasurer of the South-Eastern Union of Scientific Societies. She was a fearless but very fair critic on committees, where she displayed a fine sense of financial rectitude.

Her scientific friends knew Miss Johnston as an ever-helpful and charming personality. It was left to those more intimate with her to know of her generosity to Kew churches and of her valuable work for youth. No account of her would be complete without reference to the active benefactor she was to one of the Richmond boys' schools and to various tradesmen's rowing organizations. She was also an officer of several of the latter and guided them wisely for many years (in one case she was honorary treasurer for more than twenty-seven years until her death).

Miss Johnston maintained her activities and interests to the last, and her death, after a short illness, on January 23 was a shock to her many friends.

H. DIGHTON THOMAS

Mr. Eric Parker

FROM his schooldays at Eton until his death on February 13, Eric Parker was able to enjoy his love of the countryside. When he could no longer get about on foot, he drove himself around his beautiful garden at Feathercombe, near Godalming, in his electrically propelled chair. His last book, "Surrey Gardens", was published a year ago, and to gather material for it he visited eighty-four gardens.

Though he wrote so much on shooting and fishing, the pleasure he got from sport took second place to his interests as a naturalist. His eye was attracted by the detail of all around him: the water rat biting off the head of a lily; martins flying south as high as he had ever seen them, on a warm westerly wind in October; the change in the song of a bird; the wild-flowers of the hedgerow.

Before he joined the staff of *The Field* in 1910 to take over the shooting from James Harting, he was writing prolifically, at one time for *The Field, The Spectator, The County Gentleman, The Gamekeeper,* which he edited, and *The Cornhill Magazine.* At the time when he was editor of *The County Gentleman,* he formed a great friendship with Anthony Collett, for whom he did the illustrations to "British Inland Birds".

Parker never accepted any statement lightly, and this led him to analyse the observations of the early writers on natural history and to compare them with those of recent naturalists and his own. He experimented with a bow and arrow to reproduce the drumming of the tail feathers of a snipe. He held the belief that the drumming of woodpeckers is vocal, and in his "World of Birds" he gives accounts of trials he made to prove it and presents the case for and against his own conviction. He neither feared controversy nor failed to attack practices he condemned, as in his "Ethics of Egg Collecting". He hated any form of cruelty. He was opposed to tail docking of horses and dogs, and it was mainly due to his attack on the caged-bird sellers of Club Row that the traffic in wild birds was stopped. But he had no room for false sentimentality, and in 1931, after he had become editor of *The Field,* he organized a committee to consider measures to be taken against the spread of the grey squirrel.

To the Lonsdale Library, which he edited, Parker contributed much, including the volume on "Game Birds, Beasts and Fishes". The many books he wrote at his table before the window through which birds flew in to the food tray were in the purest and simplest English. Anyone reading the 'week-end' books alone could add much to his general knowledge.

On the day of Eric Parker's funeral an incident occurred which it would have given him pleasure to watch. Two of his grandsons saw a field mouse by the roadside which the youngest one gently handled and released.

R. N. ROSE