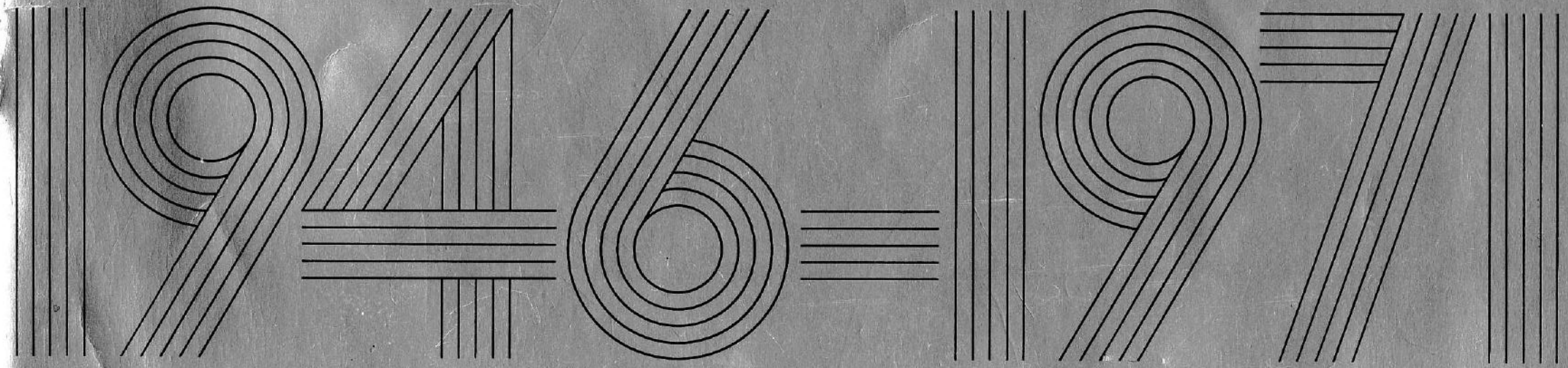
FULMER RESEARCH INSTITUTE 25TH ANNIVERSARY



The Fulmer Research Institute

The Institute is a sponsored non-profit distributing research organisation specialising in materials technology. It obtains, under contract and strict conditions of commercial security, new information about materials and processes. The facilities of the well equipped laboratories are also used for the design and manufacture of specialist components and for testing, consultancy and technical litigation work. Fulmer is unique in being owned by a professional body of scientists, The Institute of Physics. It does not receive any grant or subsidy and is completely independent of any commercial affiliation.

This brochure describes Fulmer and its origins and discusses our achievements under four main headings:

Much of the net income from Fulmer's operations is used to purchase advanced scientific equipment for contract research programmes and for sponsor's own investigations.

1, 2 Transmission and scanning electron microscope both equipped for X-ray analysis.

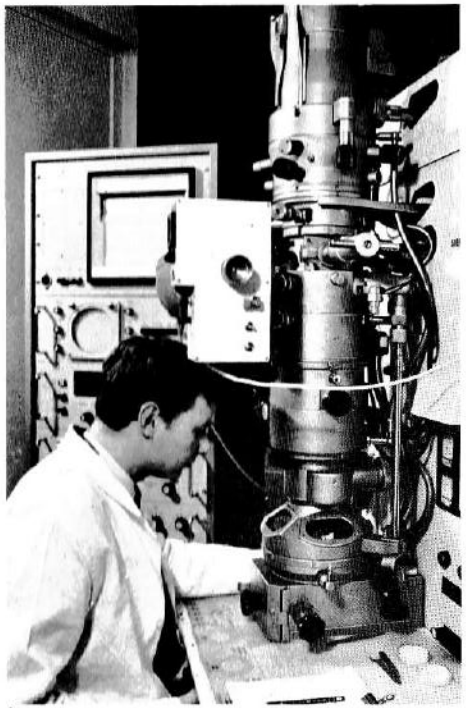
3 Mass spectrometer with electrical detection for rapid processing of results.

4 Test equipment for crack propagation studies.

5 Electron spectrometer for investigation of surface phenomena.

6 Mass spectrometer for gas analysis.

7 Beta-probe for rapid quantitative analysis.



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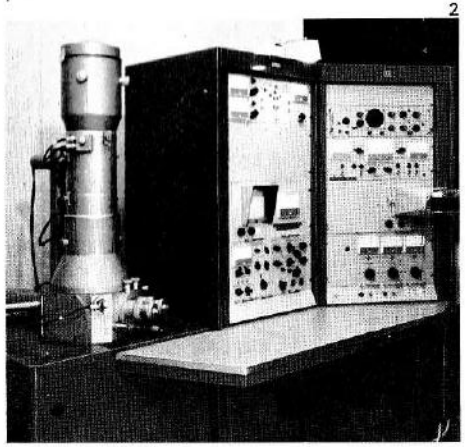

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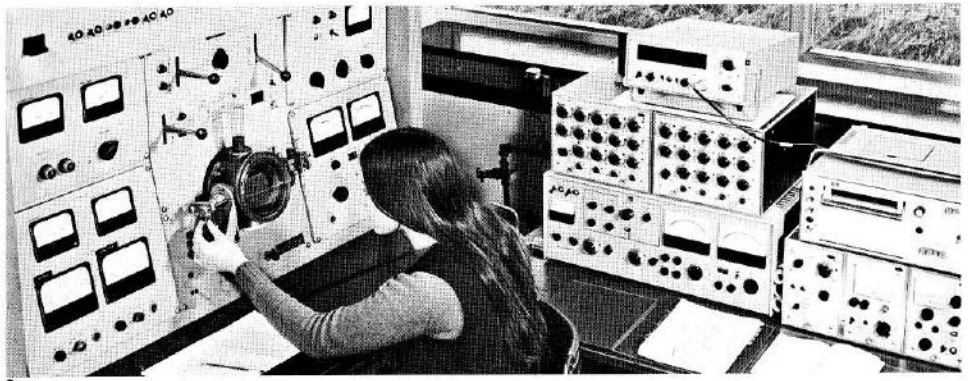

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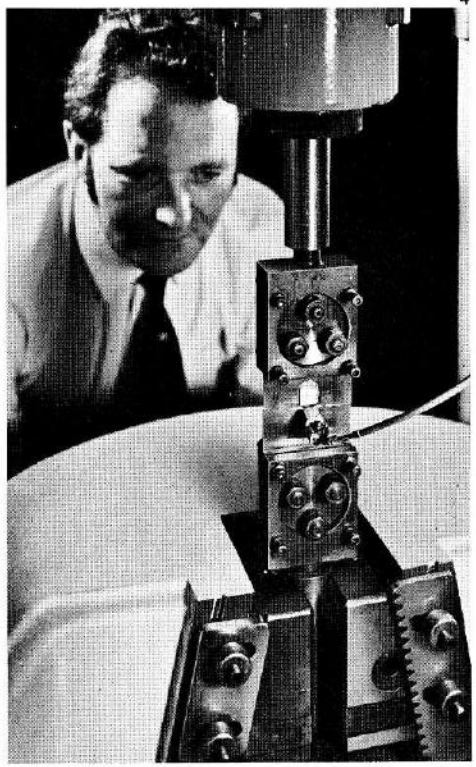

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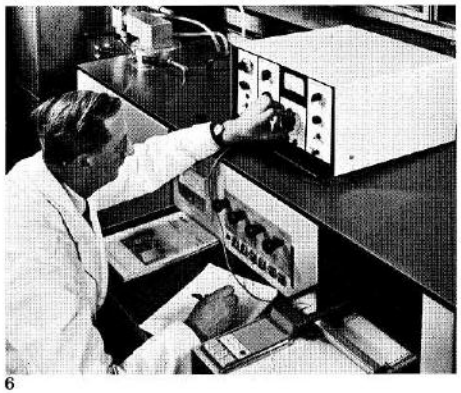

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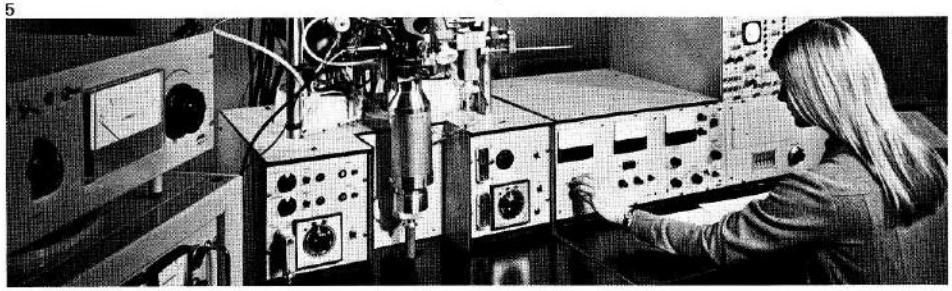

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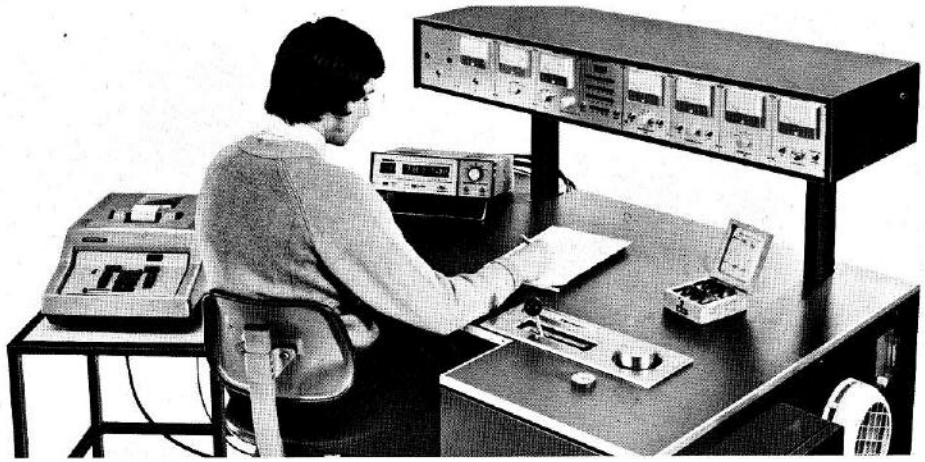

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Advantages of contract research at Fulmer

Minimum costs
Low project costs irrespective of size of sponsor.

Limited financial liability
Spending agreed before work started and completion date decided.

Maximum effort in minimum time
Even for large organisations research can be costly to initiate and time is needed to orient and train staff and assemble apparatus. At Fulmer the necessary skills and apparatus are ready and work starts promptly.

Simple control
Rate of working on agreed programmes may be varied to suit external factors. If it is necessary to reduce or stop work this involves no cost to sponsor due to idle staff, equipment or space.

Fulmer is multidisciplinary
Our research has a broad base, often drawing on a wide experience not available within many specialist organisations.

A new problem to you may be an old one to us
This applies particularly to trouble shooting and when experience in litigation may be of additional value.

Independent organisation may provide a fresh viewpoint and new ideas
Sponsors have come to us for immediate answers to a problem which had troubled them for many years.

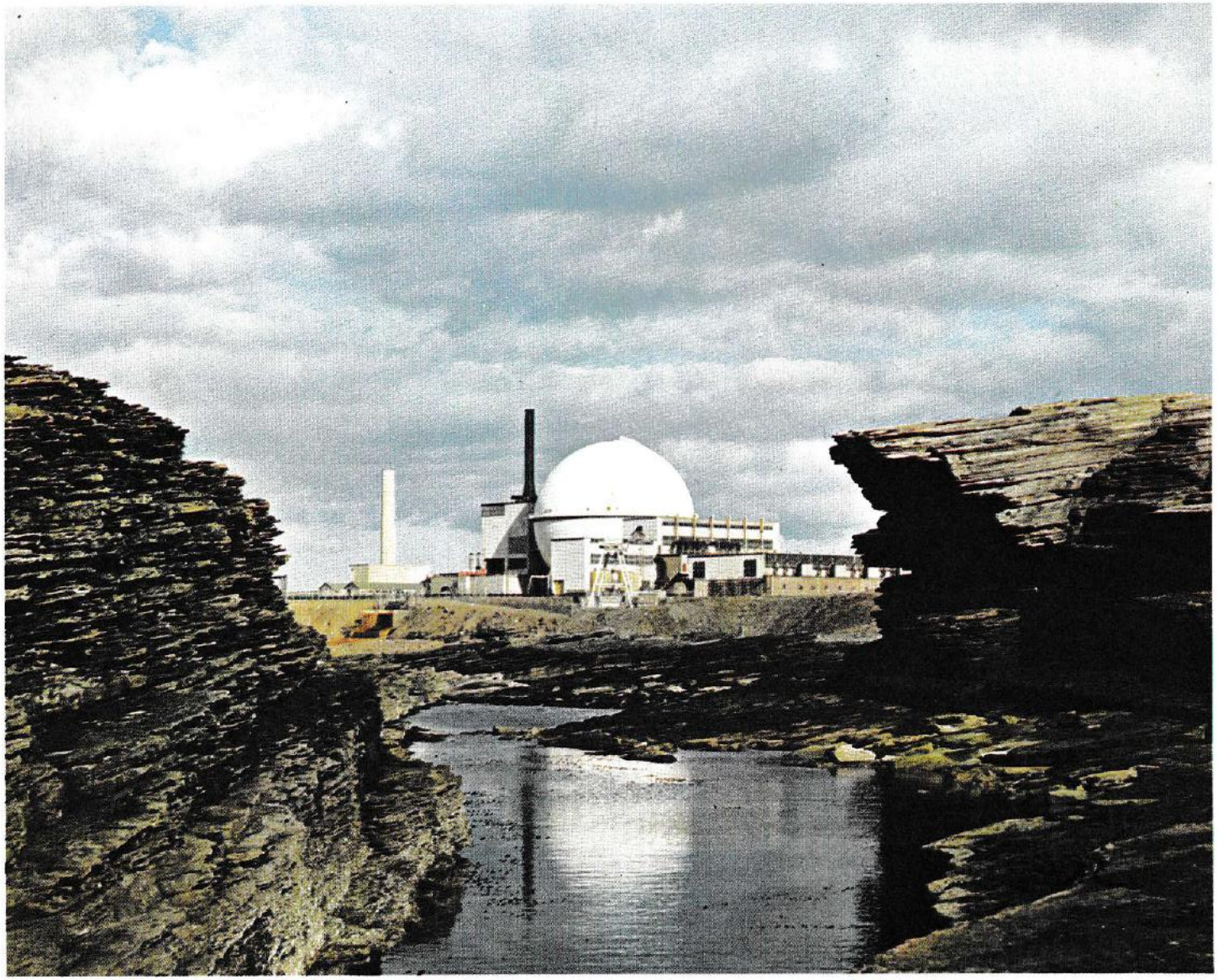
Multiclient sponsorship
Where the problem is a general one, Fulmer can arrange with a group of sponsors troubled by the same problem, to fund a programme which would otherwise be too expensive for the individual companies.

Immediate access to modern techniques
Equipment such as that shown on page 1 cannot always be justifiably purchased by the sponsoring organisation but is readily available at Fulmer.

Aluminium-tin plain bearings were made possible by Fulmer research. Now 96 per cent of all diesels and 58 per cent of all motor cars in the United Kingdom use them. Many races and rallies have been won on aluminium-tin including the tough 1969 East African Safari Rally.

The efficiency of the Dounreay Fast Reactor depends upon liquid sodium cooling. Fulmer has provided extensive data on the corrosion properties of this molten metal and its wetting behaviour which affects heat transfer.

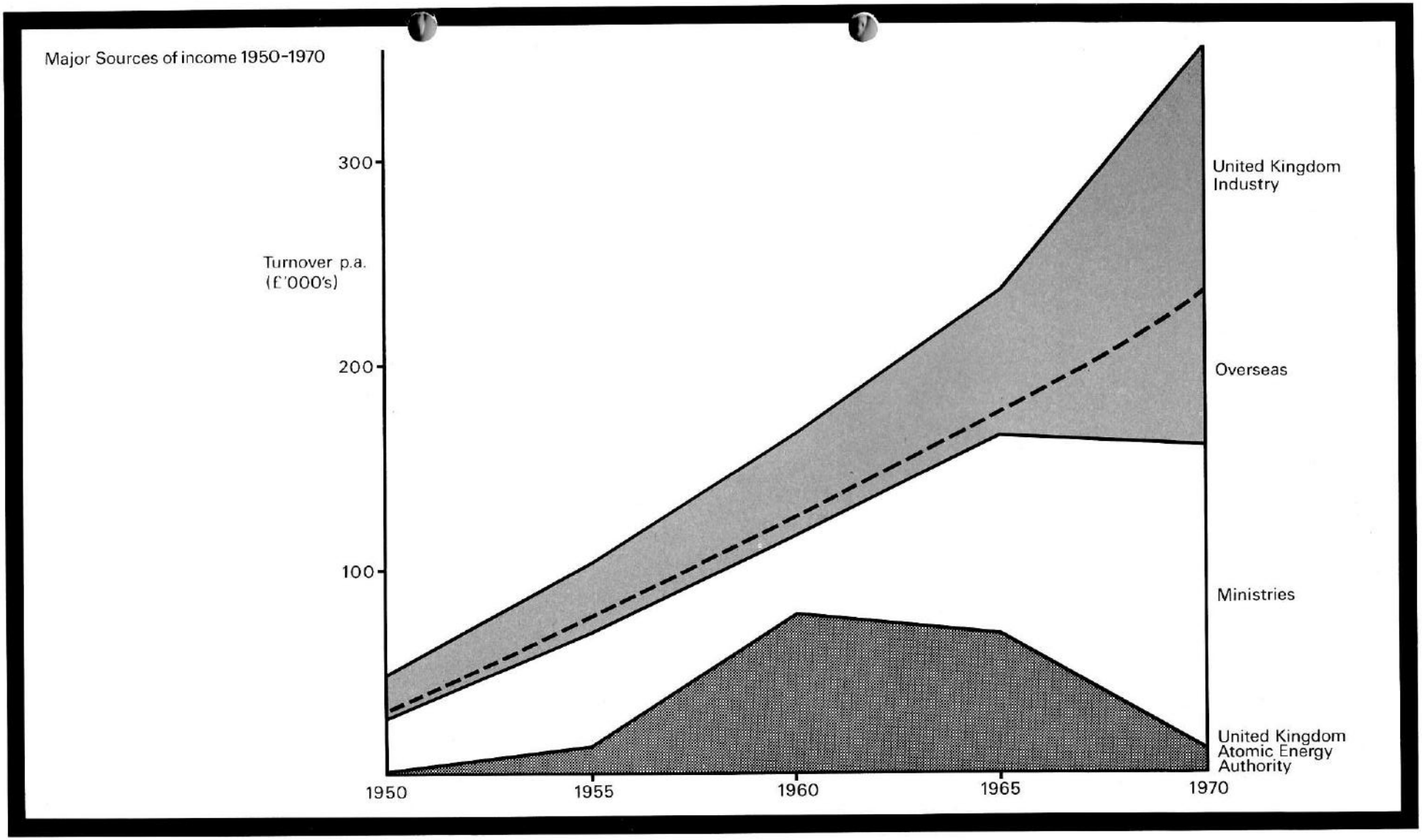
Other examples of Fulmer achievements are shown throughout this brochure.



The origin of Fulmer

Fulmer was founded in 1946 as part of the Almin (Associated Light Metals Industries) Group. Both Almin and Fulmer were created by Colonel Devereux, formerly Managing Director of High Duty Alloys, in response to the challenge presented to aluminium fabricators by the sudden decline in aircraft production following the end of World War II.

Colonel Devereux attempted to meet this challenge by intensive design and marketing activities to extend the scope for aluminium. For this purpose he also needed a research group but realised that Almin was not large enough to carry alone the costs of the kind of research group which would be of a viable size. He had, however, always been impressed by the value of contract research organisations to industry in the United States and so formed Fulmer, the first contract research organisation in the UK. In the event, the problems of the Almin Group were far more of a marketing and design nature and Fulmer never received more than 10 per cent of its income directly from this group.



In 1952 Colonel Devereux died. His first Director of Research, Mr. E. A. G. Liddiard, continued his policies and Fulmer maintained a steady expansion. In 1960 the Almin Group was acquired by the Imperial Aluminium Company which at that time was jointly owned by ICI Ltd. and Alcoa, The Aluminum Company of America. Although the Impalco management took an interest in the operations of Fulmer, they had adequate research facilities available elsewhere. In 1965, at the instigation of Sir James Taylor, then Treasurer and later President of The Institute of Physics and The Physical Society, Fulmer was sold to the IPPS.

This has proved to be a very happy arrangement. The now Institute of Physics is assured of a sound and stable investment for its funds. Fulmer is assured of the independence from long term commercial influences which is essential for a contract research organisation. The Council of the Institute of Physics is responsible for appointing the Board of Directors to whom the management of the Institute is then entrusted. Fulmer keeps all members of the Institute of Physics, and sponsors past and present, appraised of its activities, so far as it is able to do so within the bounds of its contractual obligations, by means of a quarterly Newsletter which also has a wider circulation. If you are not on our mailing list, please advise us.

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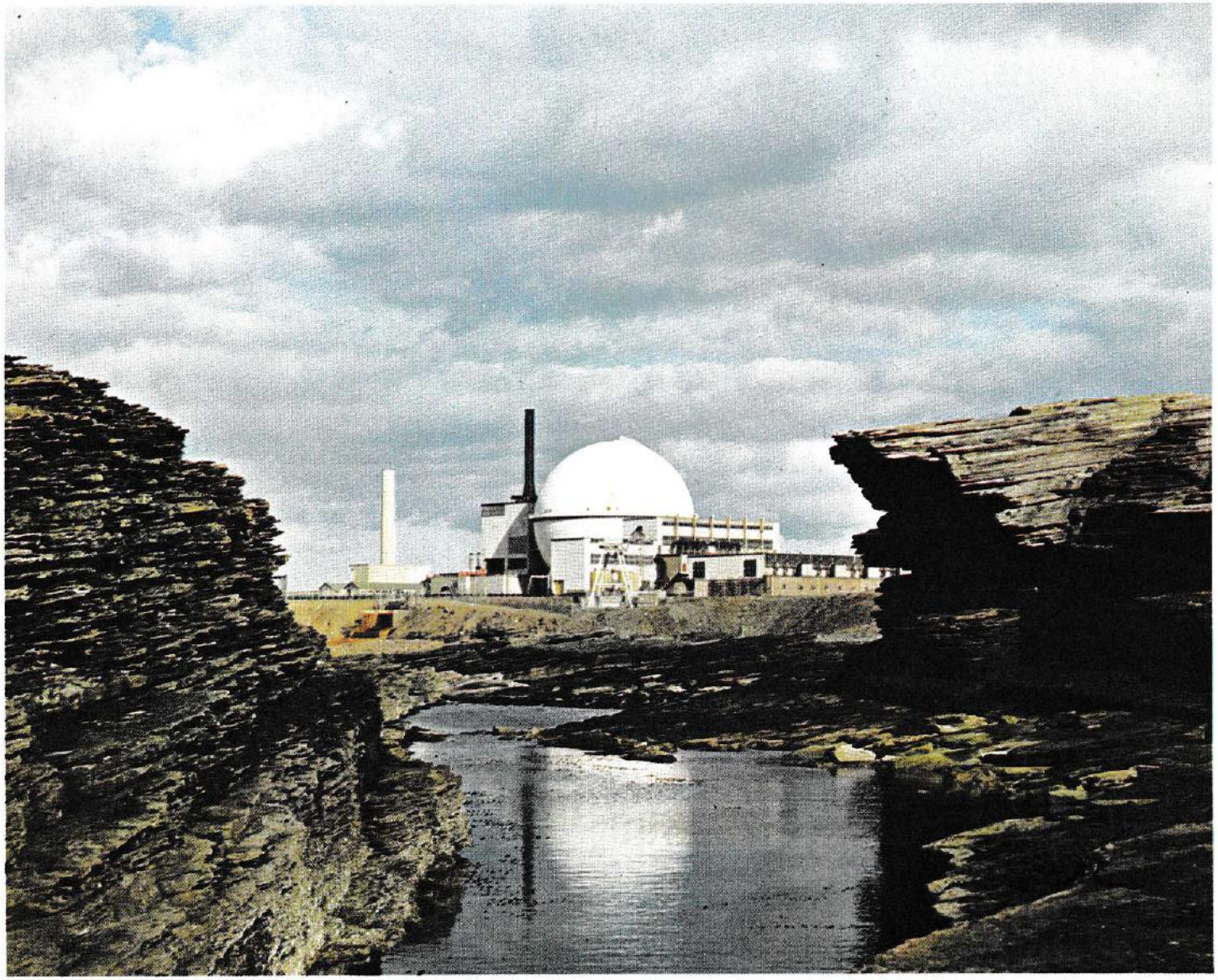


Corrosion fatigue studies

In many applications of high strength steels, such as aircraft undercarriage legs, good fracture toughness is required together with good corrosion resistance. Most of these steels have poor natural resistance to stress corrosion and hydrogen embrittlement and require a protective coating. While this may be successful in reducing corrosion under moderate conditions of service, it may embrittle the steel and render it more prone to stress corrosion fatigue.

Fulmer has acquired considerable experience of these problems using special rigs to measure the rate of corrosion under various loading conditions. Electron microscopy is used to relate corrosion behaviour to microstructure and other mechanical properties.

Stainless steels

The wide range of alloys and applications covered by stainless steels is even now not fully appreciated in spite of the comprehensive information available. From the problems brought to Fulmer it is clear that any stainless steel is supposed to resist corrosion in most common environments, and is expected to possess high strength, good ductility and adequate fatigue life.

Recent investigations on stainless steels have included structural studies on possible alloys for use in nuclear reactors, the supply and fabrication of steels with special closely controlled compositions, liquid fuel tanks for aero-space applications, effects of fabrication procedure on subsequent fatigue life of pipework, and use of stainless steel rigging in yachts.

Control of properties

ALUMINIUM ALLOY DEVELOPMENT

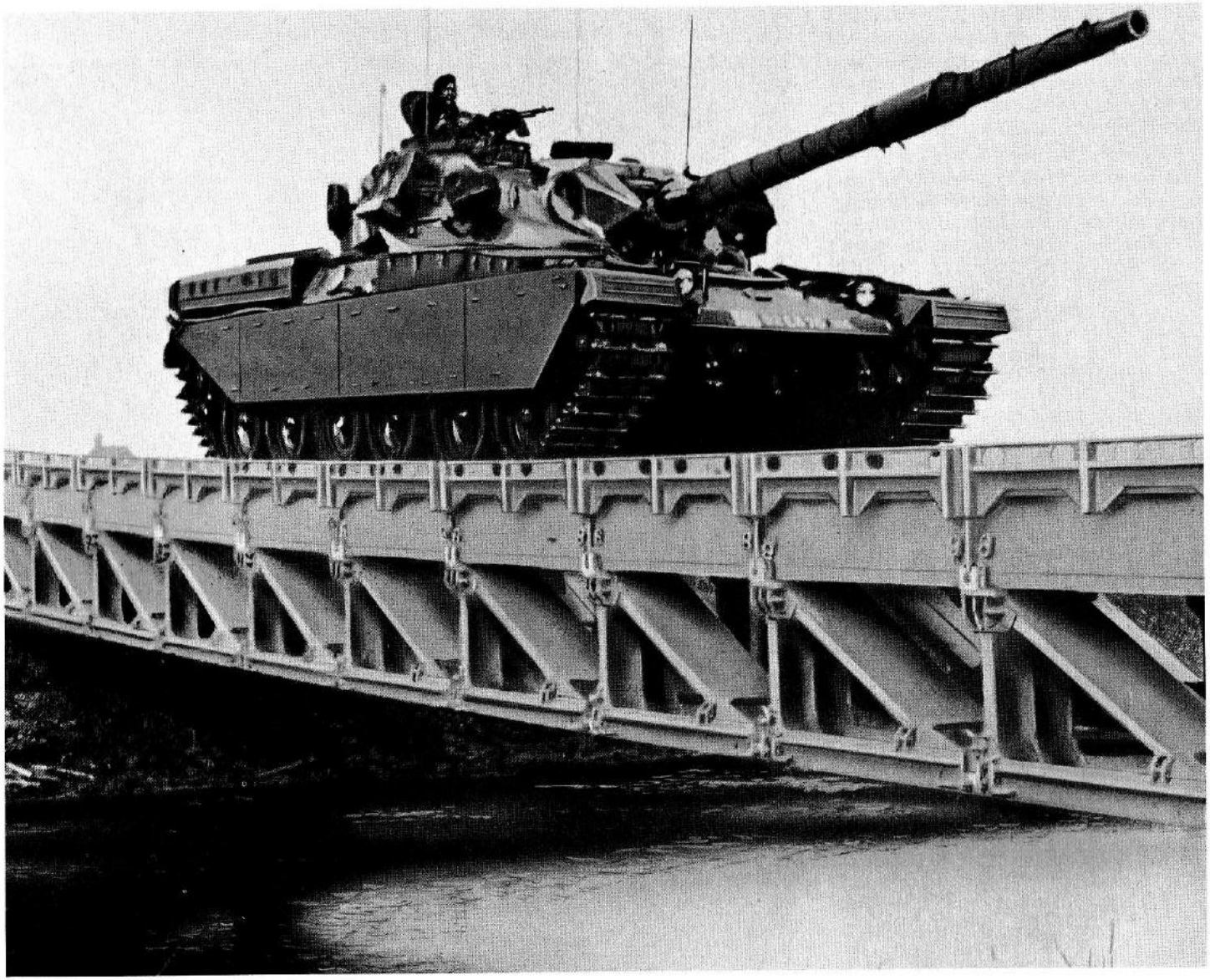
Much of the fundamental X-ray and phase diagram work on the aluminium-copper age-hardening system was carried out during the first 15 years of the Institute. This work led to a substantial investigation into the role of trace elements on age-hardening which has been reviewed in Fulmer Special Report Number 3.

Trace element developments

More recent work on trace element additions to aluminium-copper alloys has shown that elements such as cadmium, indium and tin can inhibit precipitate coarsening and so influence creep behaviour. This research led to the discovery of specific nucleation by combined additions of magnesium plus silicon and of magnesium plus germanium. These alloys, on which Fulmer owns the patents, have high static strength combined with good creep resistance and fracture toughness, and are suitable as skin materials for high performance aircraft.

Al-Mg-Li alloy

While alloys with improved high temperature creep resistance are necessary for certain military uses and for SST projects, the majority of people will continue to fly in aircraft which make different demands on the aluminium alloys used to build them. For this application, aluminium alloys of lower density and good mechanical properties offer the attraction of improved payloads. Fulmer is working on the development of a new class of aluminium-magnesium alloys containing lithium. These have high specific strength and high modulus and could also be suitable for applications such as light-weight bridges.



Control of properties

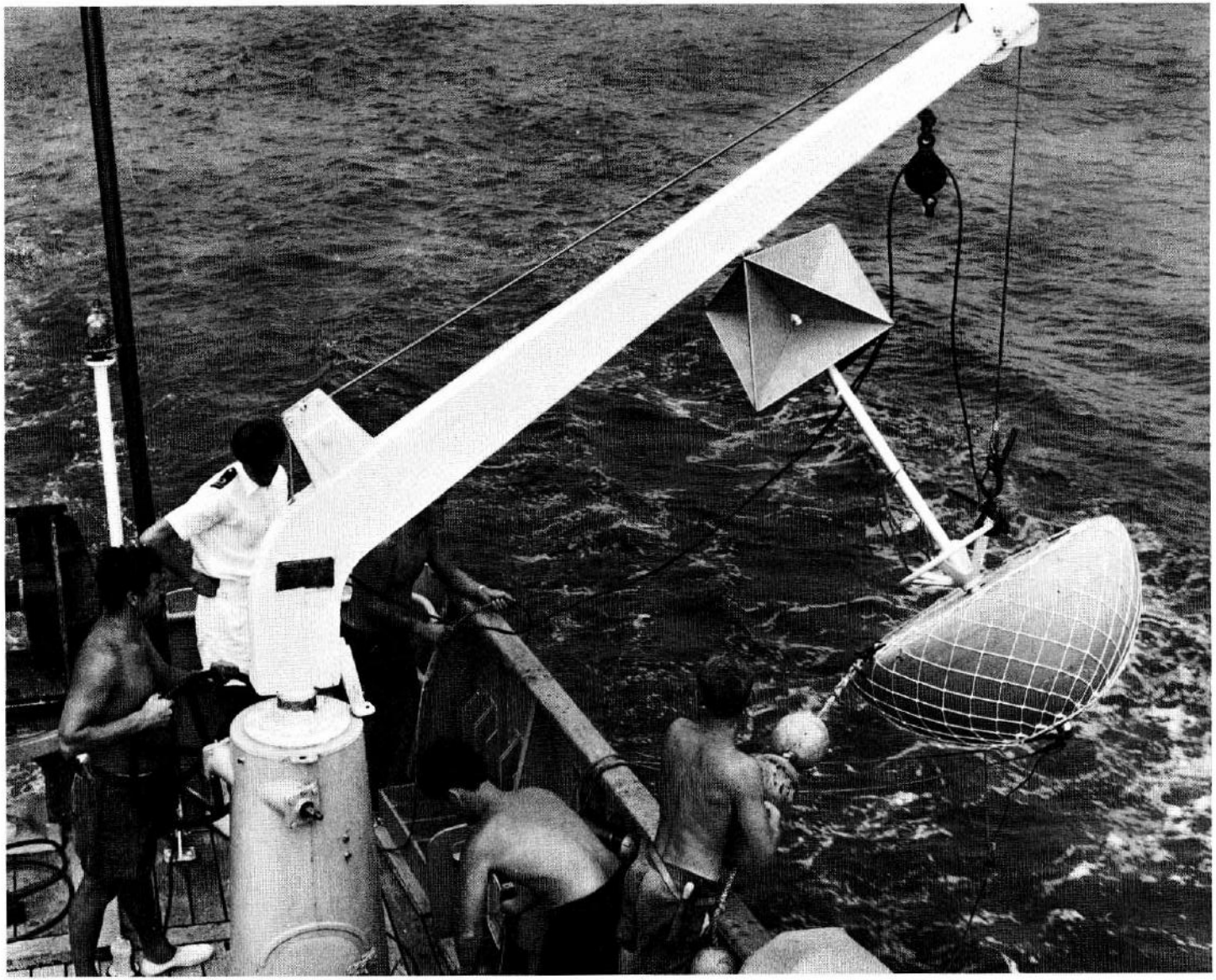
COPPER ALLOYS

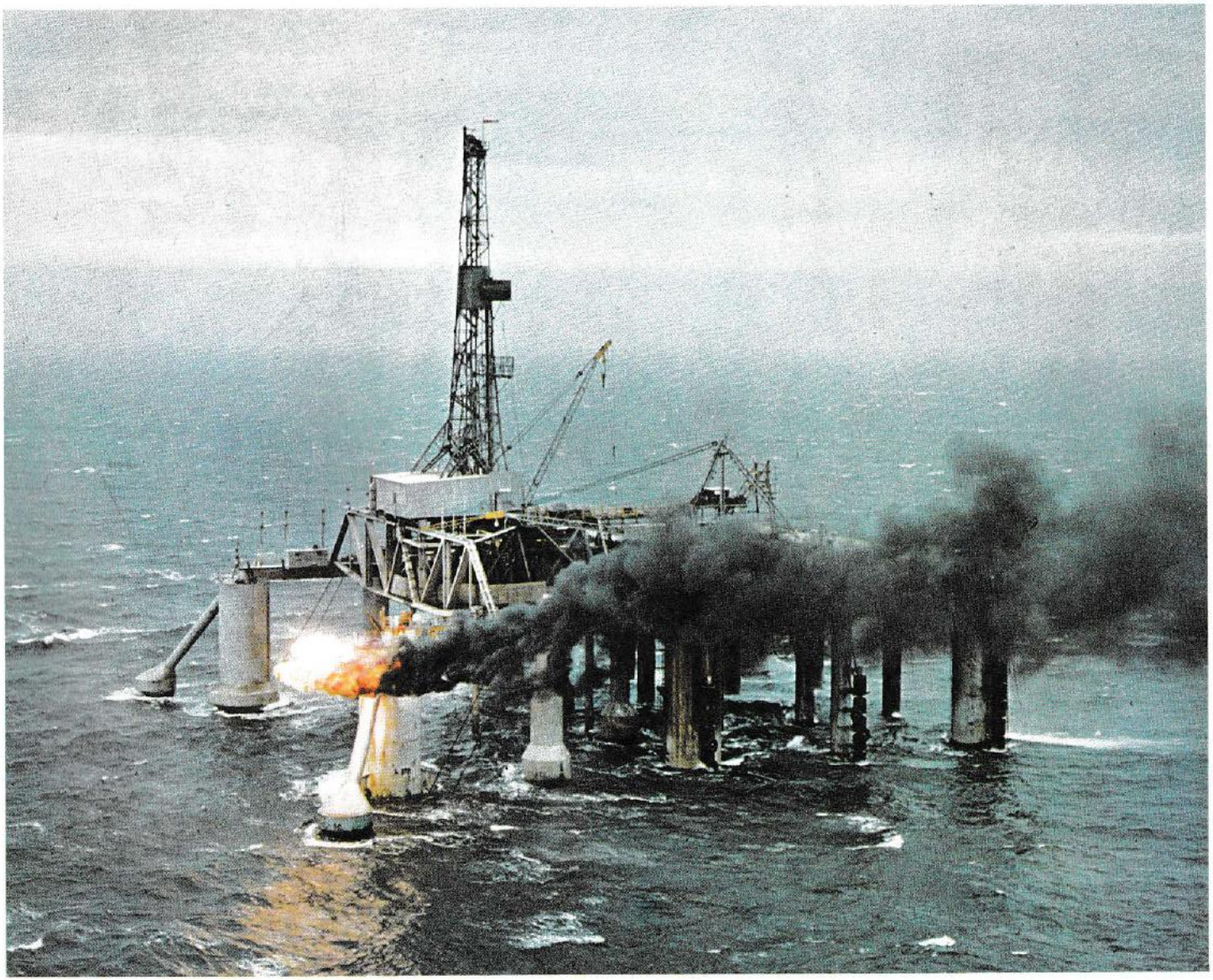
Fulmer is currently studying many of the valuable engineering properties of copper alloys.

Development of alloys with low magnetic permeability

The magnetic mine is still regarded as a formidable weapon, therefore the magnetic permeability of metal parts used on mine sweepers must be as low as possible. Fulmer expertise in alloy structure and applied electron microscopy has solved the problem of ensuring uniformly low magnetic permeability in the medium strength aluminium-silicon bronze alloys.

Initially the investigation showed that the magnetic permeability is controlled by the type and morphology of the precipitation phases. With this information it was possible to recommend a simple heat treatment which avoids the structure with high permeability precipitates. The work has recently been extended to cupro-nickel casting alloys.





Copper casting alloys

For engineering equipment working in marine environments, corrosion has always been a major problem. Where painting or similar protection is not practical, materials such as aluminium bronze or cupro-nickels are often used for pipe-line valve gear and similar applications.

Fulmer has made detailed studies of the mode of crack propagation in these alloys in relation to microstructure and fracture toughness. As a result cast copper-nickel-manganese alloys are being developed to have a higher strength than wrought aluminium bronzes whilst being weldable and retaining adequate fracture toughness and corrosion resistance.

Other investigations include surface tension determinations and corrosion fatigue studies of cobalt aluminium bronzes.

Control of properties

HIGH TEMPERATURE MATERIALS

Fulmer has made a number of contributions to high temperature materials, largely as a result of a multidisciplinary approach.

New corrosion resistant high temperature alloy

Fulmer has produced a new class of corrosion resistant high temperature alloys based on the cobalt-chromium-aluminium system. These alloys, which contain 20–30% Cr, 6–8% Al and W, are strengthened by the precipitation of intermetallic compounds. At 870°C under sulphidation corrosion conditions, such as are found in road and marine gas turbines, the alloys show a five-fold improvement in resistance compared to the best commercially available alloy. At higher temperatures, when sulphur-promoted oxidation is the dominant mode of attack, a two-fold improvement is obtained compared to the best alloys which are based on nickel.

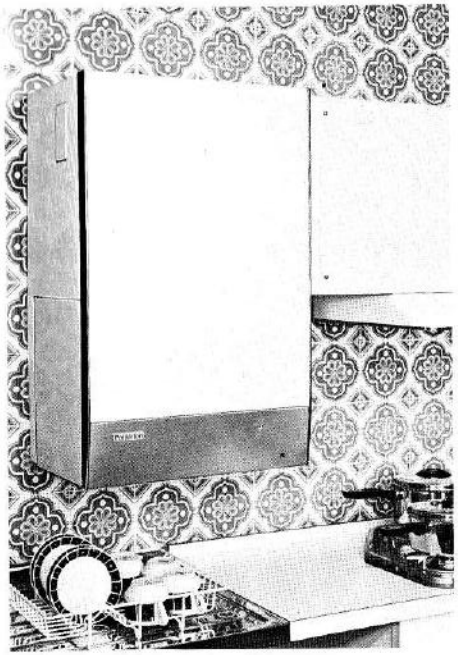
Ceramics and glasses

Research in ceramics has covered a wide range of specialised problems. Two past successes are the preparation of ultra-high purity alumina by electron beam zone refining and the development of vitreous enamel coatings of very high reliability.

Current work includes an investigation into designing with brittle materials using Weibull techniques and the development of protective glazes to enable metals such as niobium to be used for blades in high performance gas turbines.

Nickel-free steels

The relatively high price of nickel and other special alloying elements, has prompted investigations into cheaper alternative materials, at least for selected applications. Fulmer has produced a special nickel- and chromium-free aluminium-silicon steel to withstand oxidation for long periods in dry air at temperatures up to 900°C. Coating with aluminium still further improves the high temperature oxidation resistance and reduces rusting. This steel, whose properties are summarized in Fulmer Special Report No. 2, can replace 18/8 stainless steel for such applications as radiation baffles in furnaces and heat exchangers.



High speed steels

A leading machine tool manufacturer has retained Fulmer for many years to check, with the latest techniques, the quality of steel used for tool production. With this experience, Fulmer has drawn up an improved specification for certain tools, to the exclusive benefit of the sponsor. Fulmer has also investigated alternative alloys for high speed drills and is currently carrying out a survey of the utilisation of tool steels in the UK.

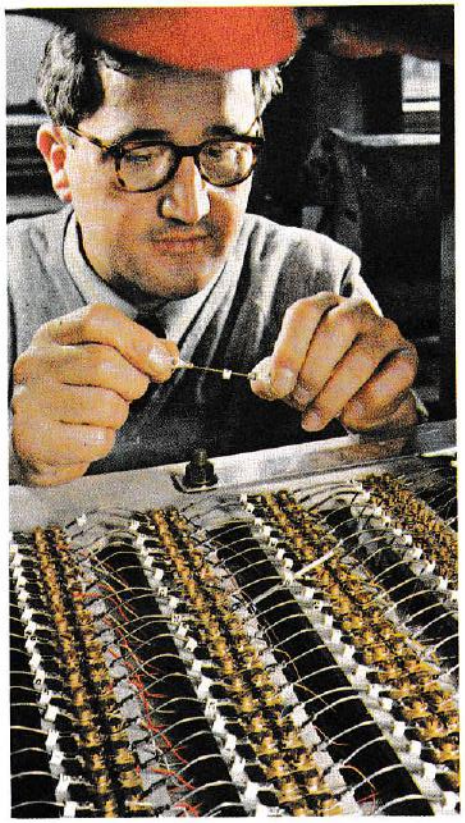
Control of properties

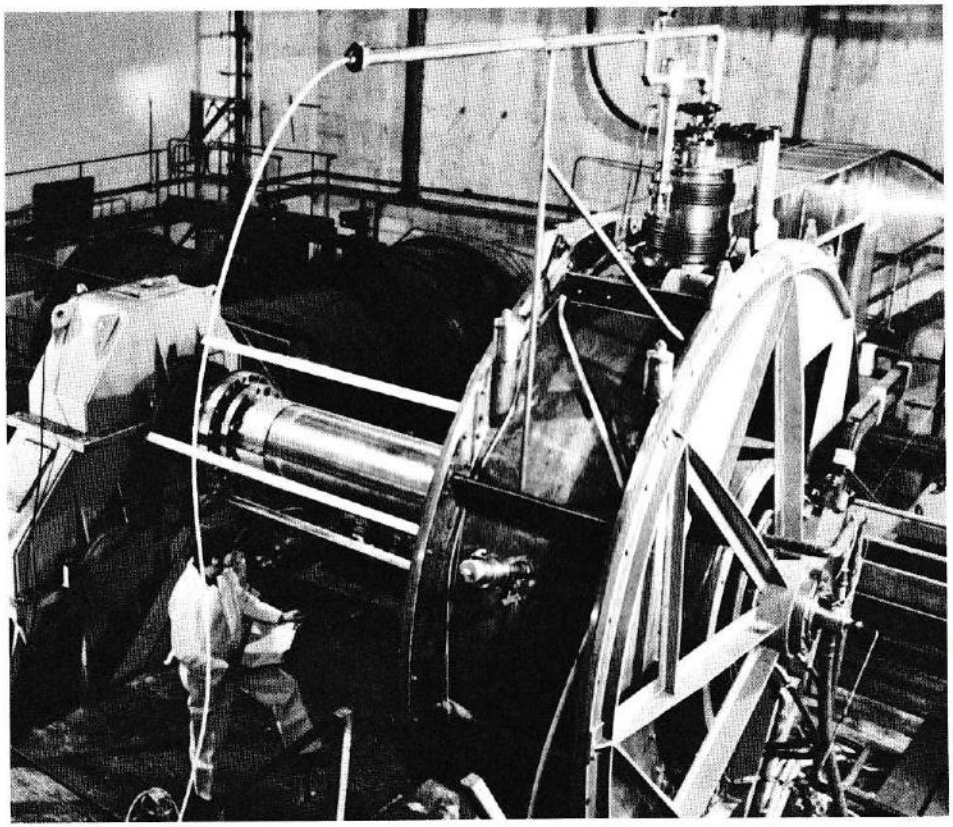
ELECTRONIC MATERIALS

Experience gained in alloy development programmes is being used to produce improved properties in electronic materials.

Crimped joints

In aerospace engineering electrical contacts are frequently made by crimping the wire conductors. In service these parts suffer frequent temperature fluctuations which may cause failure. Fulmer has assembled a rig which simulates operating conditions and monitors the electrical performance of batches of crimped joints. Failed joints are examined metallographically and by X-rays and their structures compared with others in the same batch as well as those of uncycled joints. Crimped joints made by different manufacturers are under investigation and the effects of surface plating and plastic deformation during the crimping operations are being assessed.





Superconductivity

Superconductive devices such as high field magnets and the homopolar motor offer considerable advantage in efficiency and space saving compared with conventional equipment. These devices require materials having high superconducting transition temperatures (Tc approaching 20°K) with the ability to carry large currents in high fields. Using a chemical vapour process we have produced short lengths of V_3Si coatings deposited on flexible tapes, having a performance approaching that of Nb_3Sn which is the best material known at present.

The effect of ternary additions on the transition temperatures of binary alloys has been studied in detail, leading to further understanding of the factors which may give material of high Tc and the limitations occurring in practice.

Improved substrate materials for plated wire memories

A new form of memory system for computers involves plating a Ni-Fe magnetic alloy onto a copper alloy substrate in the form of fine diameter wire. Fulmer has developed a suitable alloy with greater purity than existing materials, so that electro-plating defects in the Ni-Fe alloy are reduced. For the second generation of plated wire memories even finer substrate wires will be required and Fulmer is also engaged on developing entirely new alloys having the required properties at these smaller diameters.

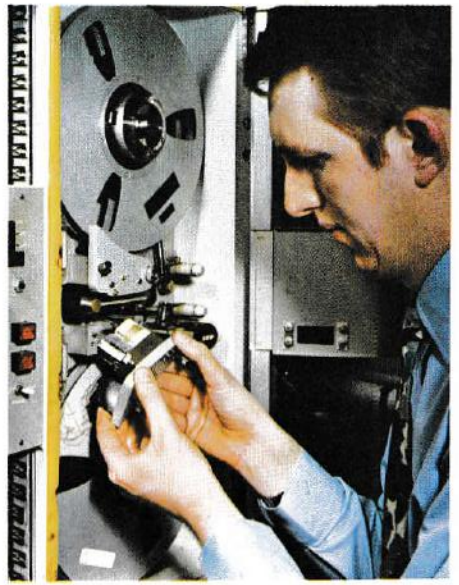
Switching phenomena in amorphous materials

Thin films of amorphous materials are being studied by electron spectroscopy to see how their switching and memory characteristics in computer applications depend on chemical analysis and short range order.

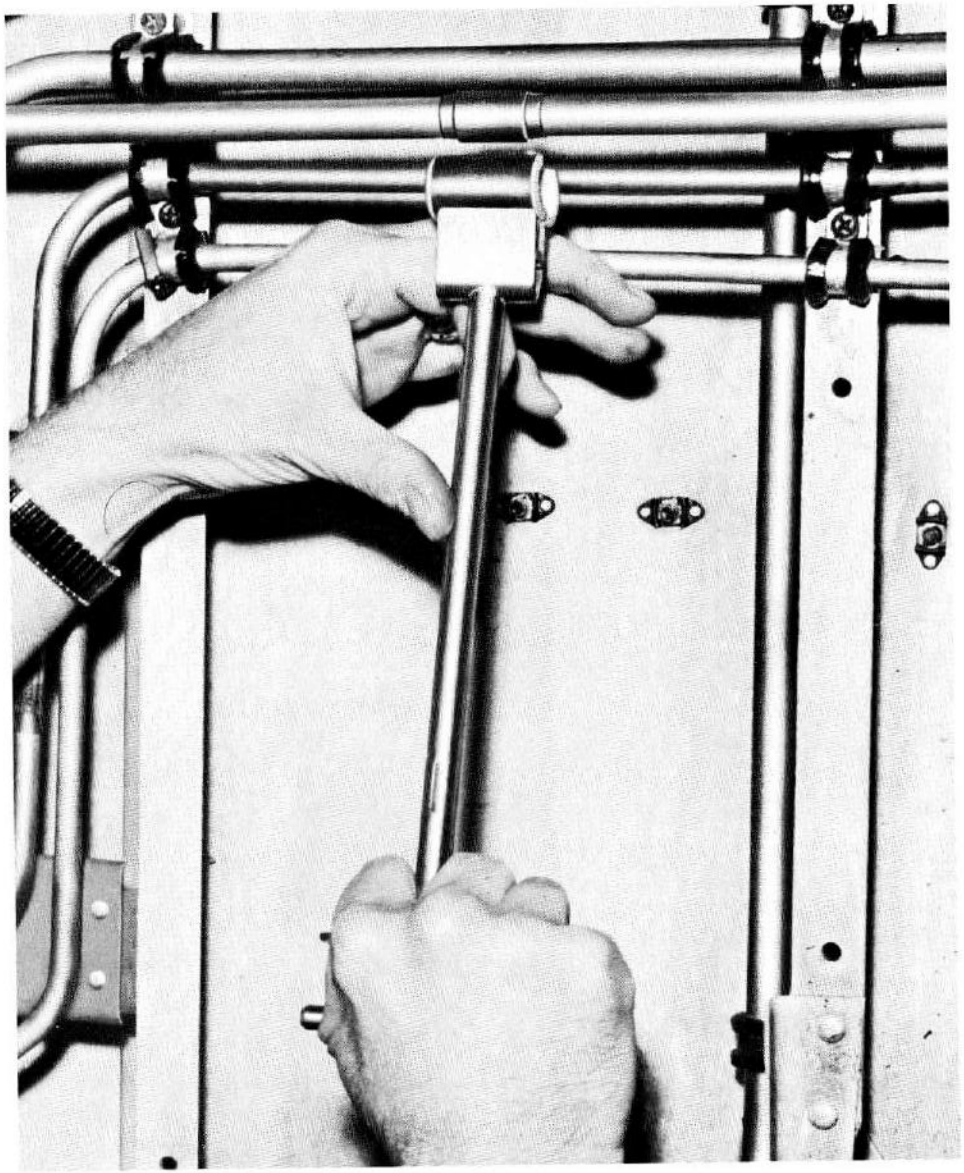
Abrasivity of magnetic tapes

Experience shows that magnetic tapes of the kind used in computers, or as videotapes in television, vary in abrasiveness. Consequently some tapes cause excessive wear of expensive recording heads.

Fulmer has developed a device to detect rogue tapes. The device consists of thin resistive films deposited on to a polished alumina substrate to simulate a recording head. As the magnetic tape passes over the head, material is abraded away and the rate of change of electrical resistance of the simulator gives a measure of tape abrasivity. The magnetic tapes are analysed so that their performance can be correlated with chemical composition.



Control of properties



HEAT RECOVERABLE MEMORY ALLOYS

Memory materials can be deformed into a new shape at one particular temperature and will change back to their original shape on heating to a higher temperature.

This behaviour has been found in both polymers and metals and products incorporating memory or heat shrinkage materials are now commercially available.

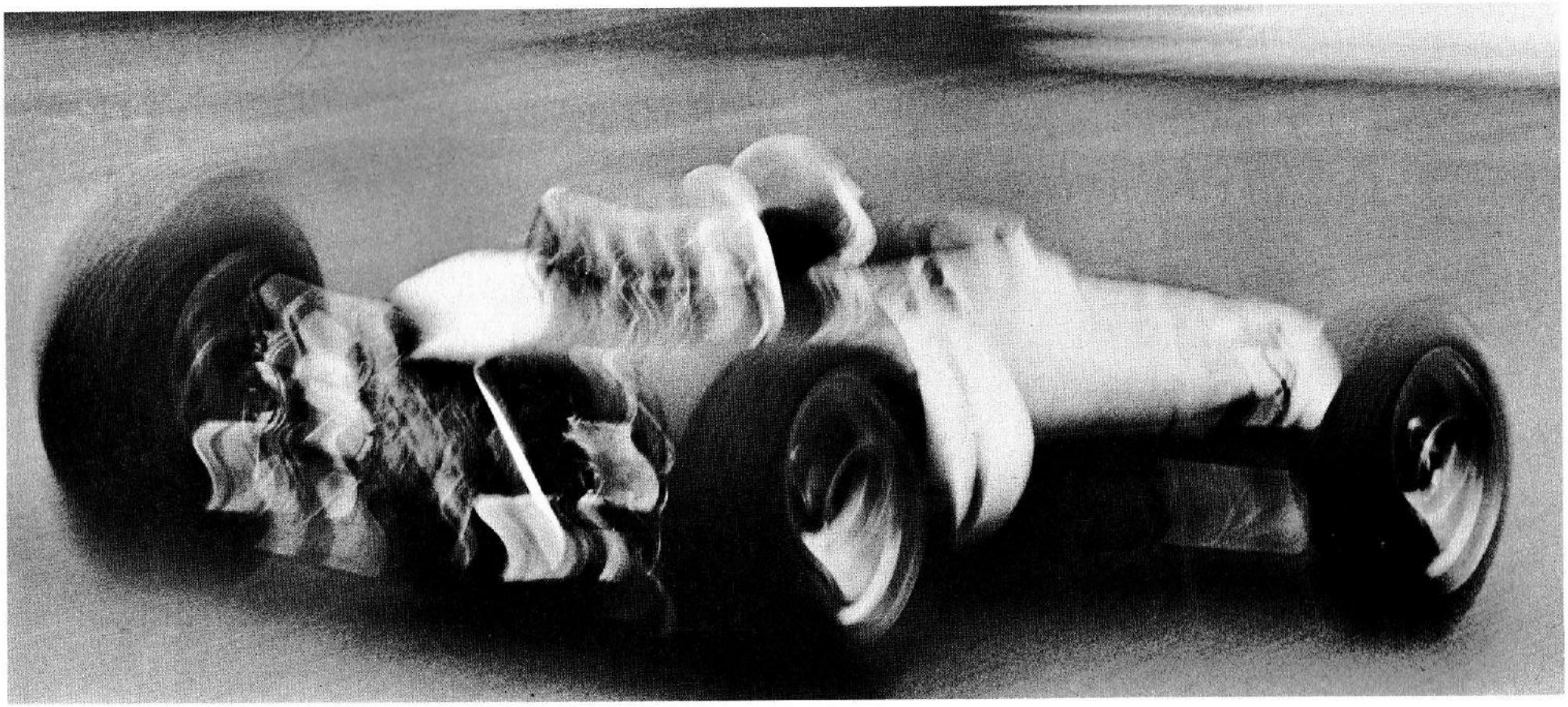
In the Ti-Ni system heat recoverable properties are now well known in alloys based on the TiNi compound. Fulmer is undertaking further research into the phenomena underlying this property.

The shape changes are reversed on heating by a simple mechanism. The deformation strain is accommodated by a predominantly shear transformation and not by slip or mechanical twinning. On reheating the original morphology of the alloy is restored thus reversing the strain.

Uses for these materials can be found in all branches of engineering. Lightweight tube couplings are a present application especially for aero-space. These also make use of the large forces exerted when the shape change is prevented mechanically.

NOISE REDUCTION

Fulmer is engaged in the development of a new range of alloys which have high damping capacity in both cast and wrought form. One advantage of these alloys is that the temperature range over which the damping capacity is produced can be varied from cryogenic temperatures to about 200–300°C.



Control of properties

PLASTICS, POLYMERS AND COMPOSITES

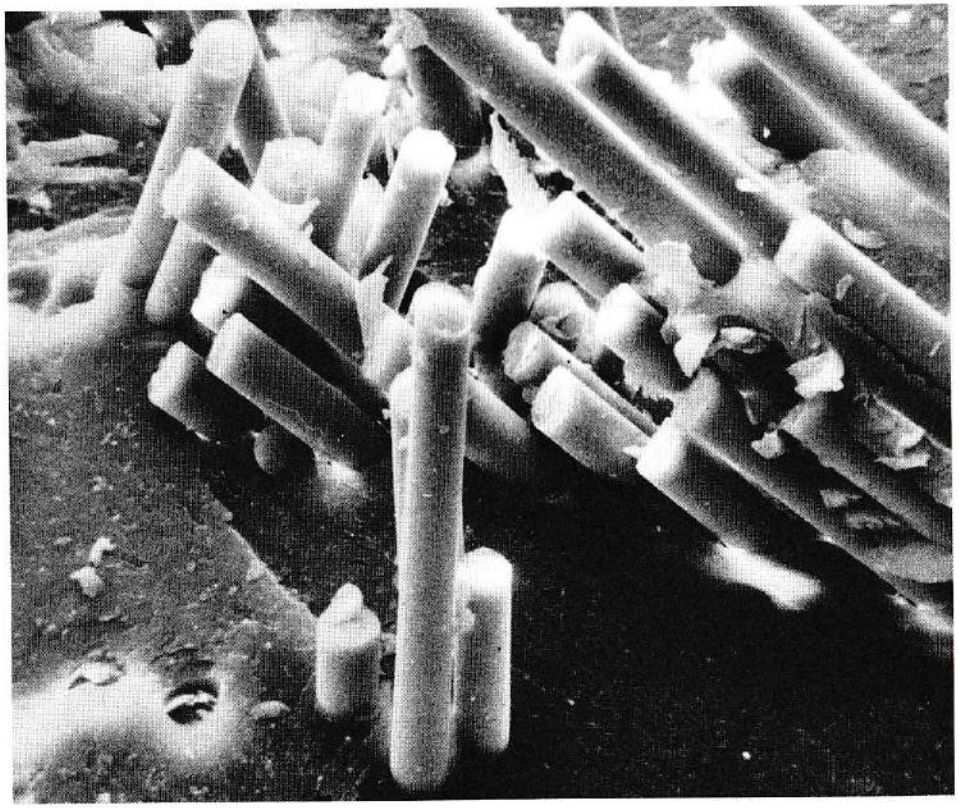
As in metals, much useful information can be gained from the interpretation of the physical properties of these materials in terms of their microstructure.

Fracture behaviour

Safe and efficient design in all types of materials requires detailed information not only on deformation but also on fracture, a relatively neglected field of polymer research. It is in the area of fracture studies that the greatest gains are to be expected from the application of metallurgical experience to polymeric materials. A programme of work aimed at identifying the fracture morphologies of several commercially important plastics and relating the microphenomena of fracture to both the microstructure and to the mechanical properties observed in fracture toughness and strength testing is now in progress.

Composites

A parallel programme on composite materials is also being initiated to relate various processing parameters such as consolidation effects, glass and void content and distribution to the mechanical properties of glass reinforced polyester resins.



CARBON FIBRES

Carbon fibres have been coated with metal and alumina barrier layers for subsequent incorporation in metal matrices, using both chemical vapour deposition and electrodeposition.

Electron spectroscopy

Electron spectroscopy for chemical analysis (ESCA) has been used to characterise the surface of glass and carbon fibres prior to their incorporation in resin matrices since this can markedly affect their bonding.

Surface coatings

	CHEMICAL VAPOUR DEPOSITION	VACUUM DEPOSITION OF THIN FILMS
PROPERTIES AND ADVANTAGES	High deposition rate; 0·5 mm/hr. High throwing power. High density deposits, impermeable to most gases and liquids.	Coatings of accurately controlled thickness, down to 100 Å. Deposition area precisely defined by masking techniques. Facilitates construction of multilayer assemblies.
SUITABILITY	Particularly refractory metals and compounds, e.g. Mo, Ta, W, Re, SiC, $MoSi_2$, V_3Si, BN, BP, WC, TiC, Al_2O_3.	Conductors, resistors, insulators, dielectrics, optical systems. Integrated circuits.
EXAMPLES OF APPLICATION	Tungsten – Rocket nozzles. Tantalum – Chemical plant. Rhenium – Resistojets. V_3Si – Superconducting tapes. Nickel – Satellite surfaces. Al_2O_3 – carbon fibres.	Electrical contacts and active devices. Thin film potentiometers of NiCr. High modulus bonding of piezoelectric transducers.

SURFACE COATINGS

Extensive facilities and expertise in surface coatings are available at Fulmer. We shall be pleased to recommend the technique appropriate to your problem and apply it on a laboratory or industrial scale.

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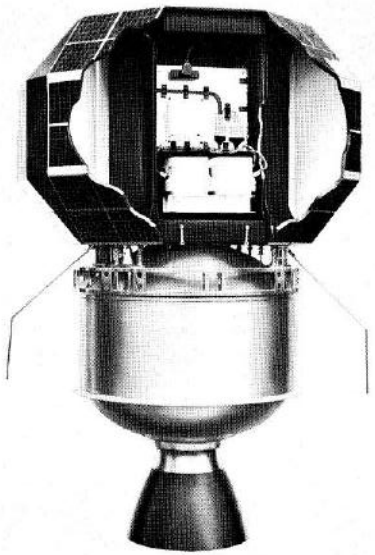

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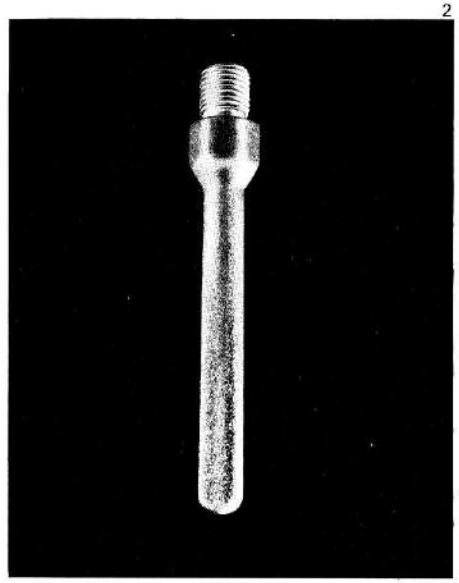

ELECTRODEPOSITION	FLAME SPRAYING	ENAMELLING AND GLAZING
Wide range of metals and alloys can be deposited cheaply. Different deposit characteristics readily obtained. Continuous or batch processes. Complex shapes. Large outputs – barrel plating.	Speed. Versatility – use of wire, powder or ceramic cord. Codeposition of metals. Cheapness. Thick coatings possible. Portability of equipment.	Ease of application. Cheapness.
Decorative and protective finishes. Wear resistant coatings.	Corrosion protection. Oxidation protection. Repair of components. Ceramic coating. Special coatings of high purity and good thermal contact. Hard facing.	Glass coatings for corrosion protection and decoration of metals. Sealing and decoration of ceramics. High temperature oxidation protection.
Nickel and chromium for car trims. Protection of steel by tin plating. Coating of plastics.	Protection of large structures. Building up worn parts. Improvement of crucible performance. Cyclotron targets. Abrasion resistant facings. Wire drawing cones.	Widespread uses in building, chemical engineering and in the home.

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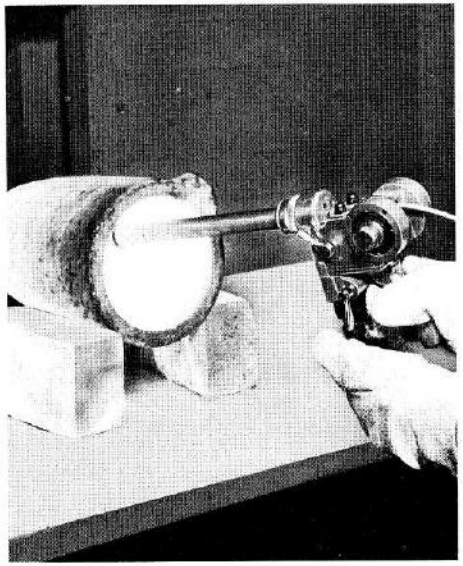

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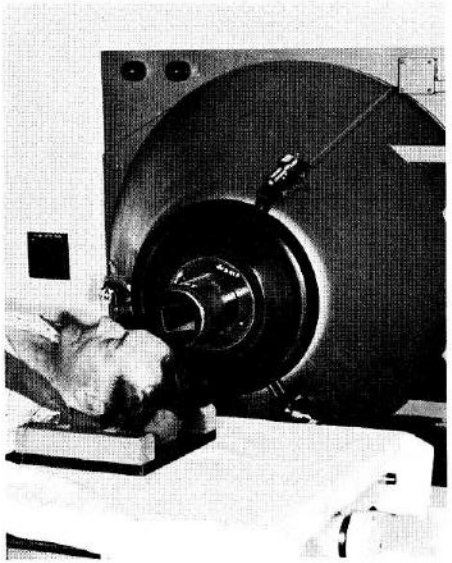


1 Rocket motor with tungsten coated exhaust nozzles.

2 Tantalum coated thermo-well

3 Electrodeposited decorative protective coatings.

4, 5 Flame sprayed coatings for crucible linings and cyclotron targets for medical use.

Measurement of properties

There is a considerable demand for reliable physical, chemical and engineering data. To provide these data, Fulmer has a wide range of specialised equipment and experienced staff.

Liquid metals

In heat transfer in liquid metal cooled reactors, in brazing operations and in certain composite materials, a knowledge of wettability and surface tension is important.

Wettability of liquid sodium on reactor materials is being studied by means of the sessile drop technique.

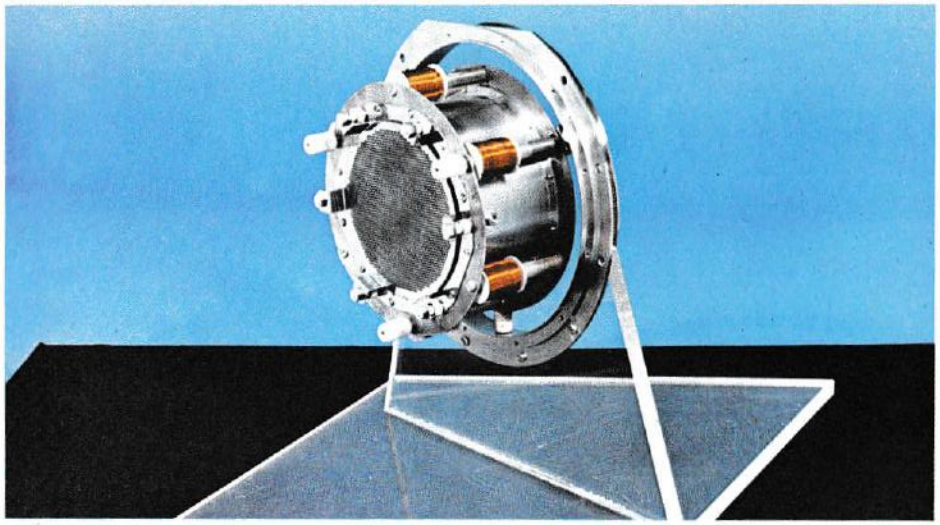
Surface tension measurements are made on a variety of alloys used in brazing. Infiltration of a liquid metal is governed by a combination of surface tension and wetting angle. In order to achieve maximum penetration it is important that the additives which are introduced to promote wetting do not significantly decrease surface tension.

Further information on the behaviour of metals has been obtained by an X-ray diffraction study of the structure of the liquid phase.

SPECIALISED TESTING

Ion engine

Fulmer has often undertaken specialised development programmes and is at present building and testing a British ion engine. The aim of the work is to extend the life of certain components and so improve the usefulness of this type of engine which is used in some communication satellites. These satellites require periodic orbital adjustments to maintain an accurate station. Chemical rocket motors are unsuitable for these minor manœuvres which only call for small power outputs over extended periods of time. Ion engines do not suffer from a heavy fuel penalty and derive their thrust from the Newtonian reaction to the discharge of mercury ions by repulsion from a grid charged with electricity from solar cells.



Resistors

Accurate testing is also required for the development of improved resistors. For specialised measuring equipment, resistors having a low temperature coefficient (t.c.r.) are required. With suitable alloy compositions and appropriate heat treatment t.c.r.'s better than 1 ppm. per degree centigrade can be achieved. A programme to link the electrical properties of these materials with atomic structure is in progress and the information obtained is being used to extend the range of resistors available.

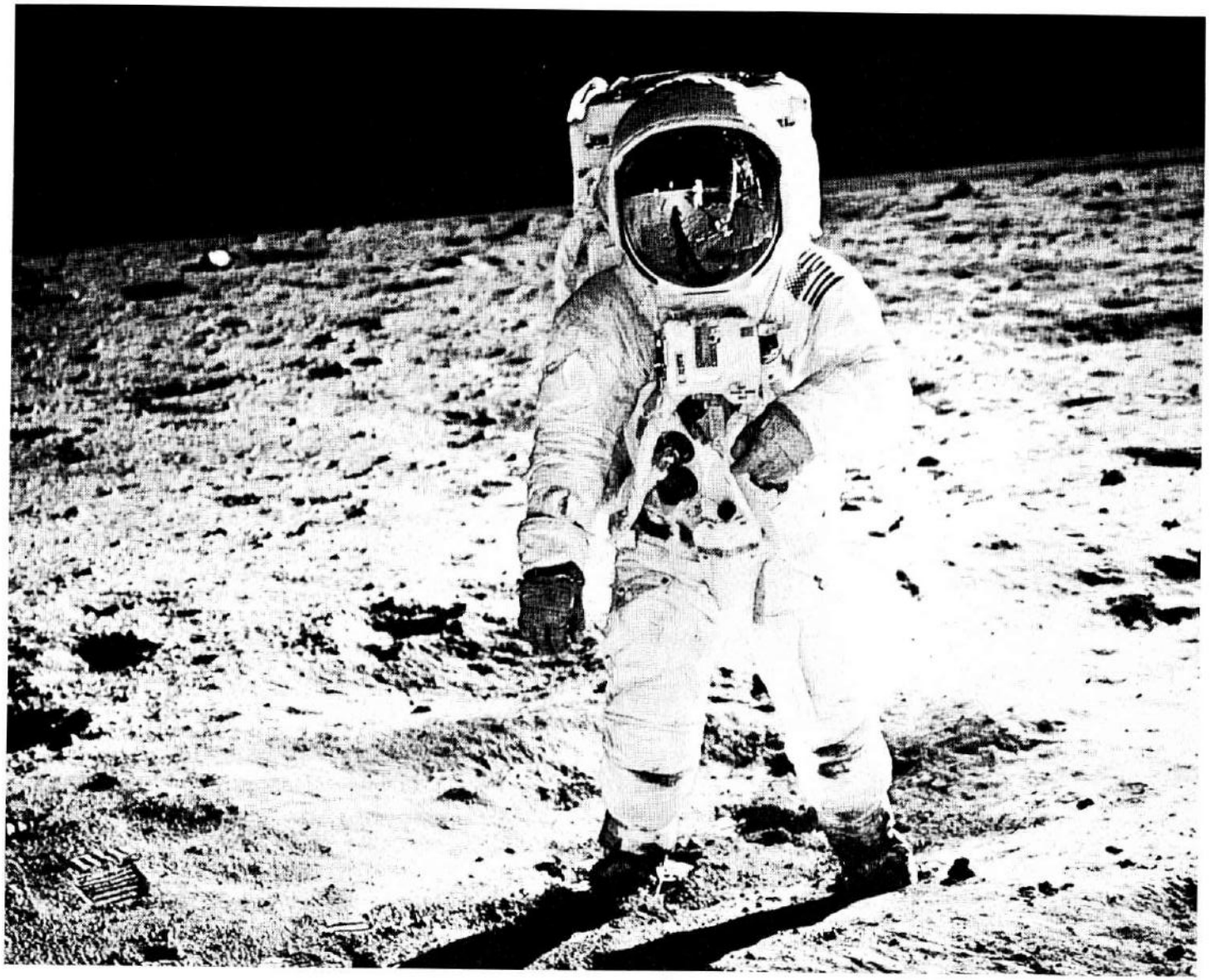
Measurement of properties

Thermochemistry

A knowledge of thermodynamic data is necessary for calculating the equilibrium of chemical reactions. This has technological applications in a wide range of chemical manufacturing processes, in the extraction and refining of metals and in the production of electronic materials. Thermodynamic data are also valuable in understanding the mechanism of attack in high temperature corrosion and determining phase stability in physical metallurgy.

Fulmer has made extensive measurements of thermodynamic properties of compounds – heats of formation, free energies, activities and specific heats. The calorimetric techniques employed have led to data of a very high accuracy.

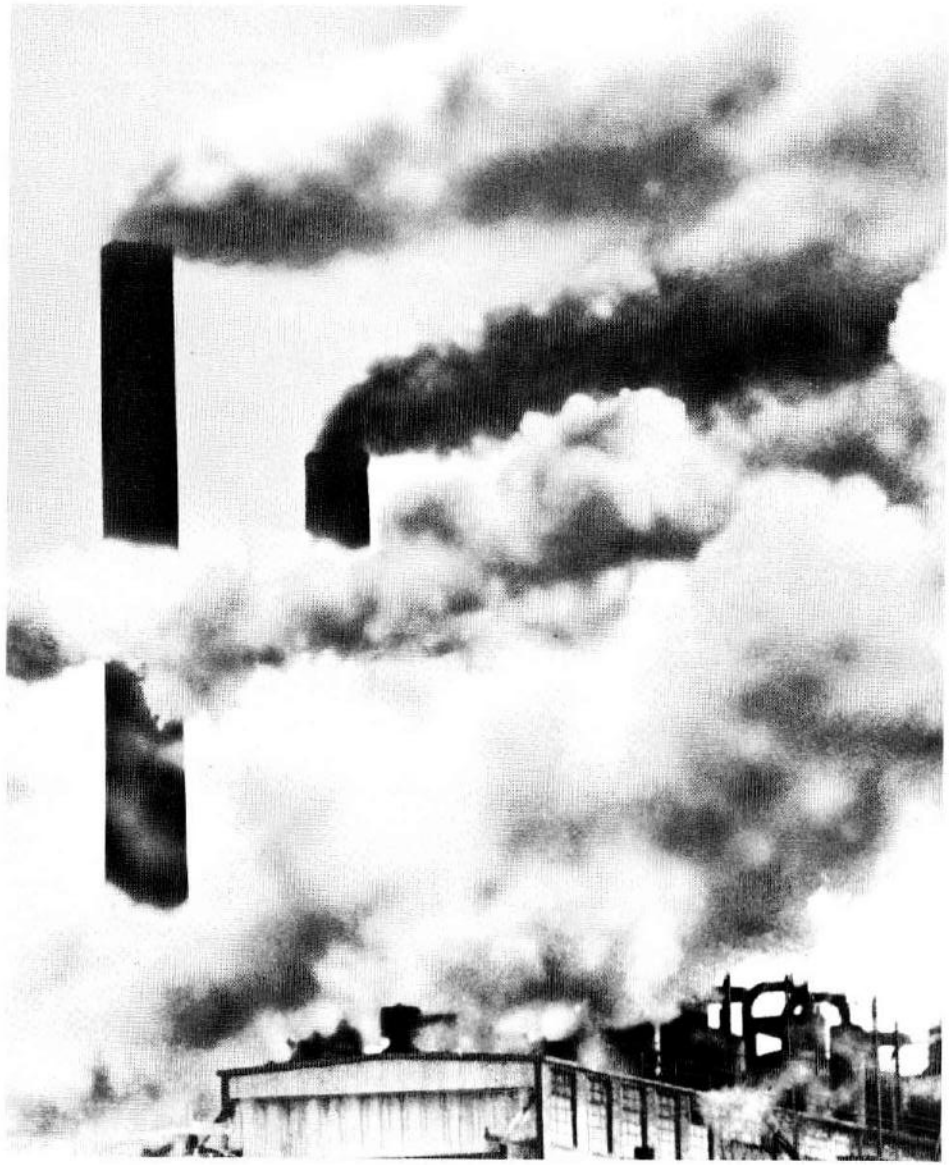
During the early stages of the American space programme, Fulmer supplied thermochemical data on high temperature chemical reactions as part of the evaluation of possible rocket fuels.



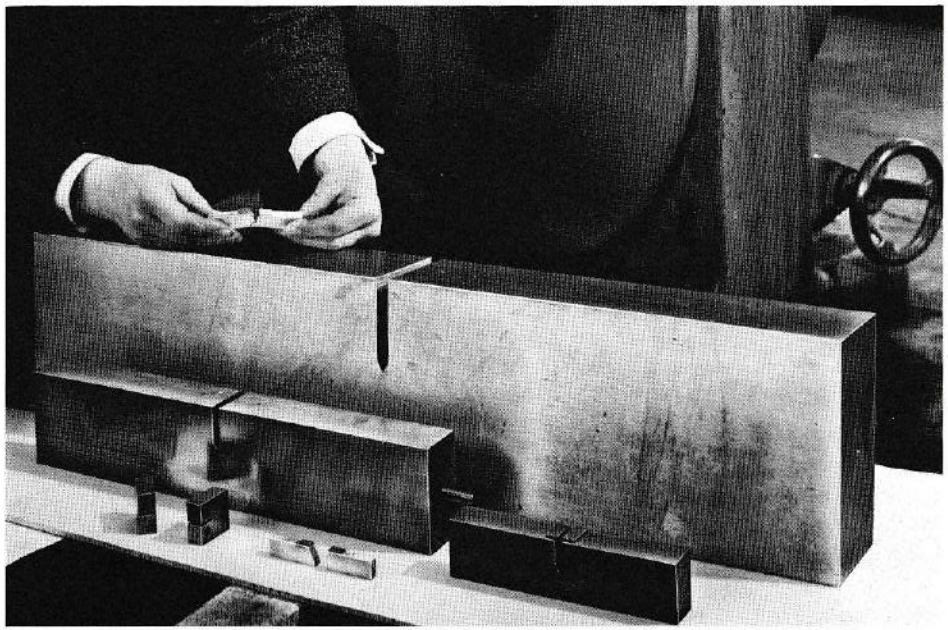
Pollution

In addition to using X-ray diffraction techniques to provide standard analytical data, and to explore the structure of liquid metals, Fulmer has devised a rapid X-ray method for identifying and sizing large numbers of samples of atmospheric pollutants on a routine basis.

A consulting service on pollution is available.



Measurement of properties



ENGINEERING

The function of the engineering activities of the Institute is to develop new techniques for the study of mechanical properties, and to carry out the testing and provide advice for industry with the Fulmer Technical Services Unit.

In addition to evaluating tensile, compression, fatigue, creep and impact properties of materials, the engineering staff have devised procedures for service-simulation testing of whole components. These include studies of the factors affecting the wear of machine tool slideways, the environmental testing of metal window frames for resistance to air and water penetration and the manufacture under licence of slipping clutch and thermal fatigue machines.

Much of the present work in the engineering laboratory is concerned with methods for evaluating fracture toughness in materials and the factors such as microstructure and environment, affecting this parameter.

Tension meter

Fulmer has developed a simple and versatile portable meter for measuring loads in tensioned wire, cable, rope, rod or strand. Applications include yacht rigging, overhead cableways, prestressing cables in concrete, radio and TV mast support cables, and all kinds of lifting gear.

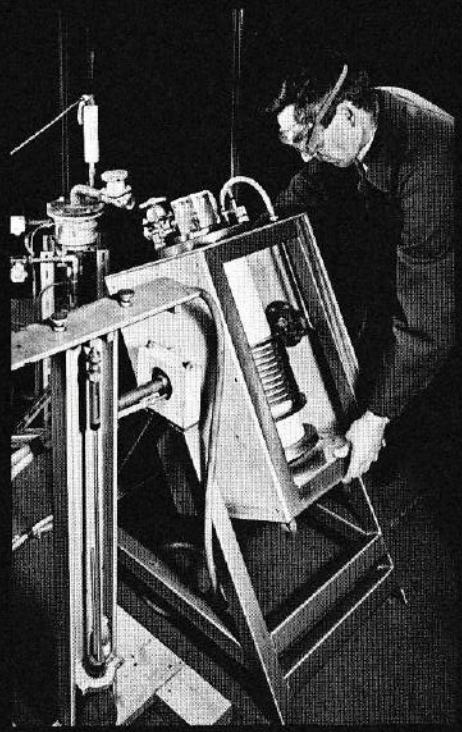
High accuracy creep machines are available in support of Fulmer's own contracts and are providing long term data to the chemical engineering industry and the Concorde programme.

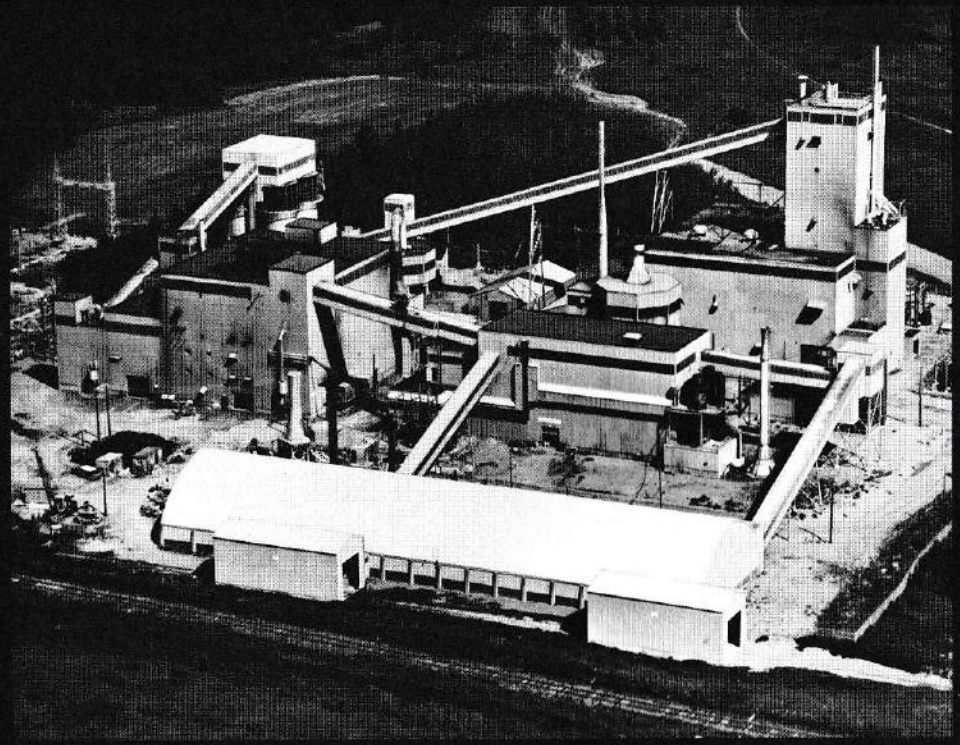
Process investigations

Many of the R and D projects investigated by Fulmer call for special materials or processes. Fulmer has developed the necessary expertise and equipment for the special melting and fabricating techniques required.

Production of special metals and alloys

Advanced engineering projects such as the nuclear power programme often require a range of trial alloys with carefully controlled compositions for evaluation purposes. The quantities involved are however usually too small to be available from the usual suppliers. Fulmer has met this demand by supplying a small quantity of crucible or vacuum melted alloys either as ingots or wrought products with a delivery of 10–14 days.





Melting and refining

Electroslag refining (ESR) is one technique being developed to provide the engineer with better high performance materials. Fulmer has already carried out trials with this technique by modifying an argon arc consumable electrode furnace to produce ingots of the nickel-titanium "memory" alloy Nitinol and of high strength steels.

Eutectic structures for electronic applications

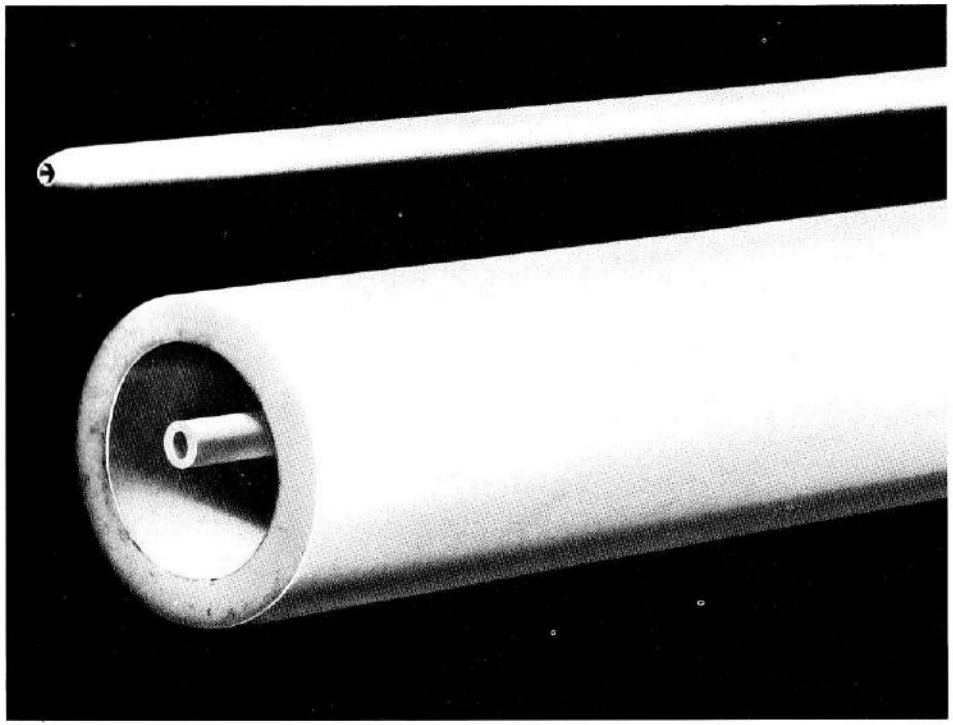
New electronic devices with enhanced properties can be produced by using materials grown by unidirectional solidification. Various eutectic alloy systems are being examined to produce rods of an electronically conducting phase in a semi-conducting matrix.

Extraction metallurgy

The application of gaseous halide processes for the extraction of metals from their ores has been studied extensively at Fulmer. The metals investigated include aluminium, titanium, beryllium, copper and vanadium.

Probe for analysis for surface tension

Our experience of surface tension measurements has been used to develop a new method for the analysis of liquids. A probe to monitor continuously the surface tension of liquids offers a simple technique to follow rapid changes in solute content down to a few parts per million. The device, on which a patent has been applied for, is at present designed to measure oxygen in liquid metals. The possible applications include detergents in water and surface active compounds in oils.



Metal conservation

The requirements for metals and alloys change from time to time. Technical considerations as well as all the demands of fashion and the dictates of economics and politics all play a major part in determining the best material for the job at that time.

In many cases, Fulmer has been able to advise a sponsor of alternative cheaper materials for a particular application without sacrificing quality. If however, no suitable alternative material exists, Fulmer is able to undertake the necessary development work to obtain the required properties in an available material.

As well as the development of high temperature aluminium-silicon steels without the costly nickel, work has included studies for recovering a valuable metal from scrap contaminated with non-metals. Other work has included the development of novel analytical methods for the determination of metal content in possible new ore sources of the element.

Fulmer technical services

The test and consultancy services of the Institute have grown steadily and now account for over 20% of the total income. To meet and encourage this demand it was decided in 1970 to form a special unit called Fulmer Technical Services.

The aim of this unit is to make industry aware of the accumulated expertise and specialised facilities of the Institute and emphasise that Fulmer can assist industry to solve its day to day problems. Having identified the problem, the unit is then responsible for liaison and action to provide the required information in the shortest possible time at minimum cost.

DIAGNOSTIC SERVICES

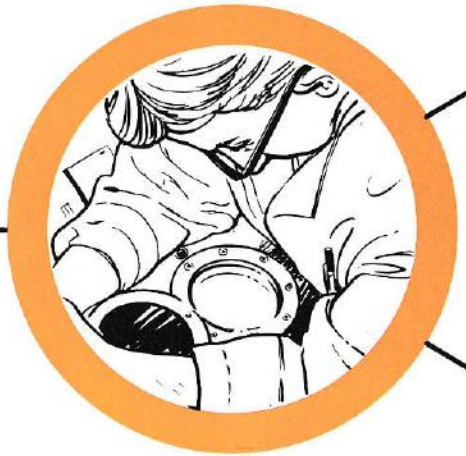
Much of the work of this unit covers failure diagnosis, mechanical testing, analytical services, physical techniques, especially electron microscopy and X-ray diffraction, corrosion testing, physical and electrical property determinations, measurements of thermodynamic data and the supply of special materials and fabricated parts. The unit also has considerable experience in arranging for technical litigation and patent advice.

Management services

Research management services are also provided through the unit. A major feature of these services is the use of Research Planning Diagrams (RPD) based on computer programming flow chart notation. In addition to its qualitative uses as an aid to clear thinking and to communication, RPD notation forms the basis of a straightforward quantitative analysis giving valuable time/cost/probability information on a proposed research plan.

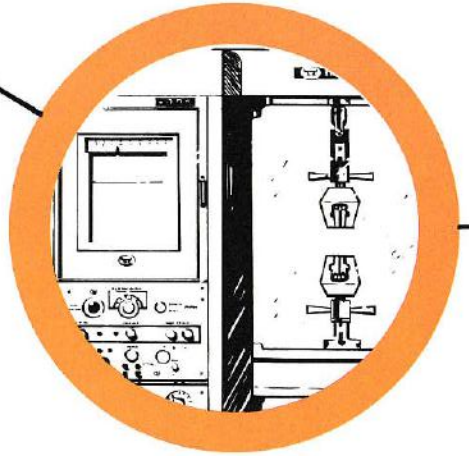
Problem

Information



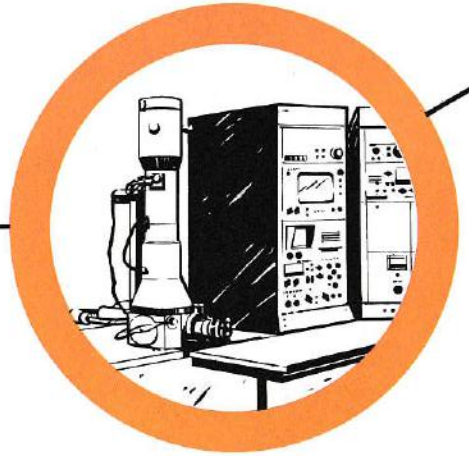
Visual Examination

Chemical Analysis

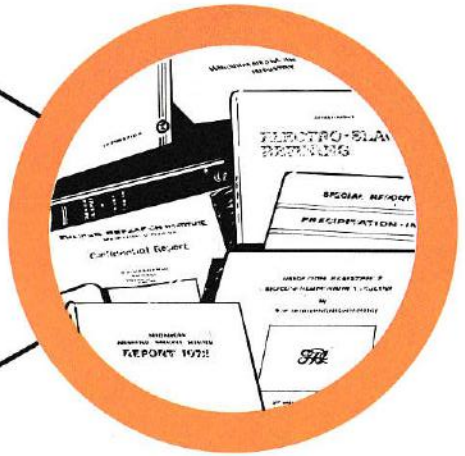


Mechanical Tests

Optical Microscopy and
Electron Microscopy



Micro-probe Analysis and
Electron and X-ray Diffraction



Report and Recommendations

This brochure has demonstrated the wide area of experience available at Fulmer. If you are faced with problems and opportunities in the fields of materials technology and processing, please contact us at:

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Telephone: Fulmer 2181 Telex: 84314 Fulmer
Cables and Telegrams: Research, Slough

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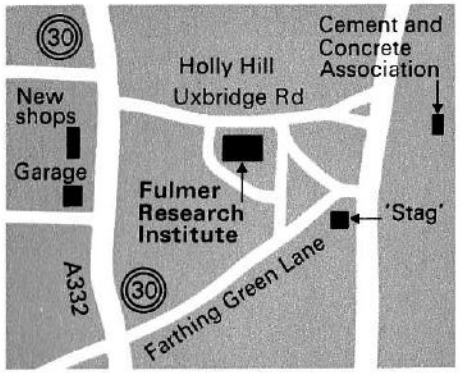
Designed and printed at The Kynoch Press, Birmingham, England



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