BRITISH NON-FERROUS METALS RESEARCH ASSOCIATION

THE completion by the British Non-Ferrous Metals Research Association of twenty-five years of service to the non-ferrous metals industry was marked by a luncheon in London on November 21, 1945, attended by the Lord President of the Council and the President of the Board of Trade. Speeches made during the luncheon touched on the past history of the Association and the help and encouragement it received from a few enthusiastic supporters in its early days, the work carried out during the last twenty-five years including more recent contributions to the war effort, and the future plans envisaged to maintain its growth and provide an expanding industry with the increased facilities for co-operative research which it will need in the years immediately ahead. The following article touches briefly on the main points under the above headings.

In 1918, about the time that the research association movement was being launched by the Government through the Department of Scientific and Industrial Research, a small group of representatives of the non-ferrous metals industry in Birmingham was exploring the possibility of setting up an organisation which would serve as a technical intelligence bureau for the industry and eventually undertake, if required, researches of general interest which might lend themselves to co-operative rather than individual and possibly redundant effort. The outcome of these discussions was the founding of the British Non-Ferrous Metals Research Association in January 1920. Its income at the start barely amounted to the £2,500 required to secure a share of the grant made by the Government to the research associations, and for the first two years it was maintained only by the enthusiasm of the small group of industrialists who had sponsored the Association. But late in 1922 the wrought brass and copper trade associations of Birmingham added their support, and from that time onwards the Association's history has been one of steady if unspectacular growth.

At first the Association occupied a small office in Birmingham in which it established its library and information department, while its researches were conducted in the laboratories of universities, government departments and member firms. In 1930 the step was taken of centralizing the research work in London, and a laboratory was established in premises near Euston Station. In 1938 a modern laboratory building was erected on an adjoining site and in this the majority of the Association's equipment and its experimental foundry are housed to-day, the older premises having been destroyed by enemy action in 1940. Most of the Association's research work is at present carried out under its own roof, although a small amount of extra-mural work still remains.

In appreciating the work undertaken by the research associations, its relation to that of the universities and of industrial laboratories must be considered. These three types of research establishment provide the research facilities available to industry to-day. Each has a sphere in which it can operate more efficiently than the others, and the contribution of each can only be a part of the total research effort. Industrial laboratories are mainly responsible for the *ad hoc* investigation of practical problems of production. They are necessarily somewhat specialized, being designed to deal with the particular range of processes and products with which the company is concerned. The role of the universities is in the realm of pure science, free from the necessity of considering narrow and immediate needs, but maintaining fundamental scientific knowledge in advance of industrial application. The research associations should properly fill an intermediate position in that their work has a longer range and a more fundamental bias than is possible in most industrial laboratories, while being much more closely integrated with the requirements of industry than is the purely fundamental research work of the universities.

The British Non-Ferrous Metals Research Association's work on melting and casting a typical research association investigation—is well known to its members, and the results have been given wider circulation from time to time by publication in the technical Press. It had its origin in the early days of the Association in an investigation on the casting of brass ingots. The procedure adopted at the outset of this investigation is of interest as it is typical of the way in which the Association sets about such problems. A survey of existing knowledge was made, coupled with a series of visits to representative works to observe current methods at first hand and to examine in detail the normal products of the industry. Then, after consideration of the information assembled, every aspect of the casting process was thoroughly studied. At the conclusion of the work, recommendations were put forward which, it is not too much to say, have had an important influence on brass foundry practice.

Similar researches have been carried out on sand- and chill-casting in other materials such as bronze, gun-metal, nickel silver, aluminium and magnesium alloys; but the result of this diversity has not been a mere collection of reports dealing with each alloy and its particular casting characteristics. From the results of more than twenty years work in this field, the information gained about the casting process has been distilled into a statement of fundamental principles of the widest application to the casting and solidification of the metals and alloys of all sections of the industry.

The following may be quoted as an indication of the variety of past investigations carried out by the Association: (*a*) The first systematic examination of the effect of small quantities of impurities in copper. The results of this work were summarized in a research monograph which has become the standard work on the subject and is widely consulted and quoted in problems related to the use of this metal. (*b*) The development of the spectrograph as an analytical tool in non-ferrous metallurgy. Since then the instrument has come to be found in a large proportion of the metallurgical laboratories in the industry. The work on spectrographic analysis is also summarized in a research monograph, and like the casting investigation continues to be pursued but with a somewhat more fundamental bias than heretofore. (*c*) The Association's work on atmospheric corrosion revealed for the first time the fundamental role of corrosion films in preventing further corrosion after the initial stages of the attack; and the same feature has since been found in other branches of the Association's corrosion researches to be of vital importance in determining the suitability of a particular alloy for a specific purpose. (*d*) Much work has also been done on the mechanical properties of non-ferrous metals, particularly lead and lead alloys. Much information on creep and fatigue has been obtained and the B.N.F. ternary alloys of lead were developed to give improved materials to the lead pipe and cable industry. (e) Mention should also be made of the work on tin solders; this forms the subject of yet another research monograph.

Some of the many contributions made by the Association to the war effort were referred to by the Lord President of the Council at the Association's jubilee luncheon, when he announced for the first time some details of the *L*-delay fuze. This is a delayed action fuze about the size and shape of a fountain pen. The principal mechanism is a striker attached to a spring which in turn is attached to a small piece of lead alloy. This small piece is about 7/10 in. long, 3/16 in. diameter and is ground in the middle to a neck to an accuracy of 0·0001 in. When the fuze is armed, the spring applies a load to the piece of lead, which breaks after a predetermined interval of time. In order to obtain exact consistency and reliability of functioning, it was essential that this lead alloy should be of uniform properties throughout, and in particular that the size of the grains that make up the alloy should be controlled very carefully. This work was done by the Association, on the basis of knowledge gained in pre-war researches. As a result, very considerable accuracy was obtained and fuzes timed to go off at times ranging from one hour to one month at normal temperatures were prepared. The fuze was used on every front during the War from 1941 onwards, and can be used either for explosives or incendiaries.

The Association has done much in its corrosion investigations in past years towards the development of new alloys for use as ships' condenser tubes, and research on this subject was intensified during the War. The importance of this work will be appreciated when it is realized that during the First World War a ship's length of service at sea was largely determined by the life of its condenser tubes, the tubes then available being rapidly attacked by the sea water passing through them at high velocity. The aluminium brass and the improved cupro-nickel alloys which have been developed in the Association's laboratories are so greatly superior in resistance to corrosion-erosion that not only are they to-day the standard condenser tube materials, but also their long life enabled a high proportion of our warships to be kept at sea continuously at a time when the Royal Navy was so desperately short of ships.

The condenser tube work was not the only assistance rendered to the Admiralty by the Association. During the War it carried out important work for the Admiralty in connexion with anti-submarine warfare and kindred subjects which involved members of staff participating in operational trials with submarines.

The loss of our most important source of tin in Malaya in 1942 made essential the utmost economy in the use of this metal. It is an important constituent of solder, which has innumerable industrial applications and which is responsible for a large proportion of the annual tin consumption in Great Britain. The Ministry of Supply asked the Association to investigate the possibilities of using solders containing only small quantities of tin or even no tin at all. The properties of these war-time solders and the problem of using them in place of the old tin-rich solders were studied in great detail. The Association, in co-operation with its member firms, also established a Solders Advisory Panel to help users of solders with their 'tin-economy' problems. British industry did, in fact, effect a tremendous economy in the use of tin in solders during the years following the fall of Malaya, and the Ministry of Supply has acknowledged the substantial contribution to this achievement made by the Association's work.

Another war-time problem in which soldering and other methods of jointing metals were involved related to the construction of radiators, oil coolers and charge coolers for Service aircraft, failure of which usually resulted in engine breakdown. The conditions under which these coolers may be safely worked depend mainly on the strength of the joints. On the other hand, improved engine performance involves increase in working temperature and pressures for these coolers, and the problem was to increase the strength and maximum operating temperature of their joints. Work on soldering and brazing methods done by the Association in collaboration with its members made possible the use of the higher temperatures and pressures required. The charge intercoolers which were a feature of the improved Merlin 61 engine, details of which were released to the public at the end of 1942, embodied these improved methods of construction.

In the light alloy field the Association did valuable work on the treatment of scrap aluminium alloys and in obtaining information for aircraft and other designers on the properties of these alloys.

By the work already carried out, the Association has amply proved its worth and has established for itself a permanent position in the research field for the non-ferrous metallurgical industry. A careful examination of the situation has, however, revealed the fact that if it is going to provide the full service the industry needs, the scale of the Association's operation must be increased. It is not possible in a small organisation to provide that variety of expert staff, equipment and service which the industry requires. Metallurgy is not in itself a pure science which can be dealt with entirely by qualified metallurgists, but is based on chemistry, physics and engineering, all of which must be adequately represented by departments within the Association's organisation.

A review of the research field before the Association shows an enormous amount of work still to be done, and the Council has decided on an extension of the Association's activities to almost three times that on which it has been operating during the War. It is particularly desirable to provide, through the Association, machinery for carrying out researches on problems common to different sections of the industry to a stage at which the fundamental knowledge on which a particular process is based is amply established. For example, in the field of melting and casting, work on aluminium, magnesium and copper-base alloys is being extended to include a study of the fundamental problems of heat transfer in moulds of different types and the mechanism of grain refinement in different materials. In the field of corrosion resistance, work on practical problems in marine corrosion and a study of the resistance of non-ferrous metals and alloys to corrosion in domestic water systems is being continued, not only from the practical point of view but also with the additional object of studying in particular the basic causes of the development and rapid growth of pits in certain corrosive conditions.

An important section of the work is that on stress corrosion, and research at present in progress on the occurrence of this phenomenon in high-tensile brasses, aluminium-base and magnesium-base alloys is being co-ordinated with the simultaneous objectives of elucidating the behaviour of particular materials under certain conditions and of providing a basic understanding of the mechanism of stress corrosion without which the behaviour of different materials in service can never be adequately understood. Similarly, in the case of the jointing of metals, the researches mentioned above on soldering have provided information of a practical nature on the relative merits of different solders in certain applications, but the basic factors underlying the soldering operations are not understood. The Association's investigation is being deflected into a study of these factors, without knowledge of which further practical advances can only be on a hit-and-miss basis.

Other examples could be quoted, but those described illustrate the type of work which is appropriate to the British Non-Ferrous Metals Research Association and on which it will concentrate more and more in the future as the realization of its expanded programme becomes possible. It is not intended that the Association should abandon the study of practical problems in favour of fundamental ones, but that the two aspects should be combined by carrying work on questions of practical importance to a stage at which the fundamental principles underlying the phenomena observed are fully understood.

CYTOLOGY, BIOPHYSICS AND BIOCHEMISTRY

ON November 10, the Biochemical Society held a discussion meeting under the general title "The Chemical Basis of Cell Structure and Function". The main contributors, in order of speaking, were Dr. J. F. Danielli, Dr. J. H. Schulman, Prof. W. T. Astbury, Dr. E. Stedman, Dr. J. N. Davidson and Prof. E. J. Conway.

Dr. Danielli said that the task of building up a dynamic picture of the cell, even at the chemical level, involves knowledge of the permeability of the plasma membrane, the cytoplasm, the nuclear membrane, the nucleoplasm, and the various other formed bodies and organs of the cell, such as granules, vacuoles and mitochondria. At present we have a great deal of information about the permeabilities of the plasma membrane, and a considerable knowledge of the permeability of the ground substance of cytoplasm, but otherwise there are few facts available. The permeability of the ground substance of cytoplasm is high: the resistance to diffusion within it, for molecules up to the size of Trypan blue, is not much greater than that encountered in water. The permeability of the plasma membrane is often very low: the rates at which different molecules penetrate a given membrane differ enormously, and cells of different types and differing species exhibit very large differences in permeability to the same molecule. However, when the permeability of a cell to, say, three or four different molecular species is known, it is usually possible to calculate the order of magnitude of the permeability to most other molecular species. The mechanism of penetration through the plasma membrane was discussed, and it was pointed out that further advances in this part of the field are held up by the inadequacy of present-day theories of diffusion.

Of certain aspects of plasma membrane permeability we are still almost completely ignorant: these aspects include permeability to large polar molecules, such as proteins, and to large non-polar molecules, such as fats and sterols. As yet practically untouched are all secretory processes—that is, all those activities of the cell involving the movement of molecules by processes other than simple diffusion.

Dr. Schulman discussed lipo-protein associations, as revealed by the study of emulsions and monolayers. If a globular protein is brought into contact with a lipoid at an interface, it will unroll if association takes place. *In vitro* complete reversal of this unrolling process is very difficult, but the suggestion was put forward that *in vivo* reversal may be more readily achieved. Dr. Schulman said that in his experiments there is a marked tendency for the adsorption of proteins to be influenced by the sign of charge of the protein and of the lipoid surface. When the surfaces are of opposite sign of charge, vigorous adsorption of protein takes place, whereas when protein and lipoid have the same charge, often no adsorption occurs; in fact, if a protein on the acid side of its iso-electric point is allowed to become adsorbed on a negatively charged interface, and then the *p*H is shifted so as to make both surface and protein of the same sign of charge, desorption of protein will often occur. The desorbed protein may be monodisperse.

When the monolayer technique is used to study protein-lipoid association, it is convenient to spread a monolayer of lipoid, and inject protein into the underlying aqueous phase. If the protein penetrates the lipoid film, this is reflected by changes of surface pressure, surface viscosity and surface potential. In this way it can be shown that cholesterol absorbs many proteins very strongly. Lecithin has not so far been found to absorb any protein over the physiological *p*H range. Kephalin associates with some proteins at *p*H 3·7. With long-chain amines, association appears to depend in part on the length of the paraffin chain of the amine.

Prof. Astbury pointed out that, although the fine details of protein structure remain to be elucidated, some of the broader outlines are now beginning to appear. Two broad groupings of proteins have appeared in the light of physical studies: the keratin-myosin-fibrinogen (k.m.f.) group and the collagen group. These groupings exist despite marked variation in amino-acid composition within both groups. The k.m.f. group is distinguished by long-range elasticity, based on a particular method of folding of the main polypeptide chains of the protein: it now appears probable that the side chains are closely packed, with polar chains lying on one side and non-polar chains on the other side of the main chain. The basic plan for synthesis of the k.m.f. group is a standard plan apparently possessed by cells of highly diverse types; the details of this plan can be adapted to a variety of ends, as the processes of differentiation demand.

The proteins of the collagen group have their polypeptide chains extended in a manner differing from that which occurs in the k.m.f. group. The analysis of this has not proceeded so far as for the k.m.f. group. It is, however, possible that reticulin connective fibres have a structure which is intermediate between that of the two groups.