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EDITORIAL

X-Ray Research

WE are publishing this week the first part of the address given by Prof. G. L. Clark when the Grasselli Medal was presented to him by the American Section of the Society at New York so long ago as November 4. We owe an apology not only to Prof. Clark for the delay that has taken place but also to our readers for withholding from them for so long an interesting paper describing ten years of important research. Prof. Clark is well known as one who has made a profound study of the application of *X*-ray research to industrial purposes: he has, of course, done much more than this for he has been a pioneer in *X*-ray investigations generally, but it is this aspect of his work that specially appeals to a journal that is mainly concerned with applied chemistry. It is about thirty-eight years since *X*-rays were discovered and they have been familiar phenomena for the greater part of that period but we think it has only been possible to make use of *X*-rays in industry during the last ten years or so. The introduction of this new device has brought about almost as great a benefit to mankind as the introduction of the microscope did a few centuries ago. It is said that the human eye can see objects as small as the tenth part of a millimetre and that by the aid of the microscope we can see objects a thousand times as small as this. *X*-rays do not indeed enable us to see objects a thousand times as small as the tiny objects that can be seen by a powerful microscope; it is not quite clear that when we come to such minute proportions we are not reaching the limit when objects cease to be objects, but if we cannot see them the expert in *X*-rays can tell us from his observations how they are placed in space and how far they are distant from each other. It is supposed that in a molecule of H_2O, a hydrogen atom is distant from the oxygen atom about ·000,000,1 of a millimetre so that we are now engaged in investigating spaces and distances about a thousand times as small as microscopic spaces and distances. Possibly we shall never see the atom or the electron but already we can see their paths in space, count them, and measure them. Prof. Clark gives us a most interesting and simple account of the new methods of testing the safety of metal castings, of weapons such as fencing foils, and other metallic objects, and of finding out the goodness or badness of metal springs and storage batteries. *X*-rays have been used with conspicuous success to investigate the composition and the corrosion of many alloys and the constitution of minerals, including those highly complicated substances the natural and the artificial silicates. They have enabled Prof. Clark and those privileged to work with him to throw further light on to the chemistry of paraffin waxes, india-rubber, and cellulose. In publishing this paper we regret that several charming and interesting illustrations that Prof. Clark was able to show to his audience were found unsuitable for reproduction in print: nevertheless there are many illustrations that we can reproduce: enough to provide good examples of Prof. Clark's work and to make the readers of his paper wish for more.

Rubber and Research

Rubber is one of those allied industries into which the chemist is only slowly penetrating, so slowly indeed that the industry at large has not yet realized the help he can give it. At least this is the deduction we draw from the statements we read about the possible abandonment of the Rubber Research Association. Yet the processing of rubber, starting from the very moment it is tapped from the tree, is essentially a chemical operation, just as its formation in the plant, by polymerization of isoprene derived in its turn from glucose by the union of two decomposition products with three and two carbon atoms respectively, is one of those biochemical syntheses whose full understanding may lead us to all sorts of new conquests. The rubber industry is in the doldrums owing to excessive over-production, with the consequence that rubber is selling at an uneconomic price. Had the reverse happened, that is under-production, a synthetic rubber would ere now have been in general use. What is lacking seems to be more numerous uses for rubber in quantity, and the failure to find these may be in part due to the nature of crude rubber. Much interest has therefore attached to a material called Revertex, which is essentially an evaporated and partly purified latex. It is being used instead of benzene–rubber solutions for dipping processes, after much research has produced special methods

of treatment, for instance, with dry steam at 85 - 90° C., when the solution contains 60–62% solids and is free from air bubbles. An advantage is that thicker films can be applied in quicker succession and finished by thorough drying, dipping into a benzene solution of an accelerator, and vulcanized in hot air at 120°. The uses of this Revertex are many, some of them in markets previously inaccessible to rubber, but we are not concerned to enumerate them here: rather is it our purpose to emphasize that they, as well as the material itself, have not been arrived at haphazard but as the result of systematic research in a colloid chemical laboratory. The early history of rubber was told recently in a most attractive way in a lecture delivered before the members of the Institute of Chemistry and since published in book form. It is striking to find how all the thousands of attempts to make some use of raw rubber were based on empirical methods and how the final discovery of vulcanization was largely a matter of chance. Yet this reflects no discredit on the early workers, for they were in advance of both theory and practice in handling materials of this type. The pioneers in the new plastic industry have likewise broken new ground, but their work has been simplified and their progress more rapid because they have had the previous knowledge of colloid behaviour to build upon. The potentialities of the plastic industry, so eloquently summarized by Sir Harry MacGowan in his after-lunch speech to the Trade Association the other day, are growing greater all the time, but this is because the chemist is playing a guiding part in the industry. Phenol resins, benzyl resins, vinyl resins, caseins, and ureas all have their special fields of utility, which oftimes overlap; the diversity of raw materials makes a diversity of properties some of which invention may be trusted to utilize. The rubber industry must not abandon a single research in its adversity, rather must it redouble the efforts, seeing only that the research is of a practical and not an academic character.

Research in Australia

The subject of research has been very much in the air of late. At a time when bankers are busy men they have found time to pause for a moment to comment on the usefulness of research and its inadequacy in this country. The scientist is flattered! Technical papers have taken up the topic with zest and the publication recently of the D.S.I.R. report for the year came at the right time to give the subject a further boost. Even the correspondence of *The Times* has been given an added interest by a letter from Prof. Gibbs and Dr. Underwood commenting on some aspects of industrial research in this country that are frequently overlooked. Let us hope this burst of enthusiasm will continue—it is all to the good of both chemistry and industry. The manufacturer may take heart from the banker and look upon research as a sound investment; the scientist will continue to regard it as a normal and essential factor in progress. To whichever opinion one subscribes, the new interest in research will be welcomed, for, as we read recently, "the fact that science is recognized as the foundation of modern society need hardly be elaborated," and if modern society is to remedy some of its present defects, the advance of scientific knowledge must be necessarily a contributin factor. If research has been much in the air in England it has been carried on very usefully in Australia, and we have just read an address on the work of the Australian Council for Industrial Research which was broadcast last December from several Australian wireless stations by the Rt. Hon. A. J. McLachlan, minister in charge of the Council. In Australia, we learn, scientific research costs the Government less than £70,000 per annum, which seems perhaps a small amount when one compares it with the amount spent in other countries notably America, where it has been computed that the total funds voted to research by various industries has reached the amazing total of £40,000,000 a year Nevertheless the money has been well spent in Australia and the investigations which the Council has been able to pursue have already yielded some valuable results The subjects tackled, being those of first importance, are naturally concerned largely with the problems of the agriculturist. If anyone needs to be assured of the financial gains to be obtained from research here are some striking examples. Plant diseases alone cause an annual loss in Australia of £12,000,000 and it is worth noting that "bitter pit" in apples which has in the past cost the exporter £100,000 a year may now as the result of this research be reduced to negligible proportions. A vaccine has been found which will materially reduce losses from "black disease" of sheep, which has been estimated to cause an annual loss of £1,000,000. An interesting investigation has dealt with the Australian timber used for butter boxes. Butter packed in such boxes in the past has developed a "wood taint," and therefore wood has had to be imported. Work in the Council's Melbourne laboratory has now produced a method of treating the Australian timber to prevent the production of the taint, and in future the necessity for importing timber will probably not exist. When surveying research work abroad, one is sometimes apt to forget that the major problems may not be the same as those obtaining at home. The work in Australia soon brings us to a realization of the different conditions, for we learn that the most spectacular success has been achieved in the destruction of the prickly pear. The invasion of this tropical weed into a belt of some 60,000,000 acres in Australia has made it one of the worst plant pests the world has known, but the general establishment of the parasitic *Cactoblastic* insect has been followed with such success that the plant has collapsed in Queensland and New South Wales. Such a result, coming from the work of a few scientists, will be of inestimable worth to agriculturists. One can appreciate Mr. McLachlan's words ". . . it is impossible to express in pounds sterling the value of the results so far achieved, but it is very clear that it is many times greater than the cost of the investigations." If we have perhaps harped a little on the financial aspect of research, it is probably because we have been impressed by some remarks made recently at Nottingham by Dr. Firth, in which he condemned the unbalanced directorates of many businesses for being concerned only with financial problems, the fundamental things to them being the balance sheets and the dividends.

A DECADE OF APPLIED X-RAY RESEARCH*

GRASSELLI MEDAL ADDRESS

By PROF. GEORGE L. CLARK

The applied science of X-rays was born on that day in 1895 when the distinguished German physicist, Röntgen, observed in his darkened laboratory a brilliantly luminescent screen, excited by mysterious invisible rays proceeding from the cathode-ray tube with which he was experimenting. Until that moment this tube seemed prosaically like scores of other cathode-ray tubes which had been operated in the course of many years in many laboratories. In the keen reasoning of Röntgen's mind and in the interpretation of the newly discovered phenomenon, how exciting it would have been if in exultation he had envisioned vastly improved and truly scientific metallurgical annealing processes based purely on X-ray research results, or the wonders of a crystalline universe, or a new chemistry and industry, knowing well the ultimate architecture of material things. But his thoughts were primarily on the tool itself rather than its uses, even though radiographic diagnosis of the human body and X-ray photographs of the interior construction of fabricated objects were first made by him.

Born in the Röntgen laboratory, nurtured by Laue's discovery of diffraction of X-rays by crystals, by the remarkable interpretations and predictions of Sir William Bragg and his son, Prof. W. L. Bragg, the discovery of the crystalline analysis of powders by Hull, and by Debye and Scherrer, and by many other fundamental contributions, the applied science of X-rays still remains the infant branch of the subject. As has been the case so frequently, practical applications had to follow fundamental pure research on the radiation, its generation, properties, and the interpretation of its interaction with crystals of pure simple substances. The speaker has met frequently with the feeling upon the part of intelligent industrial engineers and executives that there is something very mysterious about X-ray diffraction patterns and their interpretation in terms of ultimate structure of materials and that the X-ray research worker is literally "seeing things." As a matter of fact, applied X-ray science is exactly what the phrase states—the use of fundamental principles and laws of radiation discovered and established in laboratories of physics and chemistry. There is sometimes a remarkable beauty in diffraction patterns, but no more mystery than there is in the refraction of white light by a glass prism into a rainbow of colours.

It was the good fortune of the speaker to serve apprenticeship in X-ray science in a research laboratory of pure physics under Prof. William Duane of Harvard University. Whatever may be the value of subsequent contributions in the field of practical applications of X-radiation, they have been made possible because acquaintance with X-radiation, the tool itself, was the first objective. While diffraction technique is quickly acquired by the novice experimenter, a thorough knowledge of the fundamental physics of X-radiation is essential if he would use the method intelligently or extend the practical utilization. An imagination guide by a knowledge of fundamentals, plus experience store up with proper enthusiasm, seem to be essential require ments in the field of applied X-ray research, as it i in all the more familiar areas.

Any attempt to estimate the value of X-ray researc and testing in industry during the past decade woul be foolhardy. Far too many factors are involved including the possible saving of human life as a resul of assurance of sound materials of construction. Th method is still experimental, and the applications to recent for such an accounting. Furthermore, wh would attempt even to guess what has been the valu in industry of such an instrument as the microscope known and used during all these many years? Almos as difficult would be an inventory of actual achieve ments: that is, the actual successful use of X-ray data in production, leading to improvements in process an product, and the evolution of new ones, the setting u of X-ray specifications for materials, the foundation o patent claims and fundamental differentiations fron prior art, and the new approach to unsolved problem upon which other methods have been tried in vain It would not be difficult to enumerate as many as 7 items in such an inventory, from direct contact during the past few years. Such an inventory might very easily assume the proportions of a large industria encyclopedia. It would seem wiser therefore to brin to your attention briefly a few examples of problem which have been attacked by X-ray research method primarily selected from recent investigations in our ow laboratory.

It is well to note at once that there are two principa types of applications of X-rays in industry. Thes two types depend upon the use of two different properties of X-radiation, namely, absorption of the rays i varying degree by different materials, and the diffractio of the rays by material substances acting as grating Upon the first of these properties depends the science o radiography. Interior defects or heterogeneities are jus as easily disclosed in the body of a solid material as a the bones of the body, or foreign objects, or tumour or tuberculosis, and in these past few years the worl has come to recognize and to appreciate the significanc of industrial diagnosis by means of X-rays, just as i recognizes the indispensability of X-rays in the medica diagnostic field. Sound castings, sound welds, depend able parts of equipment subjected to high temperature and pressures, reliable automotive and aircraft part finished manufactured products of every kind properl fabricated, coal intelligently classified and cleaned fro non-combustible foreign material—there can be n misunderstanding or under-valuation of these achieve ments. We look forward eagerly to the time when th railroads of the United States will be equipped as matter of course, as the German railroads are, wit X-ray testing cars which can be run alongside locomotiv fire-boxes or boilers and test them for incipient failur Recent unqualified recognition of X-ray radiograph leading from boiler code revisions has made it almo imperative that welded pressure vessels manufacture in this country must be subjected to X-ray examinatio and accepted if a sound structure is disclosed.]

* Given before the American Section on November 4, 1932, at New York.

might be interesting to call attention to the efforts made by manufacturers of X-ray equipment to meet this new need of dependable and elastic apparatus. Figs. 1 and 2 show some of this new industrial equipment which has been tried and found not wanting. The value of radiography in revising foundry and welding technique alone is probably beyond the powers of the imagination.

FIG. 1

Vogt X-ray machine radiographing the Homoweld

Every X-ray laboratory is called upon to make some routine or incidental radiographic examination. A thorough acquaintance, therefore, with the laws of absorption and with the proper relationship of voltage on the X-ray tube and wave length to the object under investigation is highly desirable. Radiography is no longer a purely empirical development because definite numerical data, at least for steel, copper, brass, and

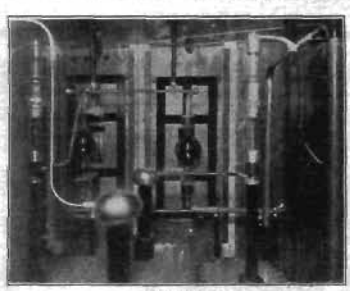

FIG. 2

aluminium, are now easily available. As examples of the type of examination that is sometimes required may be cited studies of small brass castings used in gun parts for the United States Army. In Fig. 3 is shown a radiograph for such a piece indicating a large and dangerous defect in one particular corner. Apparently the defect was due to a faulty casting technique and the discovery may, it is hoped, prevent the use of other similar defective pieces. Another interesting study has been made of steel fencing foils. An accident caused by the failure of a foil used in a University class led to a decision to subject all such foils to test. The expectation was that possibly two or three out of several hundred foils might show some evidence of the internal defects. As an actual fact, at least 90% of the foils were unbelievably bad and their use in fencing contests would involve unnecessary risk. While this represents only a very small item, the safety of human life is nevertheless concerned and rigid X-ray specifications must be set up. An almost endless number of other examples might be cited and illustrated, but in view of the obvious advantages of these practical applications it seems scarcely necessary to extend the list. To-day there is absolutely no excuse for the use of grossly imperfect materials when their detection and elimination is so simple and straightforward.

It is with the other branch of X-ray science, namely, diffraction analysis of the ultimate structure of materials,

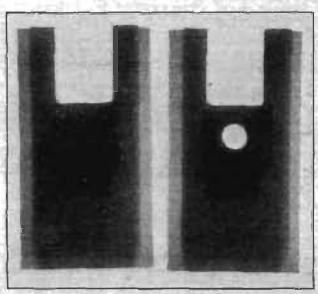

FIG. 3

that we are primarily concerned. Since the directness of application is not so readily apparent and the method involves a more profound scientific basis, I have liked to think of X-ray diffraction methods as a super-microscope simply because information is vouchsafed upon architectural plan of the ultimate building units, far beyond the power of any microscope. It is a familiar fact to all that solid matter is built in a remarkably regular and definitely organized manner. The amorphous state of matter so long familiar in chemistry prior to the penetrating analysis of X-ray diffraction effects has become one of the rarest things in the world. The beautiful large crystal with perfectly developed facets is surely constructed throughout on a lattice work upon which the atoms and molecules lie. But in addition substances which appear to have no distinguishing form under the microscope disclose the same kind of regular arrangement in particles only one ten-millionth of a cm. in diameter. If then each crystalline substance acts as a three dimensional diffraction grating for X-rays because the interplanar distances are of the same order of magnitude as X-ray wave-lengths, it follows that the

diffraction pattern which is registered upon the photographic film must be characteristic of the architectural plan of this particular substance, and when properly interpreted discloses that plan so clearly that models several hundred million times larger may be constructed. In a sense therefore we are looking through a supermicroscope to the very beginnings of spacial arrangement, and not only do we determine the ultimate crystalline structure and the arrangement in space of atoms and molecules which characterize a given substance, but we are also able to ascertain the condition of the particular specimen. In other words, we may easily differentiate between specimens with precisely the same fundamental crystalline structure and chemical composition in terms of grain size, preferred or random orientation of crystalline grains, internal strain, effects of deformation, and other properties, the knowledge of which is so important from the standpoint of practical behaviour. Some of these *X*-ray characterizations will be illustrated in the following examples.

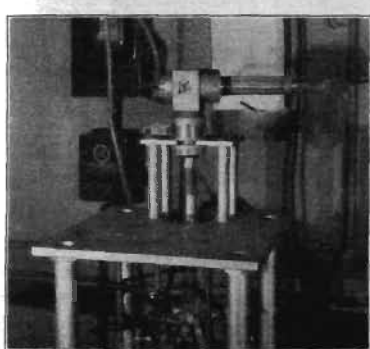

FIG. 4

Tribute must be paid to a large number of workers who have contributed towards the ever-improving *X*-ray diffraction apparatus and technique. Not long ago the time of exposure necessary for diffraction patterns often ran up to a hundred or more hours. Under such conditions the method remained very largely academic. But now *X*-ray tubes and equipment are available by which diffraction photographs may be made in a few minutes. Industrial interest and demand have been largely responsible for improving the method until it has become economically justifiable, and for making it possible to deal with unstable and changing substances. There has been no revolution in design or operation of an *X*-ray tube but merely the application of good judgment and sound principles of construction, so that *X*-ray beams of maximum intensity can be produced in apparatus which operates continuously. As an illustration may be shown a photograph of an Ott-Selmayr type tube (Fig. 4) in the laboratory at the University of Illinois with which exposures may be made in seconds or minutes.

The properties and behaviour of industrial materials depend so fundamentally upon the ultimate structures that it is only by careful determination of these that we can come to a rational understanding and control of the production and use. Out of the data which are accumulating has come a new science of crystal chemistry. There was a day when the chemist tried to destroy the solid with which he was working since he felt that he knew more about a liquid solution or gas, but in these days the process has reversed itself and the chemist dealing with matter and its changes attempts to form crystals. The ramifications and significances of diffraction analysis can best be illustrated in the following specific cases.

Structure of Alloys

It stands to the matchless credit of such men as Westgren and his associates especially that the nearly hopeless complications associated with alloys have resolved themselves into a science governed by far-reaching fundamental principles. Formation of alloy phases and intermetallic compounds depends not upon some mysterious caprice but upon the ratio of the number of valence electrons to the number of atoms in the molecule. The metallurgist must therefore take into account valence electrons, co-ordination, atomic radii, and other concepts which formerly seemed to have theoretical interest only. In 1926 Hume-Rothery suggested that the β phases of several alloy systems which seemed to be entirely analogous in structure had structural similarity because this ratio was three to two. In many cases the γ phase of a complicated cubic structure has been found having usually 52, but in some cases, 8 times 52, or 416 atoms, in its elementary cube, as in Cu_5Zn_8, Cu_9Al_4, $Cu_{31}Sn_8$, Fe_5Zn_{21}, etc. It has been possible as a result of investigations in our own laboratory on the system lead–sodium to add another member to this γ list. Analysis of the diffraction patterns shows again the same kind of characteristic cubic structure, that the formula Na_4Pb usually assigned to this phase is actually $Na_{31}Pb_8$, and that there are one and one-half times 52, or 78 atoms per unit cell. This generalization has verified the prediction from magnetic susceptibility measurements that the elements in group 8 of the periodic table appear to have zero valence. A close-packed hexagonal structure, ε, and an atomic grouping which seems to be connected with a concentration of valence electrons 7 to 4 is also commonly present in these systems. Thus the alloys of greatest industrial importance are found to depend upon the valence electrons, and upon this same basis new alloys may be predicted, their ranges of stability delimited and the nature of the metallic bond as contrasted with other types understood in a measure for the first time. The whole range of binary iron alloys is systematized upon a consideration of atomic radii.

Formation of Superstructure Alloys as an Explanation of Mechanical Failure

The problem of failure of many alloys owing to cracking has always been serious, simply because there seemed to

FIG. 5

Changes in structure with steps in rolling of low carbon sheet steel. A. Hot rolled strip; B. One pass, 7% reduction; C. Nine passes, 47% reduction; D. 14 passes, 71% reduction; E. 19 passes, 95·5 % reduction; F. 21 passes, 90% reduction; G. 30 passes, 97% reduction

be so little evidence of a change. Many of these difficulties are cleared up by the discovery from *X*-ray measurements alone of the existence of superstructure alloys. A number of binary systems have long been classified as forming a continuous series of solid solutions. Foreign atoms entering the mixed crystals may take up special positions and actually enlarge the lattice or lower the symmetry. Such a lattice is really a true compound. It is distinguished from the other compounds by the fact that it represents very slight deformation of the lattice of the pure metal. It is distinguished from a true solid solution or mixed crystal by the new superstructure lines which appear in the *X*-ray patterns in addition to those characteristic of a pure metal, or by the apparent splitting of normally single lines. The superstructure types do not usually appear with ordinary melting practice but only after careful tempering. The presence of other metals in small amounts seems to have a profound effect. In recent studies the superstructure alloys of the system gold–copper have been easily identified, particularly those corresponding to the composition AuCu. In the presence of other metallic elements this superstructure is more easily produced, with the result that fatigue and ageing failure of the fabricated gold alloy may take place. The *X*-ray method therefore, has made it possible to determine exactly the narrow limits within which a true solid solution may continue to exist following a succession of rolling and heat treatments and after quenching from very exactly determined temperatures. Further work on the ternary and quaternary alloys of gold will remove from empiricism the formulæ handed down for generations for producing gold of a given carat for a given purpose in jewellery, dental fillings, fountain pen nibs, etc.

Mechanism of Corrosion in Alloys

The corrosion of metals and alloys has been always one of the greatest problems of the chemist and chemical engineer, and many theories of the mechanism of corrosion have been put forward. A vast amount of effort has been expended to understand what corrosion is and how to prevent it and yet only now are investigations being undertaken by the *X*-ray diffraction method to discover exactly what happens on the corroded surface. The recent work by Glocker and Graf on the corrosion of gold–copper alloys and our own work independently undertaken in the same field make it possible to proceed to a study of the corrosion of other types of alloys. Such an alloy, after etching with strong oxidizing agents, produces the diffraction interferences for pure gold in a surface layer oriented exactly like the original alloy layer. Thus with the removal of the less noble copper atoms from the mixed crystal lattice, the remaining gold atoms have the power by virtue of the great lattice forces to group together into a pure gold crystal layer with entirely different lattice spacing from that of the underlying unattacked alloy. Weak oxidizing agents, sulphur-containing compounds, and corrosive gases have the effect of producing an outer layer of alloy much richer in gold than the original crystal. When gases attack the surface at high temperatures at which atoms diffuse easily, the copper atoms can all reach the surface and escape from the protective action of the gold atoms so that the corrosion zone is pure gold. In order to explain these results a definite mobility of the gold atoms is necessary after the copper atoms are removed. An interesting further observation has to do with limits of resistance to corrosion as a function of alloy composition. Tammann has stated certain rules based on experiment concerning these limits at which corrosive attack can occur in alloys. Resistance to corrosion begins at a remarkably definite content of the more noble metal component depending on the corrosive agent, with various resistance limits corresponding to contents of N/8 mole of the noble component. In the case of gold–copper alloys resistance to attack of weak oxidizing sulphur-containing and gaseous agents begins at 25 atomic % of gold (2/8 mole) and the corrosion zone is a gold-rich solid solution. The alloy with 50 atomic % of gold (4/8 mole) is the resistance limit for strong oxidizing agents and the corrosion zone is pure gold. As a result of these observations a more complete picture of corrosion and resistance mechanisms is afforded—all based upon the interpretation of *X*-ray diffraction patterns.

Stages of Reduction and the Effects of Variables on the Structure of Sheet Steel

In commercial cold rolling of sheet metals fundamental investigations have led to a knowledge of the types and degrees of preferred orientation produced in metal sheets by cold rolling. *X*-ray diffraction patterns prove that in a rolling process the face diagonals of the unit crystal cubes of iron tend to take up a position parallel to the direction of rolling, and cube face planes tend to take up a position parallel to the surface of the sheet. This behaviour is entirely compatible with what might be expected in the deformation of iron and steel.

Clark and Sisson have made a long series of studies of these problems for various metals, but the scope of the data provided is too extensive to permit presentation of results here except for a few points of especial interest.

Structural changes with successive reductions.—The change in *X*-ray patterns with successive reductions is best represented by Fig. 5 for low-carbon steel, selected from a series of 84 samples. Here the *X*-ray beam passed perpendicular to the rolling direction and to the surface of the sheet.

Pass	Gauge, in.	Percentage reduction	Pattern
0	0·158 (hot-rolled strip)	0	Large random grains
1	0·1475	7	Fragmentation below 35 and appearance of rings
9	0·084	47	Nearly complete fragmentation, random
14	0·046	71	Appearance of six-point fibre pattern characteristic of drawing
19	0·023	85·5	Passing from six- to four-point pattern
21	0·0165	90	Typical rolling pattern
30	0·005	97	Perfected orientation

From a whole series of steel samples the following average results were obtained: appearance of continuous

rings (fragmentation), 27% reduction; sharp rings, 38% reduction; six-point fibre pattern, 54% reduction; four-point fibre pattern, 76% reduction. Such values are greatly dependent on type of mills, chemical composition, thickness, grain size, and orientation in the original material. The results confirm those of Tammann, who found that in rolling, two clearly defined changes in crystal orientation can be distinguished; the first in which the force due to rotation of the rolls acts as a

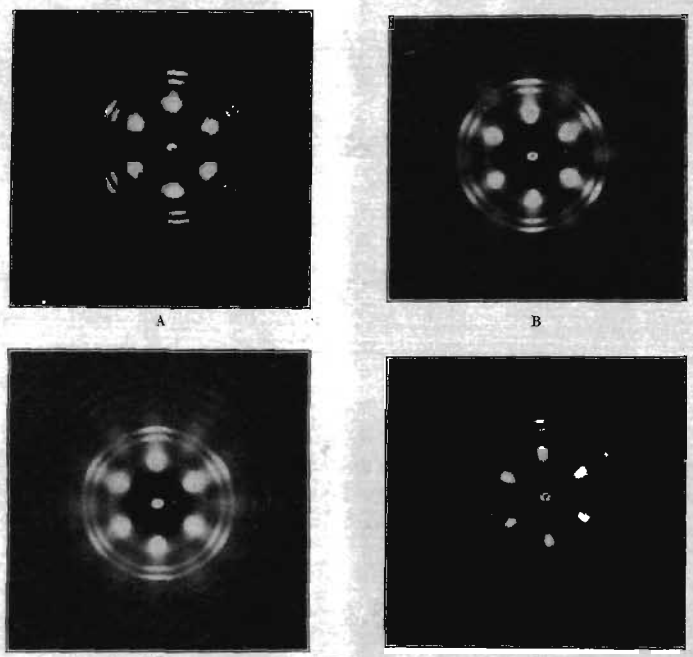

FIG. 6

Pattern for sheet steel reduced; A. 16%; B. 36·5%; C. 53%; D. 85%; *with X-ray beam tangent to sheet from which amount of cold work may be calculated*

tretching force (six-point *X*-ray pattern), and the second n which the action of the rolls is similar to that of imple compression and exerts the greatest influence n the final orientation in cases of large reductions.

Effect of initial grain size.—Grain size has considerable ıfluence upon the structure of cold-rolled steel during arly stages of reduction but after large reductions the ffect is lost. The smaller the initial grain size the ss cold work is required to produce "fibering."

Effect of initial strip thickness.—The degree of "fiber-g" depends not only on the percentage reduction but also on the initial strip thickness. A sample reduced from 0·08 to 0·01 in. does not show the same degree of preferred orientation as one reduced from 0·04 to 0·005 in., although both have received 87·5% reduction.

Effect of carbon content.—Most of the previous work on preferred orientation in cold-rolled sheets has been carried out on pure metals. In steels the pearlite is hard and more brittle than the ferrite and concentrates at the junctions of the ferrite grains with the result that when pearlitic steel is cold rolled gliding takes place only in the ferrite. During the rolling process the pearlite is dispersed while the soft ductile ferrite forms a plastic bond which is not oriented, so as to form a straight fibre structure, but is curved around the pearlite particles. The *X*-ray pattern, therefore, gives the appearance of random arrangement for high-carbon steels.

Effect of rolling variables.—(1) The roll diameter has less effect on final structure than the total percentage reduction. The smaller the rolls the greater is the

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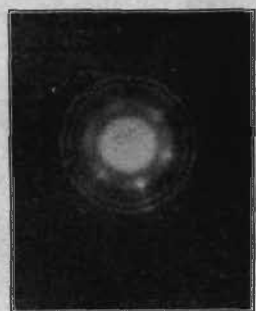

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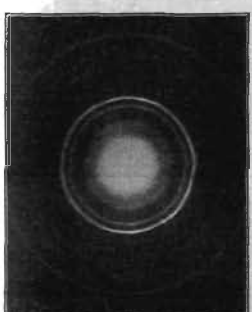

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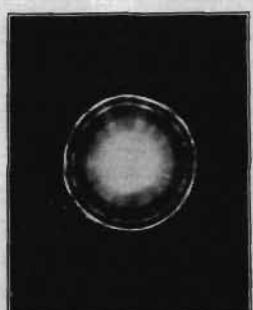

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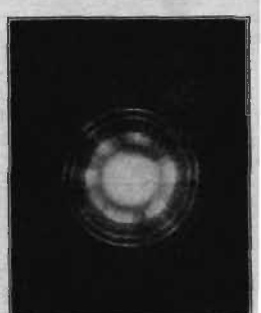

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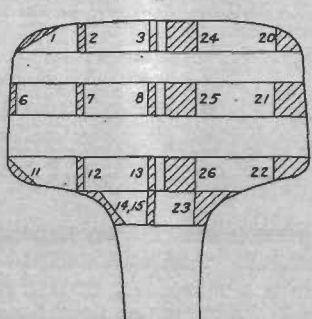

FIG. 7

X-ray study of structure of steel rail

angular divergence of the grains laterally in the rolling plane from the ideal preferred direction, while large rolls tend to produce more divergence normal to the rolling plane. Numerous other small differences may also be quantitatively ascertained, particularly for early and intermediate stages of reduction. (2) With small rolls the same structure is obtained at speeds from 70 to 800 ft. per minute, and with unidirectional or reversed passes through the rolls. (3) Various combinations of tension and compression of the sheets have been studied in detail, both experimentally and with vector theory. Fibre structures are ultimately obtained but the appearance of the four-point pattern characteristic of compression can be greatly delayed by application of tension. (4) Interesting results are obtained by rolling metals in all directions (random), at 90° (very perfect

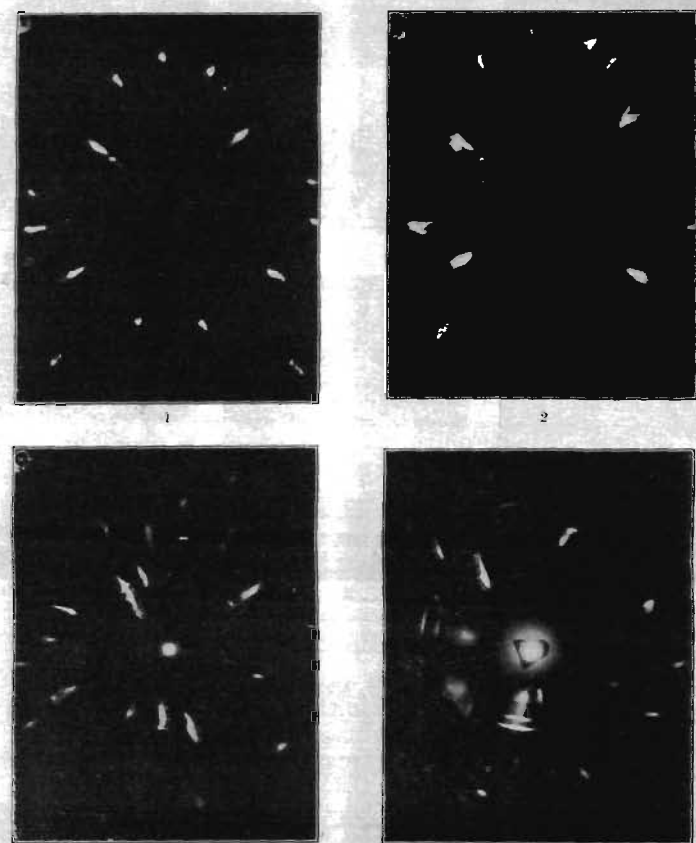

FIG. 8

Effect of successive loading of silicon steel sample with X-ray beam passing through exactly same portion of specimen: (1) 15,000 *lb. per sq. in.*, (2) 50,000 *lb. per sq. in.*, (3) 60,000 *lb. per sq. in.*, (4) 62,500 *lb. per sq. in.*

"fibering"), 60° (six-point instead of four-point patterns), etc. (5) An *X*-ray method of determining the amount of cold-rolling to which a sheet has been subjected. In the usual method of taking *X*-ray diffraction patterns of cold-rolled sheets, the *X*-ray beam passes perpendicular to both the rolling direction and the plane of rolling. Preferred orientation may appear only after 60% to 70% reduction, depending on the type of mill and original material variables. If the beam is made to pass through the material perpendicular to the rolling direction and *parallel* to the rolling plane (edge-on of the sheet), evidence of preferred orientation is obtained after 15% to 30% reduction, depending upon the above-mentioned variables. This orientation gives a six-point fibre pattern similar to that for cold-drawn wires. *Instead of the pattern changing to a fourfold* pattern upon further reduction, as is the case when the beam is normal to the rolling plane, the type of pattern remains the same. However, as the percentage reduction increases, the intensity maxima become sharper, as illustrated in Fig. 6 for 16, 36·5, 53, and 85% reduction. In certain cases it has been possible to determine very small amounts of cold work such as roller levelling after annealing, by careful examination of the *X*-ray patterns (elongation and splitting of interference of spots).

Fatigue problems in steel rails.—Co-operative efforts in *combining X-ray work with fatigue tests have not yet* been completed, although progress has been made and more will be expected. One of the chief difficulties has been in providing specimens sufficiently thin for *X*-ray analysis. As an example of such research, some preliminary results are presented in Fig. 7 for steel rails, the diagram showing the location of the samples. The ideal structure shown by No. 14 may be contrasted with No. 26, for example, which shows strain in the radial striations of the pattern for actual preferred orientation of the grains in such an area. Fissures usually occur, largely as a result of the varied structure in contiguous portions of the rail.

Effects of measured mechanical strain on commercial steel specimens.—It may be readily granted that one of the most vitally important applications of diffraction analysis is the detection of internal strain. Apart from the mechanical gauge-mark method of detecting the strain, there is no other approach. A metal specimen may be perfectly sound from the radiographic point of view and yet represent so highly distorted a structure that it is a potential cause of failure upon fatigue. There is still a great difference of opinion as to the interpretation of diffraction manifestations of strain. The speaker however, has always held tenaciously to the firm belief that asterism or radial striations upon the photographic film must represent a condition of distortion. This can be demonstrated simply by taking any single crystal specimen whose diffraction interferences are sharp Laue spots and subjecting this specimen to tension deformation which may be actually calibrated. For some time the effort has been made to build up a series of standards so that a numerical value might be assigned in terms of deforming force to any evidence of a distorted structure. Some of these changes are illustrated in Fig. 8.

(*To be continued.*)

THE PLASTICS EXHIBITION

In the absence of Lord Irwin the Plastics Industry Exhibition at the Science Museum, South Kensington, was opened on Wednesday the 5th inst. by Mr. H. Ramsbotham, Parliamentary Secretary to the Board of Education. Mr. Kenneth Chance briefly referred to the rapid growth of the plastics industry and the need for calling public attention to its most recent developments; Mr. Ramsbotham, after alluding to the efforts of the Board of Education to mould those plastic materials the minds of the schoolboy and schoolgirl, spoke of the desire of the Board of Education to assist industry and paid a well-deserved compliment to Sir Henry Lyons for his enterprise in connexion with the organization of the exhibition. Dr. Pickard and Mr. W. C. Waghorne also made brief speeches. The exhibition is one of singular interest both to the scientific person and the lay person and many of the objects displayed are of singular beauty. A more detailed account of the exhibition will be published at a later date.

FUEL RESEARCH*

The annual report of the Fuel Research Board for the year ended March 31, 1932, refers to several important matters.

Low temperature carbonization in brick retorts.—Evidence shows that considerable progress is being made towards solving some of the outstanding problems of the low temperature carbonization of coal by the use of brick retorts. An experimental brick retort has been working satisfactorily and steadily at the Fuel Research Station since November, 1930, and work is in progress on the erection of a setting of two brick retorts of the latest design and a setting of two intermittent vertical chamber ovens.

Using a medium caking coal—"Dalton Main"—a throughput of 10 tons per day has been maintained with the brick retorts, giving a yield of coke containing approximately 9% of volatile matter, and suitable for use as a domestic fuel in open grates.

Treatment of tar.—According to the report: "The production of a free-burning smokeless domestic fuel is perhaps the main object of 'low'-temperature carbonization, but the financial success depends, as has many times been pointed out, on the profitable disposal of all the subsidiary products, and the drop in the price of tars and oils that has occurred in recent years has a serious effect on the balance sheet of such processes. It has been shown that tars, produced at temperatures below about 800° C., can be converted in the laboratory to excellent motor spirit and Diesel oil, with the entire elimination of pitch."

Lubricating oils from coal.—Attention has been given to the possible preparation of lubricating oils from coal tar and hydrogenation products. A yield, small up to the present, of an oil which behaves like a good lubricating oil, has been produced by the action of aluminium chloride on certain substances obtained from light oils. The suggestion that a lubricating oil could be obtained by blending a partially hydrogenated

* Report of the Fuel Research Board of the D.S.I.R. for year ended March 31, 1932. H.M. Stationery Office, 2s. 6d.

tar oil with another oil, not having lubricating properties, is being followed up.

Trials of oil from coal in internal-combustion engines.—Tests carried out on samples of motor spirit prepared by hydrogenating coal and low temperature tars indicate that the samples have considerably higher anti-knock values than that of the petrols at present marketed in this country.

Pulverized fuel.—The report records progress in the development of more efficient burners for use with pulverized fuel. Successful results have been obtained with a burner "so constructed that a mixture of primary air and fuel issues through a 'grid' in a series of thin layers, between which are supplied layers of secondary air, preferably preheated."

A complete departure from existing methods of burning powdered coal is made in the "vortex" combustion chamber under development at the Fuel Research Station, in which "an attempt is made, for the first time, to control the motion of both the fuel particles and the air required for their combustion, in order to obtain the relative motion requisite for rapid combustion in a small space. It is also hoped by this means to deal with fuel of a coarser nature than that usually required for powdered fuel firing."

SIR ROBERT AND LADY ROBERTSON WEDDING ANNIVERSARY AT TEDDINGTON

On Saturday afternoon, the 8th inst., an extremely pleasant Garden Party was held, by the kindness of Sir Joseph Petavel, in the beautiful grounds of the National Physical Laboratory at Teddington, to celebrate the thirtieth anniversary of the wedding of Sir Robert and Lady Robertson. The weather was perfect for such a gathering, and the charming house and gardens may be taken as evidence of the esteem in which physical research is held by the Nation. Those who were privileged to attend this celebration will never forget the display of daffodils, the water colours and drawings by Lady Robertson, or the Highland dancing and folk dancing in which Sir Robert and Lady Robertson and their son and daughter took part. The bagpipes are eminently suited for such an open-air entertainment and the skill of the dancers was encouraged by the traditional music. Mr. Rintoul, who was the best man at the wedding, was present on this anniversary, and many men of science with their wives and daughters came to offer their congratulations to the Government Chemist, his wife, and family. Sir Robert was educated at the Madras Academy, Cupar, Fife, and at St. Andrews' University, where he studied chemistry under Prof. Purdie. In 1892 he was appointed Chemist in the Royal Gunpowder Factory at Waltham Abbey, where the manufacture of cordite, then a new substance, had just been started. He remained there until 1907, carrying out researches on the stability of explosives and on their manufacture and was for a time in charge of the manufacture of nitroglycerine, rendering good service when an unfortunate explosion took place in the year 1894. In 1907 he was transferred to the direction of Explosives Research at the Research Department, Woolwich, and on the outbreak of war in 1914 was confronted with many great problems, including new processes for the manufacture of trinitrotoluene and new types of cordite. In association with others, he investigated the high explosive amatol (ammonium nitrate and trinitrotoluene) which became the Service high explosive for shell, aerial bombs, and other purposes, and was manufactured on a huge scale during the war. He has read papers on the calorimetry of explosives before the Royal Society, of which he has been a member since 1917. In 1918 he received the honour of a K.B.E. In 1921 he was

appointed Government Chemist in charge of the Government Laboratory, a department that carries out chemical work and investigations for all the Departments of State. He has guided this growing institution and in addition to his administrative duties has found time to devote to research on the infra-red region of the spectrum in connexion with which several papers have been published by the Royal Society. He has been President of the Faraday Society, and of the Chemistry Section of the British Association and is Treasurer and a Vice-President of the Royal Institution, in which he takes much interest. The photograph we publish is one of a painting by Lady Robertson.

CANADIAN MINING

In his presidential address to the Convention of the Engineering Institute of Canada held recently at Ottawa, Dr. Charles Camsell, Deputy-Minister of Mines of Canada, stated that Canada's metal mining industries were for the most part excellently equipped with ample supplies of raw materials and had production costs among the lowest in the world. While Canadian metal mining industries might have to face more intensive competition than has hitherto been the case, they were well able to take care of themselves in world metal markets.

SOCIETY OF CHEMICAL INDUSTRY

OFFICIAL NOTICES

Indexes. It is hoped to complete the Joint Index to Abstracts A and B next week, when it will be distributed with the index to the JOURNAL to every paid-up subscriber or member of 1932. The definite date of despatch will be notified in the JOURNAL.

Binding the Journal. The usual favourable arrangements will again apply for binding the JOURNAL either in the Society's special cases or in plain binding. Particulars may be obtained from the General Secretary, 46, Finsbury Square, London, E.C.2.

BIRMINGHAM AND MIDLAND SECTION

The 27th annual meeting of the Birmingham and Midland Section was held at the University of Birmingham on Thursday, April 6.

Mr. H. W. Rowell was re-elected chairman; Mr. W. T. Collis, hon. treasurer; Mr. J. R. Johnson, hon. auditor; and Mr. G. King, hon. secretary. Mr. W. A. S. Calder, Prof. Hopkins, and Messrs. J. R. Johnson, J. E. Such, and J. Wilson were elected to vacancies on the committee.

The report, read by Mr. King, stated that during the year, Mr. Rowell, supported by the committee, placed before the Council of the Society a definite scheme for *reorganization which might have far-reaching results*. Mr. King stated that the programme for next season would include a joint meeting with the Chemical Engineering Group, and contributions of direct interest to the Food and Plastics Groups.

EDINBURGH SECTION

The annual general meeting was held on March 23 at the North British Station Hotel, Edinburgh, at 7.30 p.m., when the officers and committee for the session 1933—34 were elected as follows: *Chairman*: Mr. W. M. Ames; *Vice-Chairman*: Mr. David Bain; *Hon. Librarian*: Dr. Alexander Lauder; *Committee*: Messrs. G. F. Merson, W. A. Macgillivray, W. H. Wilkinson, J. B. Westwood, Profs. A. Findlay and T. Slater Price, Drs. J. McB. Ross, W. O. Kermack, W. McCartney, and W. M. Stokoe, and Messrs. A. M. Cameron and A. P. Mieras. *The last four are new members.*

At 8 p.m. a joint meeting with the local section of the Institute of Chemistry was held when Dr. Littler, of Imperial Chemical Industries, Ltd., read a paper on "Drikold," which gave a short history of the origin and growth of the solid CO_2 industry. Some problems of the production of solid CO_2 were touched upon, and it was shown how the application of thermodynamics had enabled economies to be effected. Methods of handling and transporting solid CO_2 were described, with special reference to those evolved by Imperial Chemical Industries to deal with their product Drikold. The evolution of this technique had enabled production to be centralized in large producing units, making use of by-product CO_2.

Two of the most important applications of Drikold were described, namely as a source of CO_2 gas in place of liquid CO_2 and its use as a refrigerant. Some method of effecting temperature control in spaces refrigerated with Drikold were mentioned, and also the advantages of its use in the handling of foodstuffs, in particular the bactericidal effect of the evolved gas.

The paper concluded by pointing out that the future organization of the solid CO_2 industry would take the form of a few large producing units and a distribution net-work which would enable solid CO_2 to be supplied and stored at the consuming centres.

The attendance at the meeting was a record, and judging from the numerous questions asked and ably answered by Dr. Littler, much interest was taken in the lecture. Brewing, baking, aerated water, fire insurance, and other branches of industry were represented and each commented on the paper. Dr. Kermack proposed a vote of thanks to the lecturer, and this was received with acclamation.

LONDON SECTION

A meeting of the London Section of the Society was held on April 3 at Burlington House, with Dr. G. W. Monier-Williams, chairman of the Section, presiding, when a paper on "Modern Methods of Examining Pictures" was read by Prof. A. P. Laurie. A large audience listened with much interest to the paper which was given illustrated by a number of slides showing the lecturer's investigations. In the course of the lecture Prof. Laurie said:

The application of various methods derived from the laboratory to the examination of "Old Masters" has made considerable progress of late years, the object being to trace as far as possible by exact methods the history of a picture, to assist in correct attribution, and to guide the restorer. The questions to be answered are the date of painting of a picture, what is the condition of the picture, the extent to which it has been repaired and overpainted, and whether it is a forgery.

The first step is the examination of the picture under the microscope. For this a magnification of some 30 to 60 diameters is required, and the microscope should be mounted on a travelling horizontal bar so as to be moved systematically over the whole picture. The best illumination is daylight. Much information is obtained in this way by those who have had long practice and experience. The nature of the successive layers of *cracks, the approximate determination of the pigments*, and their fineness of grinding, and the presence and extent of repainting are all revealed by this examination, while forgeries are often at once detected. Information is also obtained as to the probable nature of the medium, and scaling and cracking examined to determine the nature of the repairs.

The next step is the identification of the pigments which have been used in painting the picture. Tiny portions are removed with the point of a hypodermic needle, or the needle having been converted into a tiny cork borer samples are taken right through the picture. The recognized methods of micro-chemical analysis are applied to these fragments, or in the case of certain crystalline pigments, the polarizing microscope can be used for identification. From the time of Sir Humphry Davy many chemists have investigated the pigments used in the past. Among these contributions are the researches of Raehlmann, my investigations of the

pigments used in painting illuminated manuscripts from 700 to 1700, the *Scientific Examination of Pictures* by Martin de Wild, and a recent monograph by Heinz Hetterich issued by the Technical College laboratory at Munich.

There is also a considerable amount of literary material, from Pliny onwards, contained in manuscripts on painting by monks, early painters, and others which have been edited and translated by various authors. The monumental work by Ernst Berger, *Die Maltechnik des Altertums*, contains all the information and references on this branch of the subject, but is unfortunately mixed with special pleading for theories which are open to question. The information from these literary sources has to be examined with the greatest caution, as they often contain recipes compiled without critical consideration, and are unreliable in nomenclature. It is necessary to check it by actual identification of pigments, obtained from undoubted contemporary documents. . . . In Pliny's time the artificial preparation of white lead, massicot, red lead, vermilion, verdigris, indigo, and lakes on an alumina base were known. Painters used in addition the earth colours such as red and yellow ochre, terre verte and the umbers, cinnebar, orpiment, azurite, and malachite. The artificial silicate of copper and calcium, Egyptian blue, was used in classical times and the early centuries of the Christian era, ultramarine from lapis lazuli is known from the 7th century, and Naples yellow prepared from the oxides of antimony and lead was known in the 15th century and madder lakes were prepared. A very fine azurite came into use in the closing years of the 15th century and remained the favourite blue up to the middle of the 17th century, when it disappeared from the artist's palette. The close of the 16th century saw the introduction of smalt, and the 17th century the preparation of artificial carbonates of copper, blue, and green bice, and the 18th century the discovery of Prussian blue. The 19th century saw the introduction of a host of new pigments to the artist's palette.

While the identification of pigments by micro-chemical methods can readily be accomplished, the identification of mediums is much more difficult. Beeswax is found as the medium in the portraits from Egypt of the 2nd century and has been found on Russian paintings as late as the 6th century, and may have been used much later as a ground to paint on mixed with yellow ochre in Russian and Venetian painting. The first account we have of the use of linseed oil as a painting medium was in the 12th century. It is possible that the transition from wax to oil is gradual, the drying oil, which was known as a varnish as early as the 4th century, being mixed with the wax. The use of yolk of egg is definitely known in the 13th, 14th, and 15th centuries, after which it is replaced by oil, and such mediums as gum, glue, and flour paste are known from the earliest times.

The identification of size and egg and gum is not difficult, as size and gum are soluble, egg insoluble, and both egg and size contain nitrogen and egg contains sulphur. Eibner identifies nitrogen by evolution as ammonia in a capillary tube. I have found a useful test is to place a tiny particle on a quartz slide, lay on it a tiny fragment of sodium and heat, moisten with ferrous sulphate, evaporate, moisten with ferric chloride, and examine for Prussian blue under the microscope. Micro-chemical tests are known for sulphur and also for the identification of an oil film, but the more complicated questions as to whether linseed, walnut, or poppy oil is used, whether resins were introduced and how far emulsions of egg and oil were used, await solution. I have recently approached the question of media indirectly by the measurement of the refractive index of the film. The film of a drying oil continues to rise in refractive index with age. I have a linseed oil film which was painted out on the glass of a Herbert Smith refractometer 7 years ago. During the drying the refractive index rose from 1·480 to 1·472. It then stopped rising for two days and then began again rising, reaching 1·494 in two days. Readings at intervals have been taken. By November, 1926, it had risen to 1·501, and to-day is 1·503, so that it is continuously rising though at a slower and slower rate. I have examined the refractive index of the film of a considerable number of pictures of different dates and have been fortunate enough to be able to examine a white lead priming on a painted stone statue of the end of the 13th century. The following are the approximate figures for different periods which may be regarded as preliminary. Late 18th century 1·53, late 17th century 1·55, late 15th century 1·58, close of 13th century 1·60. The yolk of egg film has an approximate refractive index of 1·534, and a sample from a 15th century picture gave 1·533, so apparently egg when once dry changes little in refractive index and its presence can be confirmed by staining with albumen peacock blue and then washing with alcohol. I am at present investigating the indices of films of linseed, poppy, nut, and stand oil, an oil copal varnish, and measuring their rate of change in the hope that it may be possible to identify such media by this method.

The method of observation is simple. I select the white lead, as this has almost certainly been ground in oil, and the oil film has in each case been exposed to the same catalytic action, and white lead has been used and made by the same process from the time of Pliny. A particle of white lead paint is cleared by immersing in very dilute cold nitric acid. It is then immersed in a series of liquids of rising refractive index and its refractive index determined by the method of light fringes under the microscope, the index of each sample of the immersing liquid being measured in an Abbé refractometer. Two readings are ultimately obtained, one above and one below that of the particle, by which it is possible to determine the refractive index to an accuracy of 0·002. Old oil films are not much affected by the liquids used in the determination, and one film may be used for several readings, being washed each time with the fresh liquid, but the final result should be confirmed with two fresh samples. In the case of a new film a fresh sample must be used for every reading.

Linseed oil was probably the oil used in the north of Europe. Italian painters used both linseed and walnut oil. Poppy oil may have been used in the 16th and succeeding centuries and stand oil may have been used by the Dutch painters.

Considerable progress has been made in the application of X-ray photography to the examination of pictures. A photographic film is placed beneath the picture, the X-ray is passed through, and a shadowgraph obtained. The results depend on the nature of the pigment, the closeness of packing of the particles, the coarseness with which they are ground, and the thickness of the layer of paint. Much valuable information is obtained as to what lies underneath the surface paint.

Ultra-violet light is not of much value in identifying pigments immersed in oil with the exception of zinc white which turns yellow, but it very often reveals repairs and overpainting, though it is not infallible for this purpose. Photography by ultra-violet light has been immensely improved, and is more reliable than examination by the eye, as selected wave-lengths can be used.

In addition to the methods described, examination through coloured screens, photomicrographs of brush-work, and photographs taken in a slanting light are also used. Every picture presents a new problem, the various methods of examination are systematically applied, and each method is needed to accumulate data which usually lead to a positive conclusion. The forgers are very ingenious, and forgery and heavy repainting have been practised in the past and are practised to-day, but the forger usually makes a slip somewhere which leads to his detection.

After thanking Prof. Laurie for his address Dr. Monier-Williams threw the meeting open for discussion, and commented on the use of ultra-violet light. This was the primary influence in the fading quality of sunlight, and he suggested it might be necessary to use it with caution.

Dr. L. A. Jordan thanked Prof. Laurie for dealing with the mechanical side of his work. This was important, for most of the problems of preservation arose from the fact that from the artist himself to the picture restorer the individuals concerned were interested in the result, and not the mechanism. It was however necessary to translate such interesting work into terms the artist could understand, and which would permit of more lasting pictures being painted. Much had been said of the help which science could give the artist, but it was no use saying it unless scientists gave such help, as Prof. Laurie had done. Scientific work in pictures had in the past been concerned too much with isolated facts; but paint should be regarded as a system and a very living thing, and not a mere mixture of pigment and oil.

Mr. Noel Heaton expressed his agreement with Dr. Jordan as regards the necessity for the chemist to be of real help to the artist by studying paint as a system in which there was mutual reaction between pigment and vehicle. The difficulty in the past had been lack of understanding and sympathy between the artist and the chemist. He stressed the point that the real purpose of such scientific examination of pictures was to assist the artist in his judgment, not to supplant him. Prof. Laurie had referred to orpiment as being an obsolete pigment, but the speaker thought it was still used to-day in the East in the preparation of shellac. There were many such instances of the survival of a pigment for a particular purpose, and this suggested that a certain amount of caution was necessary in deciding the date of a picture from identification of the pigments used. In his experience it was not always so easy to distinguish between the natural ultramarine prepared from lapis lazuli and the synthetic product as Dr. Laurie had suggested, and he would raise the question as to how far the artist was justified in thinking that the natural product had qualities not possessed by the synthetic. The details given as to the application of X-rays and fluorescence under ultra-violet light to the examination of pictures were of great interest, and he was particularly glad to note the restraint with which the author had put these methods forward. Their application was subject to great limitations, and particularly with ultra-violet light it was difficult to interpret the results obtained with accuracy.

Mr. C. E. Sage said that the lasting qualities of some of the old natural colours of mineral origin were far beyond anything produced by modern methods, and as the real test of such painter's materials was the effect produced by time, we should have to wait to see the effect of London atmosphere on some of our modern art treasures. The frescoes executed by eminent artists with modern materials were already very badly affected and the canvasses used to-day needed special means of preservation if they were to survive for the benefit of posterity.

Dr. Levinstein commented on the historical value of the investigations of Prof. Laurie and others, and said there was ample evidence to show that the Egyptians must have had, taking into account their facilities, a research organization of great efficiency.

Dr. G. E. Foxwell asked if Prof. Laurie thought that the pigments used for painting to-day were inferior as regards brilliancy and durability to the pigments of the past centuries? Frequently instances were known of a painting acknowledged to be a genuine masterpiece and valued at thousands of pounds which was displaced from its position by the discovery of another previously unknown. Immediately the first picture dropped prodigiously in value. Seeing that the primary object of a painting was to delight the eye and the first picture was so good that it had passed the criticism of the experts, why should there be this fluctuation in value?

In replying to the discussion Prof. Laurie said that he had dealt with only one aspect of modern interest in preserving pictures. Why old pictures lasted longer than the modern ones had been the subject of much research, and he had therefore dealt with some aspects of the old artist's work. The rotting of the canvas of modern pictures was due not so much to the sulphur in the atmosphere as to the oxidation of linseed oil and the production of organic acids. He suggested that artists in the past had been frequently misled by the hurried conclusions of the chemists, an instance being their advice against the use of white lead, but which was in use hundreds of years ago with great success. The methods of the old masters were often sound and based on long experience.

MANCHESTER SECTION

The annual meeting of the Manchester Section was held on April 7, Dr. T. Callan presiding. On the proposition of Dr. A. Schedler, a hearty vote of thanks was accorded Dr. Callan for his services as chairman of the Section.

The following officers and members of committee were elected: *Chairman*: Dr. A. Schedler; *Vice-Chairman*: Dr. T. Callan; *Hon. Secretary and Treasurer*: Mr. A. McCulloch; *Hon. Assistant Secretary*: Mr. H. Shaw; *Hon. Auditor*: Mr. H. Browning; *Committee*: Dr. W. H. Brindley, Dr. A. Coulthard, Mr. T. Horner, Mr. D. M. Paul, Miss Rona Robinson, Mr. F. Scholefield, and Mr. C. M. Whittaker.

The subsequent proceedings took the form of a textile symposium, the following papers being read and discussed: "The Detection of Oxy and Hydro-Cellulose," by Dr. H. A. Thomas; "The Influence of Vat Dyes on the Light Tendering of Cellulose," by Mr. C. M. Whittaker; "Some Observations on the Quantitative Description of the Dyeing Properties of Direct Cotton Colours," by Mr. S. M. Neale; "The Glass Electrode and its Use for the Measurement of the p_H of Hypochlorite Bleach Liquors," by Mr. G. F. Davidson; and "The Analysis of Mixtures of Cotton and Rayon," by Drs. B. P. Ridge and K. Turner.

It is hoped that some particulars of those papers not already published (cf. J.S.C.I., pp. 79–90 T, March 31, 1933), together with a report of the discussion, will appear in a later issue of this JOURNAL.

SOCIETY OF PUBLIC ANALYSTS

An ordinary meeting of the Society was held at the Chemical Society's Rooms, Burlington House, on Wednesday, April 5, the president, Mr. F. W. F. Arnaud, being in the chair.

Certificates were read in favour of G. V. Hall, G. Holland, H. S. Howes, F. W. M. Jaffé, and M. McF. Love.

The following were elected members of the Society: G. F. Caley, W. R. Dracass, and Y. V. S. Iyer.

The following papers were read and discussed: —

"Notes on the Iron and Copper in Liver and Liver Extracts," by H. G. Rees. A summary was given of the amounts of iron and copper previously recorded for the livers and liver extracts of various animals, and it was shown that these metals had been very incompletely extracted in the aqueous extracts. In the author's experiments the proportion of iron was somewhat higher, whilst the copper was very much lower than the figures by Meyer and Eggert. The significance of these elements in the therapeutic action of liver extract was discussed.

"Determination of the Freezing-Point of Milk," by Dr. G. W. Monier-Williams. The various errors to which the measurement of the freezing-point of milk or of any aqueous solution was liable were described. The three main factors influencing the determination were: (i) supercooling; (ii) the water-value of the container, thermometer, bulb, and stirrer; and (iii) the heat-exchange with the surrounding medium, and the author discussed the nature and magnitude of the respective corrections which must be applied to ascertain the true freezing-point. With the new type of apparatus devised by the author the supercooling correction could be determined with a fair degree of accuracy, the final temperature remained constant for several minutes, and excellent heat-insulation was secured by the casing of compressed cork.

CORRESPONDENCE

THE DISSOCIATION CONSTANTS OF ACIDS

SIR,—My communication to the Chemical Society discussion on March 2 was certainly not intended to suggest in advance that Mr. Wynne-Jones's conclusions would be vitiated by the special considerations involved in the interpretation of the dissociation constants of *o*-substituted acids, as he reads it in his letter in your issue of March 24 (p. 273). His work on the influence of solvents on dissociation constants should provide theoretical organic chemists with a sounder conception and more valuable data than the simple values of dissociation constants in water which they have been able to relate to one another in terms of structural and valency considerations in suitably related molecular structures.

The way the structural and valency effects apparently emerge in these cases must be something of a coincidence, with a phenomenon in which the solvent may influence (*a*) the direct interaction between the substituent and the acidic group in the molecule and in the ion (compare Burkhardt and Cocker, Receuil trav. Chim., 1931, **50**, 839), (*b*) the association of the acid, and (*c*) the degree and heat of solvation of the molecule and ion. But because the effect of a substituent on the dissociation constant of an acid, into which it is introduced, shows such definite parallelism to the effect of the same substituent on other phenomena, it has appeared very reasonable to conclude that these effects must be interpretable in terms of structural and valency considerations, as Dr. Flurscheim first pointed out (J.C.S., 1909). So when Mr. Wynne-Jones drew attention to the dangers inherent in such interpretations and quoted *o*-nitrobenzoic and 3 : 5-nitrobenzoic acids as examples, it was necessary to point out that in considering how his work affects these conclusions it will be important to discuss *o*-substituted acids separately and to consider in particular more significant, if less striking, examples than the one he quoted: *e.g.*, *m*-nitrobenzoic acid is weaker than the *p*-isomeride in water, and although the difference is relatively trivial, this relationship is maintained in ethyl alcohol and is in accord with other effects of the nitro group in similar structures. The values which he quotes in his letter suggest that the field effect of a substituent *m*- or *p*- to an acidic group is acting more powerfully in the solvents of lower dielectric constant than in water (cf. Ingold, Solvay *Reports*, 1931, 493).

I am, Sir, etc.,

Manchester
Apr. 10, 1933

G. N. BURKHARDT

1 : 2-DIMETHYLPHENANTHRENE

SIR,—During the Chemical Society discussion on œstrin, reported in the issue of CHEMISTRY AND INDUSTRY of March 31, 1933, Butenandt announced the synthesis

1 : 2-dimethylphenanthrene, which proved to be identical with the hydrocarbon obtained from œstrin and retrobilianic acid.

We have been engaged in the preparation of phenanthrene homologues, and the synthesis of a number of new $C_{16}H_{14}$ hydrocarbons, including 1-ethyl, 1 : 2-, 3, 1 : 8, 2 : 3, 2 : 5, 3 : 4, and 4 : 9-dimethylphenanthrene have been completed, whilst others are in progress. Our synthetical 1 : 2-dimethylphenanthrene melts at 142—3°, and its picrate, styphnate, quinone, and quinoxaline melt at 154°, 153°, 214°, and 144° respectively. Butenandt gives 140° and 148° for the hydrocarbon and picrate.

We are, Sir, etc.,

R. D. HAWORTH
C. R. MAVIN

Armstrong College,
Newcastle-upon-Tyne
Apr. 5, 1933

MOTOR SPIRIT FROM SCOTTISH SHALE

SIR,—We observe in the leading article in your JOURNAL of March 31 that you refer to benzole as being still "only native motor spirit." We would however, draw your attention to the Scottish shale-oil industry, which was established about 1850 and has been a regular producer of motor spirit since the internal-combustion engine was invented.

The production of motor spirit from Scotch shale, while not so large as that of benzole, is hardly negligible, and it is estimated that this year it will exceed 15,000,000 gallons. We feel sure that you would not wish to leave a production of this order out of account when considering available supplies of "native motor spirit."

We are, Sir, etc.,

FOR SCOTTISH OILS, LTD.,
R. W. MEIKLE, Secretary

Glasgow
Apr. 6, 1933

BRITISH PHARMACOPŒIA IN AUSTRALIA

SIR,—May I be allowed some comment on the last few sentences of your editorial headed "British Pharmacopœia in Australia" in your issue of March 17?

Whatever may be the merits or demerits of the new "B.P." it is certainly "used in places far overseas." Any British subject carrying on business in any Treaty Port of China does so under the domestic law of Great Britain, so that if he be a pharmacist the "B.P." means as much to him in Tientsin as it would in London. The "B.P." has the same authority in Crown Colonies as in Great Britain. It furnishes the standard for drugs in some Dominions, if not in all.

In Canada the official importance of the "B.P." is twofold. Its standards of purity and strength are enforced by the system of inspection centering in the Food and Drugs Laboratory of the Department of Health. Quite independently of this, its provisions have a fiscal bearing. Many imported materials receive Tariff rating which depends on their conforming to current "B.P." standards. Certain concessions, reducing Excise Duty on alcohol, are made to cheapen B.P. preparations. The provisions governing these are liable to change in accordance with changes in the B.P. formulæ, and have, in fact, been changed on that account within the last few months. Such questions come under the control of the Department of National Revenue, which draws its technical information on anything of a chemical nature from the Customs-Excise Laboratory.

Changes in official regulations had to be made and advice on these changes had to be given, while we were all provided with no better than second-hand information as to the new provisions of the "B.P." which were to be met. This was not at all a comfortable state of affairs, though all inconvenience might have been avoided by a little more breadth of vision on the part of those responsible for issuing the "B.P."

The fact is that this book became, years ago, a document of world-wide importance and its publication is still handled in a purely municipal spirit.

I am, Sir, etc.,

ALFRED TINGLE,
Chief, Customs-Excise Chemical Laboratory

Ottawa
Mar. 29, 1933

PERSONAL AND OTHER ITEMS

We regret to announce the death on March 21 of Mr. Walter C. Reid who was an original member of the Newcastle Chemical Society founded in 1868, of which he was secretary from 1878 to 1880 and served on the committee when that body merged in 1883 into the newly-founded Society of Chemical Industry. After training under John Pattinson, Newcastle City Analyst, Mr. Reid in 1867 joined the Blaydon Chemical Works, now known as the Blaydon Manure & Alkali Co. (1877), Ltd., of which he remained a director until recent years. Amongst his many chemical and mining interests, he took an active part in the development of the fertilizer industry and in 1876 contributed a paper to the transactions of the Newcastle Chemical Society entitled "Mineral Phosphates and Superphosphate of Lime." Mr. Reid was 86 years of age.

We regret to announce the death on April 3 of Mr. James Wood, a member of the Society since 1918. Mr. Wood was a graduate of Aberdeen University and was at one time assistant to the Lancashire County Analyst at Liverpool. He joined the research department of the Co-operative Wholesale Society in 1917, and at the time of his death was in charge of all the important work on foodstuffs supplied by the C.W.S. He was the vice-chairman of the Northern Section of the Society of Public Analysts.

The Minister of Health has appointed Mr. J. S. Carter, M.Sc., Ph.D., F.I.C., to be an Inspector under the Alkali etc. Works Regulations Act, 1906. He has been assigned to the district with headquarters in London.

We regret to announce the death on March 19 at his home in St. Louis, U.S.A., of Mr. John Francis Queeny, a well-known figure in American chemical circles, his connexion with the industry covering a period of over 60 years. Mr. Queeny, who was seventy-four years of age, founded the Monsanto Chemical Co., St. Louis, over 30 years ago and by his courage and industry lived to see it grow to its present importance, operating 7 plants in America and 2 in England. A dominating

personality, possessing an unflagging spirit and a progressive policy, his career showed evidence of thoughtful planning and careful preparation at every stage. It was only two years ago that Mr. Queeny retired from active control of his vast interests, after spending some time in the successful development of the Monsanto Group in this country. He was a member of the Society for nearly thirty years.

Chemical Society: Announcements

It was announced on April 6 that the next meeting of the Research Fund Committee will be held in December, 1933; no grants will in future be allotted in June.

A meeting of the Society jointly with the University College, Bangor, Chemical Society will be held in the Chemistry Lecture Theatre, Memorial Science Buildings, Bangor, on May 5 at 5.15 p.m. when Prof. C. S. Gibson, F.R.S., will deliver a lecture entitled "The chemistry of gold."

At the invitation of the Chemical Department of the University of Leeds, the Society has arranged a discussion on "Substitution in aromatic systems," which will take place at Leeds on Friday, May 12, 4—6 p.m. and 8—10 p.m. Prof. G. T. Morgan (president) will preside, and Prof. R. Robinson, Prof. C. K. Ingold, Prof. G. M. Bennett, and others will take part.

Chemical Society: Hugo Müller Lecture

The sixth Hugo Müller lecture, entitled "Chemistry at the Cross Roads," will be delivered by Prof. H. E. Armstrong, F.R.S., in the meeting hall of the Institution of Mechanical Engineers, S.W.1, on Thursday, May 25, at 5.30 p.m.

Chemical Society: Library

The telephone number of the Library is Regent 1342, and this number should be used for all inquiries relating to the Library.

Books may now be issued in response to a telephoned request from a Fellow subject to subsequent confirmation in writing and to the parcel being posted to an address registered with the Society.

Royal Technical College, Glasgow

The Journal of the Royal Technical College for January this year contains some papers of interest to chemists: one on the "Radioactivity of Well Waters from Dumfries" by Prof. Muir, one on "Derivatives of *d*-Nor-ψ-ephedrine" by Miss J. M. Stratton and Prof. Wilson, one on the "Interaction of Acetonephenylhydrazone and Phenylisocyanate" by Prof. Wilson, W. A. Caldwell, J. Chapman, and H. W. Goodwin, one on the "Naphthidine Bases" by W. M. Cumming and G. Howie, one on the "Theory of Double Salts" by Prof. Caven, one on "Theoretical Decay Curves of Radium-B" by J. A. Cranston and C. Benson, one on the "Adsorption of Radium-B and Radium C on Nickel" by J. A. Cranston and C. Benson, one on the "Corrosion of Lead," by A. H. Loveless, T. A. S. Davie, and W. Wright, and one on the "System $C_2H_4 + H_2O \rightleftharpoons C_2H_5OH$" by A. H. Loveless and W. Wright.

British Barytes Trade

Barytes is used in this country for a number of industrial purposes, notably as a base for paints, as a "filler" in the rubber industry, as an ingredient in electric-cable insulation, and for "weighting" textiles and leather. Until recently the bulk of the requirements were imported from the Continent, the annual value of the imports being about £200,000. It is of interest to note therefore that a company which operates the Arran barytes mines in Scotland has recently installed plant capable of dealing with 20,000 tons of the mineral a year, or more than half of the amount normally imported. The barytes is taken to Glasgow, where it is crushed, and the owners of British coastal shipping are giving special facilities in order that the industry shall become well established. The barytes is claimed to be of as good quality as any in Europe.

A New Agricultural Award

The Council of the Royal Agricultural Society has decided to institute a gold medal to be awarded annually either for some outstanding piece of work of benefit to agriculture or to someone who shall have obtained pre-eminence in the practice or science of farming.

Institute of Fuel

Following the annual general meeting of the Institute of Fuel on Wednesday, April 26, a meeting of the Institute will be held at 6 o'clock at Burlington House, Piccadilly, when a paper will be presented by Dr. Ing. H. Trinius on "Economic Regenerators for Open-Hearth Furnaces." A paper will also be read by Mr. H. Southern entitled "Calculations of Open-Hearth Regenerators." Further meetings of the Institute include one on May 10, at Burlington House, when a paper will be presented by Dr. V. H. Legg entitled "Air-Gas Flow in Open-Hearth Furnaces," at 6 p.m. On May 22, at the Institution of Mechanical Engineers, Storey's Gate, S.W.1, the Société des Ingénieurs Civils de France, has invited the members of the Institute of Fuel to join them at a meeting of their members, which will be held at 6 p.m., when a paper will be presented by Dr. G. E. K. Blythe entitled "Pulverized Fuel and its many Industrial Applications."

Solid CO_2 from Natural Gas

Several gas wells in the United States yield a gas of high carbon-dioxide content, and some of these wells are now being utilized for the production of "dry ice" or solid CO_2. The fuel ingredients of the natural gas provide the necessary power for the purification and solidification of the CO_2. The Carbon Dioxide & Chemical Co. of Seattle has operated an experimental plant for several years, and this is now in commercial operation with a production of 2 tons solid CO_2 per day.

Sterilization of Water

It is reported that the Metropolitan Water Board intends to experiment on a large scale with the sterilization of London's water supply by ozone. In 1931 a small testing plant was installed at the Barn Elm Works, and the results have been so satisfactory as to warrant a trial on a larger scale, and the Works and Stores Committee of the Board has now been instructed to prepare a scheme for the installation at its Hornsey works of an ozonization plant capable of treating 10,000,000 to 15,000,000 gal. per day. Cost of ozonization is in the region of £1 per 1,000,000 gal., as against

the probable cost of 2s. 6d. of pre-ammoniation and chlorination, but the cost of water purification represents only a small percentage of the total running costs of a water undertaking, whilst the ozonization process is said to possess decided advantages, rendering the water more palatable and attractive in appearance.

International Society of Leather Trade Chemists

The papers read at the Conference on the subject of "Protein Swelling and Allied Phenomena," held at the Leathersellers' Hall, London, E.C.2, in December last, are being reprinted in book form, including the introductory address by Prof. F. G. Donnan, F.R.S. The book is of about 124 pages, and copies will be obtainable shortly from the offices of the I.S.L.T.C., at 17, Market Street, London, S.E.1, price 5s. 6d. post free.

Production of Coal and Mineral Oil in Japan in 1932

According to the *Journal of the Fuel Society of Japan* for February, 1933, the Department of Commerce and Industry estimates the total output of coal in 1932 at 21,137,778 tons, that is, 580,391 tons in excess of that for 1931. The total production of mineral oil in 1932 (excluding Taiwan and Karafuto) was 2,499,064 hectolitres.

Production of Ammonium Sulphate in Japan in 1932

The production of synthetic ammonium sulphate in Japan in the year 1932 is reported to have reached an amount of 732,000 tons, which is 107,000 tons more than in 1931, *i.e.* 625,000 tons.

In addition, about 50,000 tons of by-product ammonium sulphate were produced, consequently the total production is estimated at 782,000 tons, and thus a position of self-supporting in Japan is almost attained. (J. Fuel Soc. Japan, Feb., 1933).

Rich Oil Find in Albania

The *Chemische Fabrik* (Mar. 22, 1933) reports a rich oil find in the Italian concession in Albania. The available quantity is estimated to be sufficient to meet Italian requirements. A pipe line is planned from the new field to Valona.

Uses of Fluoramide

Work by O. T. Krefft has shown fluoramide NH_2F to be a useful reagent for introducing an amino gronp into compounds. Passed into 20% ammonia solution containing glue, it is said to give a 65% yield of hydrazine. Aniline forms phenylhydrazine and phenol gives aminophenol. Fluoramide is readily prepared by the electrolysis of acid ammonium fluoride, $NH_4F{\cdot}HF$.

Production of Ammonia in Finland

A plant is projected for the production of ammonia in Finland. The capacity is to be 3000—4000 metric tons of nitrogen, which would satisfy the country's present import requirements. Electrical power is available from the Imatra falls.

Transformation of Felspar into Kaolin

The artificial transformation of felspar into kaolin has been reported by R. Schwarz (Naturwiss., 1933, 2). The felspar is treated with dilute mineral acids (2—NHCl or H_2SO_4) in a pressure bomb at 300° for 250 hours.

COMPANY NEWS

THE BRITISH DRUG HOUSES, LTD.

A substantial increase in profits has been announced by The British Drug Houses, Ltd., the London manufacturers of fine chemicals and pharmaceuticals, the trading profit for 1932 being £60,303, as compared with £23,922 in 1931. With £17,324 placed to depreciation, and £10,279 brought in, there is a disposable profit of £53,257. Of this amount £20,000 is absorbed by a dividend of 5% on the ordinary shares, £12,100 by preference dividend, £10,000 is placed to reserve, and £11,157 is to be carried forward.

BORAX CONSOLIDATED

The directors decided on April 6 to postpone consideration of payment of dividend on the preferred ordinary shares until the accounts are available for the full financial year which ends on September 30. No dividend on these shares was paid for the year 1931—32.

TARMAC, LTD.

The profit of the company for 1932 was £77,131, which with £29,126 brought in, gave a disposable balance of £106,258. Ordinary dividend is 1% less than last year at 5%. At the meeting of the company on March 30 it was stated that during the year it had been decided to build a new plant at March, in the Isle of Ely, and another at Ettingshall for the manufacture of "Settite." This product provided a smooth, hard, non-skid surface, and much would be heard about it in the future. In 1932 the sales of "Settite" were four times larger than those of 1931. The company were now able to guarantee that the material would remain in a firm and hard condition for at least three years without further treatment.

BRITISH THOMSON-HOUSTON CO.

The profit of the company for 1932 was £392,015, as against £450,047 in the previous year. Dividend on the ordinary shares is at the rate of 4%, a reduction of 1% compared with 1931, and £227,795 is carried forward, an amount substantially the same as last year. At the meeting of the shareholders on March 27 the chairman, Mr. W. C. Lusk, referred to a number of important contracts fulfilled during the year, amongst which a notable achievement was the manufacture at the Rugby works of the largest steel-rolling equipment yet built in this country. This was a synchronous motor having a maximum H.P. rating of 19,000 and weighing 160 tons. The equipment was built for the Tata Iron & Steel Co. of India, and was completed and tested within seven weeks from receipt of the contract.

U.S. STEEL CORPORATION

The report of the Corporation shows gross receipts during 1932 of $357,201,705, which was slightly less than 80% of the receipts for 1931. The output of finished steel products of the subsidiaries of the Corporation was the lowest since 1901, only 18·3% of the finished product capacity being utilized.

MARKET REPORT

This Market Report is compiled from special information received from the manufacturers concerned

Unless otherwise stated, the prices quoted below cover fair quantities net and naked at sellers' works.

The following alterations in prices are reported since the publication of the last Market Report (cf. CHEM. & IND., April 7, 1933, p. 311).

RUBBER CHEMICALS

Lithopone, 30%.—£17 10s. £18 *per ton.*

Sulphur. £11 15s. *per ton. Sulphur Precip. B.P.*—£55—£60 *per ton. Sulphur Precip. Comm.*—£50—£55 *per ton.*

Zinc Sulphide. 1s.—1s 1d. per lb., according to quality.

PHARMACEUTICAL AND PHOTOGRAPHIC MATERIALS

Acid, Tartaric.—10¼d. per lb. Less 5%.

INTERMEDIATES

Items marked thus * d/d buyers' works.

Dichloraniline. 2s. 3d. per lb.

Dinitrobenzene. 8d. per lb.

Dinitrotoluene 48/50° C.—8d. per lb. 66/68° C.—8½d. per lb.

**p-Nitraniline.* Spot, 1s 8d.—2s 1d. per lb.

m-Xylidine acetate. 3s. 4d. per lb., 100%.

GENERAL NOTES

Official Trade Intelligence

The Department of Overseas Trade (Development and Intelligence), 35, Old Queen Street, London, S.W.1, has received the following inquiries for British goods. British firms may obtain further information by applying to the Department and stating the specific number. *Australia:* Boiler plant (G. 12425): Steam turbo-alternator set (A.X. 11762). *Belgium:* Bitumen and tar for roads (503): Castor, groundnut, and olive oils (504). *Canada:* Chemicals and drugs, soap (495).

Chemical Works Explosion

Messrs. W. J. Bush & Co., Ltd. inform us that the recent explosion at their Mitcham factory will only interfere with a section of their business and that arrangements have already been made for the continuation of the supplies represented by this section. At the same time the company wish to express their deep appreciation of the many messages of sympathy that have been received from various sources.

British Aluminium Co., Ltd.

The British Aluminium Co., Ltd., Adelaide House, King William Street, London, E.C.4, has removed from its Birmingham Office and Warehouse at 21, Barwick Street to Lawley and Landor Streets. The new telephone number is Aston Cross 5865-6.

Metal Spraying

Metallization, or metal spraying, is the process by which any metal or alloy capable of being drawn into wire, and of being melted in any oxy-coal gas, oxy-hydrogen, or oxyacetylene flame, is deposited by means of a special pistol on metal, wood, fabric, or any other surface. It provides an economic means of the prevention of corrosion due to atmosphere, moisture, heat, and other causes, and has wide decorative applications. The equipment with which the process is operated is explained in detail in an excellent booklet recently published by the British Oxygen Co., Ltd., Victoria Station House, London, S.W.1, which gives in addition a wealth of useful information with regard to the cost of the process, using coal gas and oxygen on hydrogen and oxygen. The company has equipped a metal spraying demonstration shop at its works at North Circular Road, Cricklewood, N.W.2, in which, by appointment, the equipment may be inspected and any metal-spraying process may be seen in practical operation. A large number of samples of metal-sprayed work in all suitable metals and upon many kinds of surface are also available for inspection in this department.

Nickel Alloy Steels

Development in engineering practice in recent years has necessitated the employment of metals of higher strength, or in other words of higher strength/weight ratio. This is particularly the case with racks, pinions, and gears which must maintain good performance under strenuous conditions, and with crankshafts, axles, propellers, etc. which must give reliability under conditions often of great stress. A publication (A. 16) which deals with this subject has recently been issued by the Research and Development Department of the Mond Nickel Co., illustrations being given of the employment of nickel steel and nickel–chromium–molybdenum steel where great strength is required, and the advantages of the alloys are explained.

PUBLICATIONS RECEIVED

THE PROFESSIONS. By A. M. Carr-Saunders and P. A. Wilson. Pp. vii + 536. Oxford: Clarendon Press. London: H. Milford, Oxford University Press, 1933. 25s.

INDEX TO THE LITERATURE OF FOOD INVESTIGATION. Vol. 4, No. 2, September, 1932. Compiled by Agnes E. Glennie, B.Sc. Department of Scientific and Industrial Research. Pp. iv + 182. London: H.M. Stationery Office, 1933. 2s. 6d.

LUBRICATING AND ALLIED OILS: A HANDBOOK FOR CHEMISTS, ENGINEERS, AND STUDENTS. By E. A. Evans. Foreword by The Rt. Hon. Lord Wakefield of Hythe, C.B.E., LL.D. 2nd ed. Pp. xv + 175. London: Chapman & Hall, Ltd., 1933. 9s. 6d.

LOW-TEMPERATURE CARBONIZATION: NARROW BRICK RETORTS AT THE FUEL RESEARCH STATION. By J. F. Shaw. Department of Scientific and Industrial Research. Fuel Research. Technical Paper No. 35. Pp. vi + 14. London: H.M. Stationery Office, 1933. 6d.

DIZIONARIO DI CHIMICA GENERALE E INDUSTRIALE. By Prof. M. Giua and Dr. C. Giua-Lollini. A—E. Pp. 1083. Torino: Unione Tipografico-Editrice Torinese, 1933. 165 L.

ENZYKLOPÄDIE DER TECHNISCHEN CHEMIE. Edited by Prof. Dr. F. Ullmann. 2nd ed. Vol. IX. No. 41. Pp. 160. No. 42. Pp. 161—320. No. 43. Pp. 321—480. No. 44. Pp. 481—656. No. 45. Pp. 657—836. *Berlin: Urban & Schwarzenberg,* 1932. Paper, 42.50 rm.; bound, 50 rm.

CHEMISTRY OF DRUGS. By N. Evers, B.Sc., F.I.C. 2nd ed., entirely revised and enlarged. Pp. viii + 256. London: E. Benn, Ltd., 1933. 55s.