

Fulmer



F130

annual
review
1979

Fulmer Research Institute Ltd

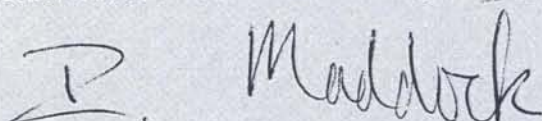
Chairman's Foreword

1979 was yet another year of solid achievement for which the Directors give great credit and thanks to the hard working and dedicated staff.

Total income rose to £2.65M and profits nearly doubled at £218,000. Research contracts earned £1.4M; testing, consultancy and information £1M; and manufacturing £250,000. £483,000 was earned overseas, mainly from U.S.A., Australia, Japan, India, Pakistan and the E.E.C. countries.

The main technological achievements of the year are described in this report. One major event was the opening of new fire test facilities at Redhill and these are featured on pages 2 and 3. The Superdart military marksman training system, developed for an Australian sponsor, has been successfully launched. Substantial advances were made in composite materials technology and in the processing of semi-solid metals for dies and die casting operations. Our radiation monitoring facilities were enhanced by the installation of a Cobalt-60 source and the new edition of the Fulmer Materials Optimizer has strengthened our materials selection service which benefited many clients during the year. Many market surveys were carried out, particularly for overseas clients.

Despite the economic difficulties facing the U.K. and much of the industrial world we look forward to even better results in 1980 in the knowledge that our skills and facilities are essential for industrial progress.



SIR IEUAN MADDOCK, CB, OBE, FRS, F.Eng

Business Activity

Fulmer is a contract research and engineering company concerned with the science and technology of materials and their uses. The main areas of activity are:

Materials and Product Testing
Product Design and Development
Materials Processing
Surface Coating Technology

Materials Selection and Specification
Energy Conversion and Conservation
Manufacture of Special Products
Technology Transfer

The company operates in five main divisions whose particular expertise is summarised on the back page of this review. These operating divisions are:

Fulmer Research Laboratories Ltd. (FRL)
Fulmer Technical Services (FTS)

Yarsley Research Laboratories Ltd. (YRL)
Yarsley Technical Centre Ltd. (YTEC)

Fulmer Components Ltd. (FCL)

Fulmer is fully self-supporting financially and the operating surplus is used to finance further development. Fulmer is owned by the Institute of Physics and is, therefore, completely independent of any commercial or industrial affiliation.

Group Trading Report

	Turnover £		Profit (Loss) £	
	1978	1979	1978	1979
Fulmer Research Laboratories Ltd. (including Fulmer Technical Services)	1,168,000	1,393,000	69,000	100,000
Yarsley Research Laboratories Ltd.	149,000	290,000	(32,000)	16,000
Yarsley Technical Centre Ltd.	633,000	750,000	25,000	84,000
Fulmer Components Ltd.	179,000	178,000	40,000	10,000
Reform Manufacturing Co. Ltd.	26,000	28,000	10,000	8,000
Group Total	2,155,000	2,648,000	112,000	218,000

The total Group staff at the end of 1979 was 240.

Front cover:

A 30 mm RARDEN gun barrel to be coated as part of a project supported by the U.K. Ministry of Defence.

Materials and Product Testing

Lottery Tickets

The security of instant lottery tickets is a problem currently being investigated at Fulmer Research Laboratories. These tickets are normally in the form of a sequence of numbers with a latex covering which, on removal, reveals a winning series and an instant prize. At present many lottery tickets are sold without the necessary consideration being given to the security aspect. By the use of scientific techniques it is possible to separate the winning tickets from a batch and hence the possibility of fraud by the distributor exists. Also the credibility of the lottery is damaged resulting in a lack of public confidence and subsequent fall in sales.

The extraction of the winning numbers from a batch was demonstrated by Fulmer Research Laboratories at the First National Lotteries Conference, sponsored by the Printing World, in London and subsequent public interest resulted in front page headlines in a major Sunday newspaper!

The Royal Commission on Gambling (July 1978) and the 1978 annual report by the Gaming Board emphasise the need for stricter regulations to cover instant lotteries and Fulmer is now advising many companies on the security standards required.

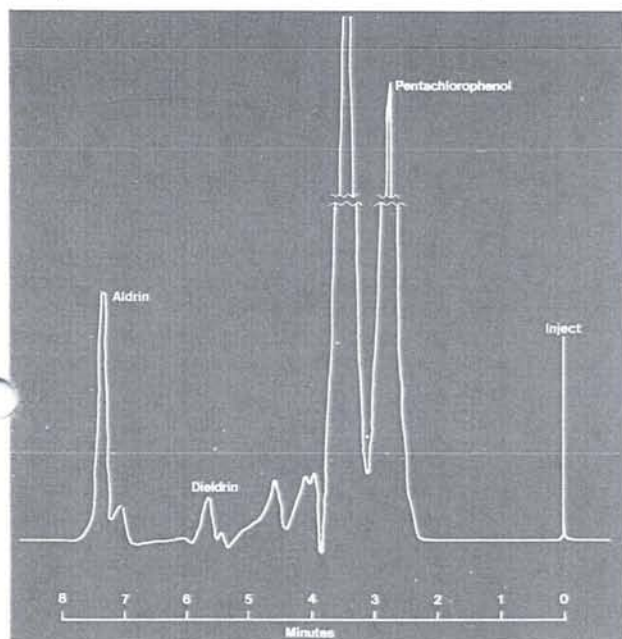


Duncan Stewart, a Research Manager at Fulmer Research Laboratories, discussing lottery tickets with other delegates at the First National Lotteries Conference

New Technique for Analysing Wood Preservatives

A new technique for uniquely and quantitatively determining the constituents of wood preservatives has been developed by the Yarsley Technical Centre.

Measurement of the level and type of wood preservative is essential in deciding if a timber has been treated properly to prevent attack by fungi and wood-boring insects. Examples of wood preservatives include lindane, pentachlorophenol, aldrin and dieldrin, and the chart recording shows the separation achieved in the latter three compounds by the Yarsley technique. Previous methods of analysis have usually been based on total chlorine content, but this has never allowed differentiation between the various organo-chloro and inorganic chloride constituents in the sample. The Yarsley technique uses a Du Pont Universal High Performance Liquid Chromatography system to analyse a solvent extract of the timber.

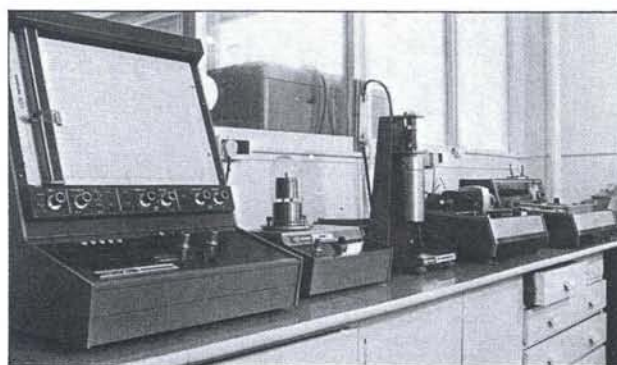


HPLC Analysis of a Typical Wood Preservative

Thermal Analysis of Building Products

At Yarsley Research Laboratories the comprehensive range of equipment for differential scanning calorimetry, thermomechanical and thermogravimetric analysis is now being extensively used for the characterisation of a wide range of building products, in particular the degree of cure of epoxide resins in paints, powder coatings, mastics, etc. A major use is for determination of the degree of conversion of high alumina cement beams which, despite its absence from the headlines, is still of major concern to local authorities.

Many other services for the building industry are provided throughout the Fulmer group and a leaflet describing these services is available.



Range of Thermal Analysis Equipment available at YRL

Fire Testing and Fire

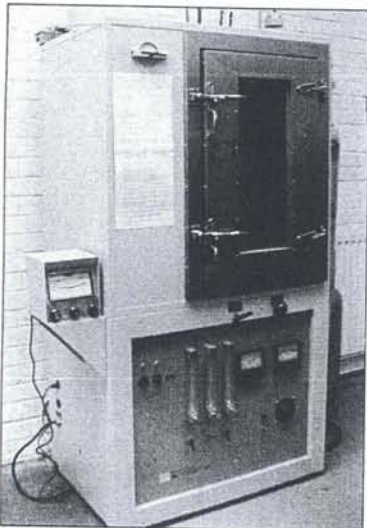
Materials and Product Testing

Fulmer has been engaged in fire research and testing since 1967, mainly through the Yarsley subsidiaries, and following the establishment of new facilities at Redhill, now has the most up-to-date, general purpose, independent fire laboratory in the UK. The new laboratory was formally opened on 29th November 1979 by Dr. I. Dunstan, Director of the Building Research Establishment.

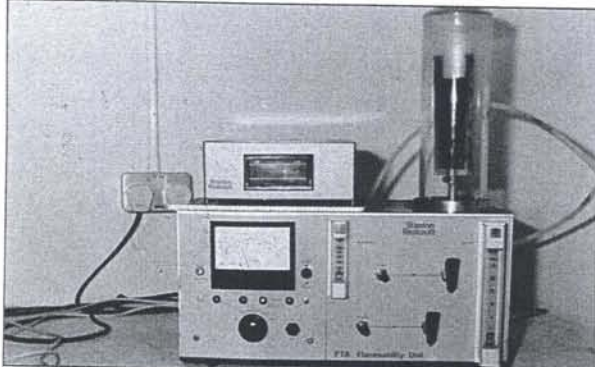
Fire hazard is one of the major problems of modern society. Despite extensive research into the causes of fire, the development of standard tests to assess the fire hazard of materials and structures, and legislative pressures to force the use of these tests, the losses – both financial and of life – continue to increase. The estimated cost of fire damage in Great Britain in 1978 was £310M, representing an 18% increase over 1977. Fatal casualties caused directly or indirectly by fire increased from 458 in 1947 to 751 in 1974 and 849 in 1977, in which year there were also over 5,000 non-fatal casualties. A very high proportion of the deaths and casualties occur in buildings, and particularly in dwelling places. When large economic losses are suffered, these too are usually associated with fires in buildings. Thus it is essential to understand the way building materials and products, the structural elements of buildings, and furnishings and fittings, behave when subjected to fire.

In design and construction most buildings are now controlled by the Building Regulations. Section E of these Regulations is devoted to rules which govern the use of combustible materials in various types and parts of buildings to ensure that the risk of a fire starting is minimal and that if one does occur, its progress will be as slow as possible. It would be possible to construct satisfactory buildings entirely from brick, steel, concrete or other non-combustible materials in order to satisfy Building Regulation requirements, but of course this approach is hardly likely to be acceptable for reasons of economy,

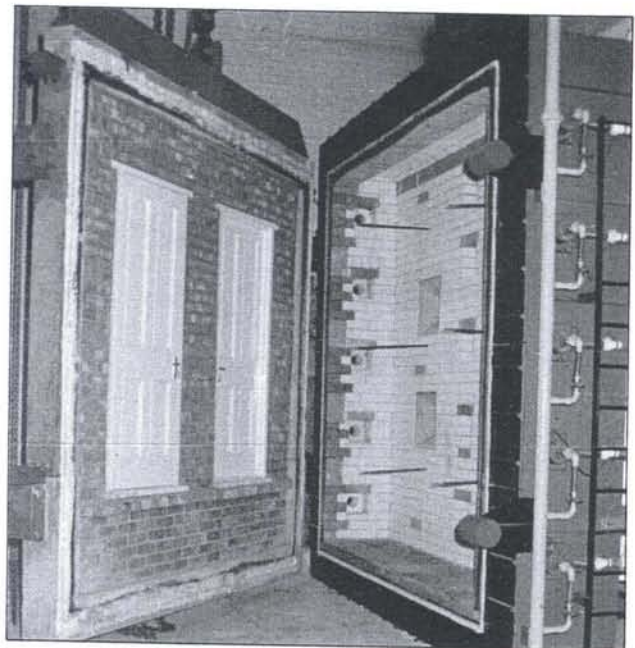
aesthetic appeal and comfort. There must, therefore, be an element of fire risk which the Building Regulations (by means of test requirements) are employed to limit. The main tests used in Building Regulations with regard to Fire Performance are available at YTEC, and the laboratory has a Certificate of Competence under the Department of Environment's Supervisory Scheme for Fire Test Laboratories.



NBS Smoke Density Chamber to ASTM STP 422, 1976



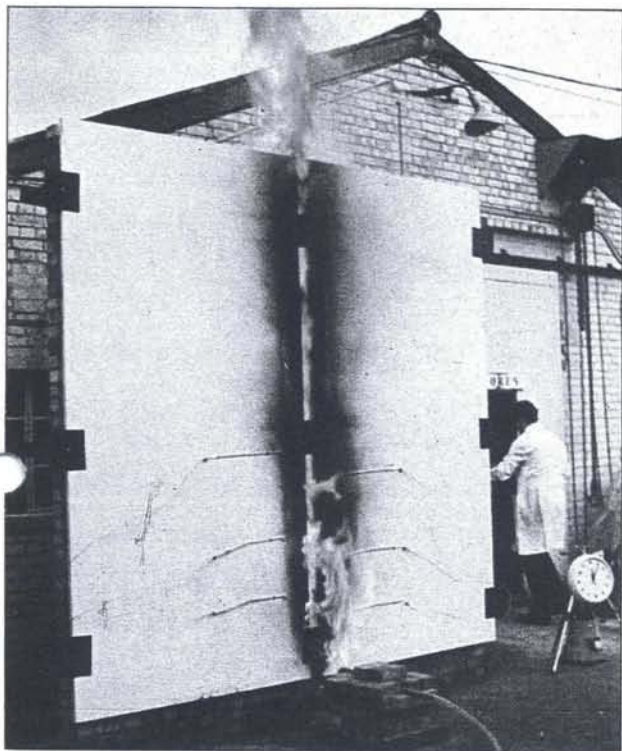
Oxygen Index Test: this measures the ability of a material to burn in a mixture of nitrogen and oxygen, which can be varied.



The new Fire Resistance furnace for tests to BS 476: Part 8, on non-load-bearing walls, partitions, etc.

Once a fire has started the type and rate of generation of smoke, or of carbon monoxide and other toxic gases, are important because danger may lie more in the products of combustion than in the combustion itself. Deaths due to the inhalation of smoke and toxic gases have increased sharply in recent years. A recent report from the Home Office Fire Department states that the percentage of deaths from this cause related to all deaths caused by fire (in England and Wales) increased from 7.64% in 1947 to 42.27% in 1974. YTEC has carried out extensive development work on smoke production and toxic gas analysis, and an NBS Smoke Chamber was installed during 1979.

Hazard Investigation



Fire test on a jointing system for GRP building cladding panels, showing the chimney effect of the gap, and the flammability of the sealing materials used.



Photograph by courtesy of Rentokil Ltd.

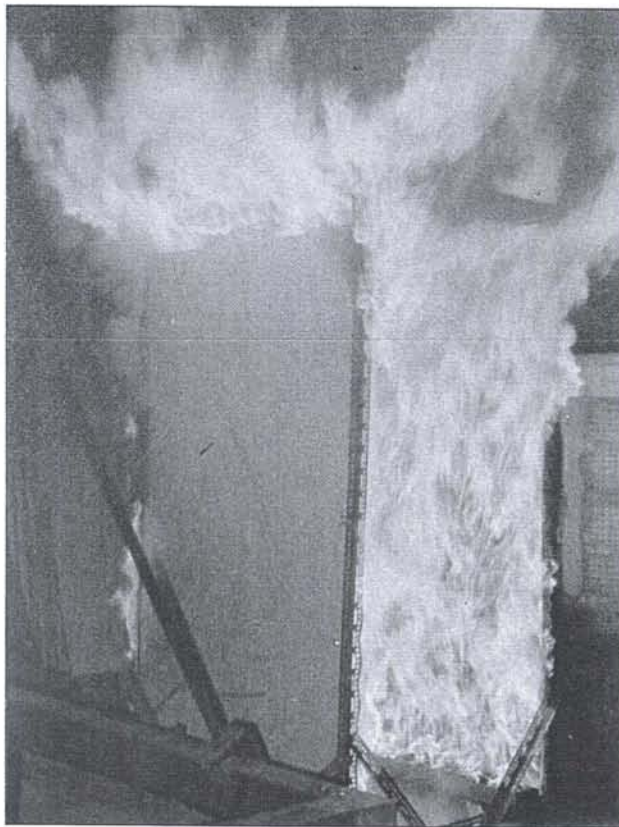
A test using a new type of fire blanket to extinguish a simulated 'chip-pan' fire. The test is conducted generally in accordance with methods detailed in Fire Research Notes 1057 and 1079.

YTEC also specialises in investigations into the underlying causes of fires and explosions. Simulated testing is carried out to determine the ignitability, flammability, liability to spontaneous heating or pyrophoric behaviour of materials. These investigations are often carried out in connection with litigation where fires or explosions have occurred, or where arson is suspected. A particular speciality of YTEC's service is in investigations of the liability to self-heating of granular or powdered materials, which can lead to spontaneous ignition at surprisingly low temperatures, even after relatively long periods of storage.

YTEC also has facilities for testing furniture and furnishings. The tests incorporated in the pending legislation, 'Tests for the Ignitability of Upholstered Seating', have also been in use in the laboratory for many years and are available for manufacturers to check the compliance of their products with the proposed new regulation.



Chair upholstery materials being tested to DOE/PSA FR3, ignition source 5, to assess ignitability.



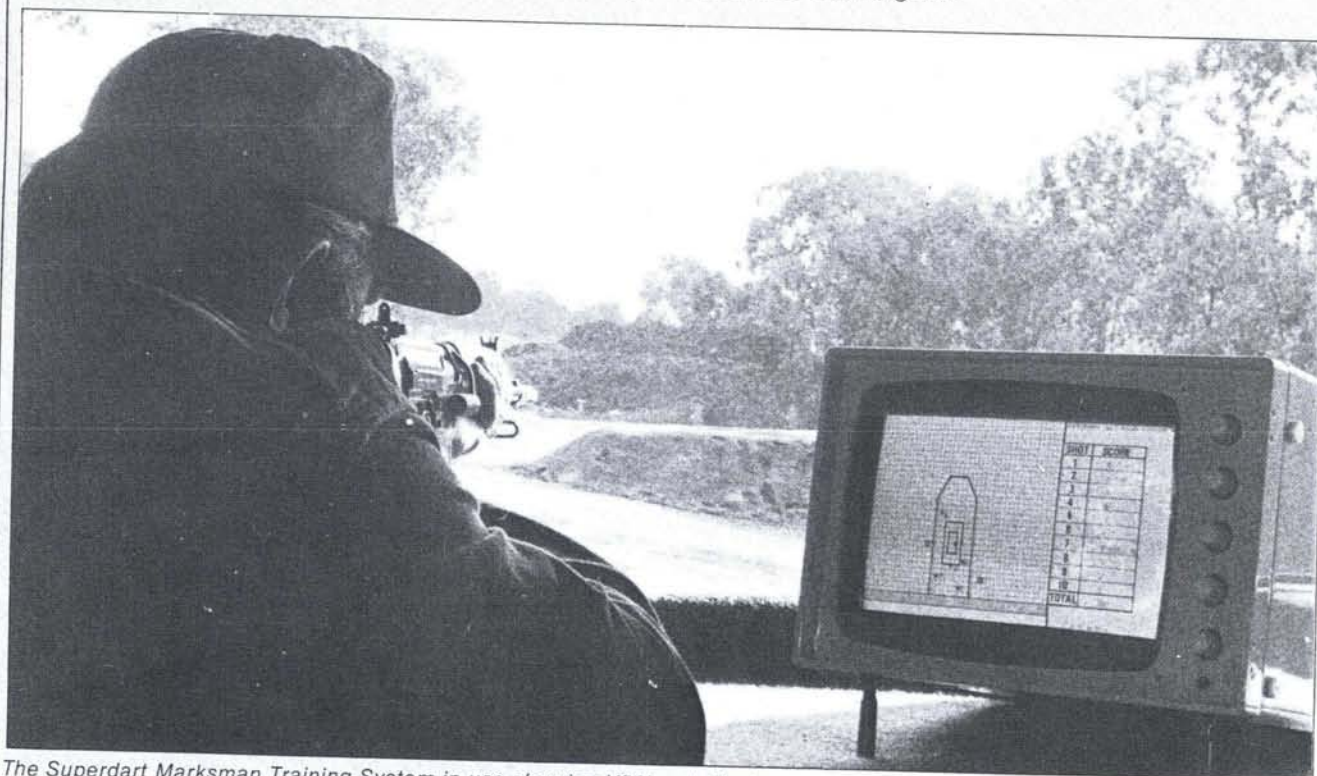
A test to demonstrate and assess the production of smoke and combustion gases in large scale fires. Smoke density in the test chamber was monitored by the fall-off in transmission of light beams. The combustion gases were analysed by infra-red spectroscopy, wet chemical and gas-reactive tube methods.

Superdart Ballistics Development

1979 saw the culmination of a very important R & D programme supported by Australasian Training Aids Pty Ltd (A.T.A.). The combined efforts of Fulmer Research Laboratories, A.T.A. and Falco Systems have been employed to produce a comprehensive system which indirectly measures and records the hit position of bullets fired by trainee marksmen. The bullet trajectory is calculated immediately after firing; its location in the target area is determined and shown to the marksman on a videoscreen. The rifle he uses is instrumented so that the reasons for deviation from the desired trajectory can be determined.

Following the definition of the performance specification for this equipment, Fulmer suggested that a method which depended on detection of the airborne shockwave associated with a supersonic projectile should be used to compute its trajectory and its point of impact on a target. During the three years of R & D activity at Fulmer a simple mathematical model of the shape and velocity of a shock front in air was refined to take account of bullet deceleration, wind, and variations in the velocity of sound which result from local variations in temperature and humidity. Omnidirectional transducers were developed which enable measurement of the times of arrival of the shock wave at fixed points in space to within 200 nanoseconds. Mathematical methods were devised which used the model treatment and the timing information to calculate the trajectory and project it into the target plane. Sensitivity analyses were carried out to map the likely random errors in hit position which would result from the random errors which were known to be present in the input parameters; these were compared with experimental results to test the validity of the model. In addition, an optimisation programme was prepared to define the positions of detecting transducers with respect to the firing point and the target which would give the best performance under any defined constraints of space and accuracy of measurement.

Development systems were built and tested at Fulmer to prove the hardware and the mathematical treatments before the technology was transferred to the sponsor's own establishment, where a series of production prototypes has now been built. The accuracy of hit locations on these systems varies with hit position and with system type. The most accurate system gives accuracy of ± 1 mm over a 1 m diameter target. Patent protection has been obtained in three countries and has been applied for in a further 21 countries, and the first contract for supply of a complete training complex has been signed.



The Superdart Marksman Training System in use showing VDU and Display

Photograph by courtesy of Australasian Training Aids (Pty) Ltd.

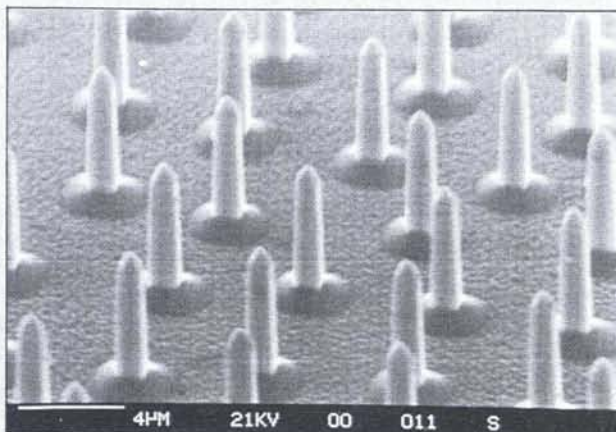
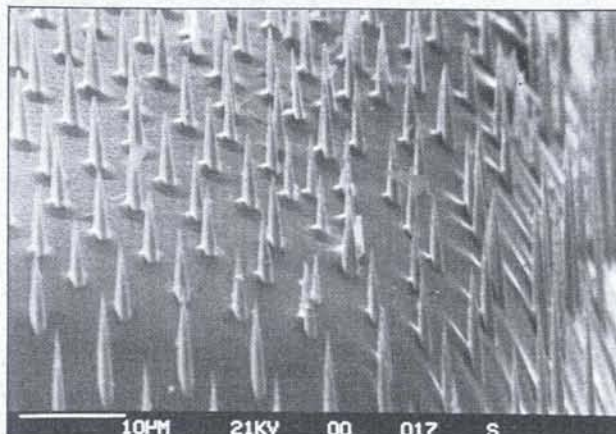
Observation of High Speed Events

Studies of the effects of high velocity impactation materials (by bullets or hammer blows) present major problems in high speed observation and recording of events. In connection with Ministry of Defence and civilian contracts, Fulmer has developed high speed photographic methods giving a time resolution of 10 microseconds which will soon be

increased to one microsecond. This is augmented by the use of strain gauge and high speed recording technology which is used to detect and record the strain waves induced in materials. The strain gauge signals may be stored in digitised form (time resolution 200 nanoseconds) for subsequent processing.

Field Emission Cold Cathodes

Directionally solidified eutectic materials (whisker composites) have been developed at Fulmer Research Laboratories for use in infra-red devices and turbine blades for jet engines. The whisker structure may be exposed by selective etching and pointed to produce a small radius at the tip of the fibre. Using this structure materials containing refractory metal carbide fibres, e.g. TaC and NbC, will operate as field emission cold cathodes for use in electron tube devices. An electron tube operating with a cold cathode in place of the conventional thermionic type has many advantages such as instant start-up and ruggedness in construction. Tests to date have shown that current densities up to 2Acm^{-2} and life times in excess of 1000 hours can be obtained.



Directionally solidified eutectics etched to produce field emission cold cathodes.

Novel D.I.Y. Coating System

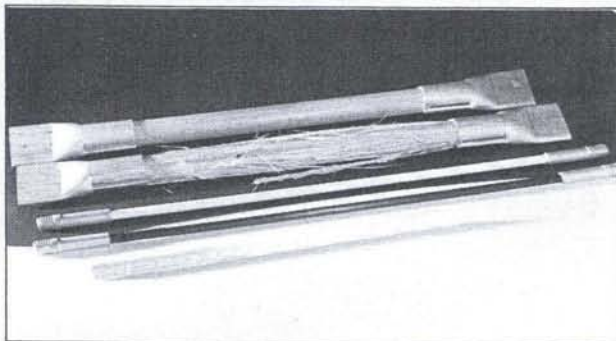
On behalf of the U.S. Department of Housing and Urban Development, Yarsley Research Laboratories have developed a novel coating system for use as a covering for lead-based painted surfaces to reduce the health hazard. The product is supplied in roll form and consists of a carrier which is impregnated and coated with a thermoplastic composition. It is applied by cutting a piece of suitable size and shape, using ordinary scissors, and ironing it on to the surface to be covered using a conventional domestic iron. A sheet of release material has to be interposed to prevent sticking to the iron but this can be used many times before replacement is necessary. The product can be made in a range of colours and it can also be overpainted with conventional paints. The product has many other possible uses in the D.I.Y. market, for example, the repair and renovation of badly cracked woodwork such as exterior window sills.

Structural Fibre Reinforced Plastic

The new process of pultrusion allows the production of a range of sections of FRP which possess high specific strength and in some cases high specific stiffness. Unfortunately the difficulties of making end attachments to these sections have limited their potential application to lightweight load-bearing space frame type structures. A reliable, low cost method of making end fittings to pultrusions has been developed at FRL under contract to the Ministry of Defence, and provisional patent cover for the method has been obtained. These fittings are capable of loading pultruded tubes to their ultimate, and have demonstrated excellent durability following simulated accelerated exposure to adverse environmental conditions.

Hearing Aids

A contract has been obtained by Yarsley Research Laboratories from the Department of Health and Social Services to develop a polymer for hearing aids with a permanent flexibility such that it will conform so closely to the patient's ear that the feedback from the inducted gap which occurs with rigid polymers will not arise. This will give a much more comfortable hearing response. Several potentially suitable polymers are now being evaluated.



End fittings on glass fibre and carbon fibre reinforced pultruded rods and tubes. The ability to load the pultrusion to its ultimate is demonstrated.

Materials Selection and Specification

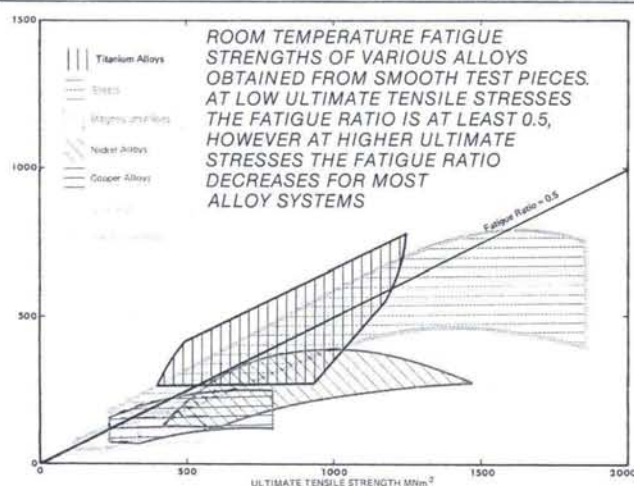
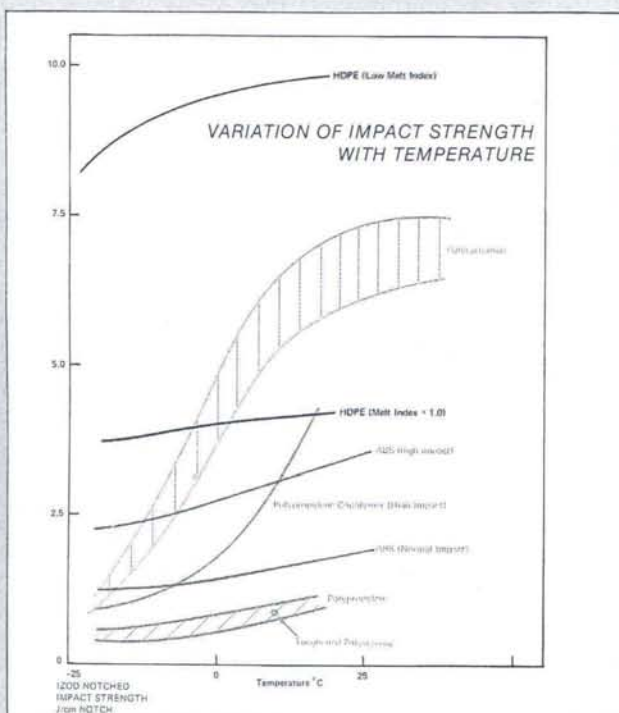
The new edition of the Fulmer Materials Optimizer is now available in a completely revised form. The first edition produced in 1974 sold out and has proved to be of great benefit to designers, production engineers, processing managers and those whose job it is to obtain maximum value from engineering materials. It also found wide acceptance as a teaching aid at Universities and Technical Colleges, bridging the gap between theoretical and practical engineering. The contents of the revised four volumes are as follows:

Volume 1 Part 1 Production Design Analysis
Part 2 Comparison of Materials
Part 3 Product Manufacturing Processes and Costs

Volume 2 Part 1 Characterization and Specification of Ferrous Metals
Part 2 Characterization and Specification of Non-Ferrous Metals

Volume 3 Parts 1 & 2 Characterization and Specification of Non-Metals (Thermoplastics, Thermosets, Elastomers, Ceramics, Foams, Composites)

Volume 4 Selection of Materials for Specialist Applications.



No information and specification system, however comprehensive, can substitute for the experience of skilled engineers and materials technologists, who are available at Fulmer for assistance on materials selection problems. Many such tasks are undertaken each year for a wide variety of clients, often referred to us by the Manufacturing Advisory Service of the Production Engineering Research Association or the Design Advisory Service of the Design Council.

Miniature Electric Light Bulbs

A typical materials selection project was the examination of possible changes in tooling materials and/or techniques to increase machine tool life and reduce overall costs in the manufacture of miniature electric light bulbs. The majority of tools used in the manufacturing process operate at temperatures between 600 and 700°C and fail by a combination of high temperature oxidation and plastic deformation. Many of the tools in use by the manufacturer were only suitable for service up to about 300°C and in one instance the material used had been incorrectly heat treated. The high temperature service environment restricts the choice of suitable materials and Fulmer recommended hot working tool steels as being the most cost effective, while cobalt and nickel alloys would have the longest life. In one case an alumina ceramic has been recommended. This project provided a striking example where the selection of cheaper but inferior

materials proved ultimately to be a very expensive choice.

Materials for Corrugating Rolls

Corrugating rolls are used in machinery for the production of corrugated paper and board. The functional requirements of rolls are to deform and transfer heat to the paper medium, to transfer roll drive, to have a specified average life, to be repairable by welding and to have restorable surface properties. Deterioration of rolls is by sliding abrasive wear and indentation of mineral particles and debris in the paper-making medium. The purpose of the Fulmer study was to increase the service life of rolls using existing engineering materials and treatments. It was shown that by specifying a different process for the externally processed roll blanks and by a modified surface heat treatment the objectives of the study could be realised.

Energy Conversion and Conservation

A study has been undertaken for the Department of Energy on the energy content of automobile components. This found that the energy savings made by changing to lighter components would not be significant to individuals, although the cumulative national effect would be substantial. This illustrates a constant theme in our energy saving work that individual incentives are not large enough to encourage serious action. If Governments are serious about national energy savings, then it is necessary to make the individual incentives sufficiently great either by subsidies or very large price rises.

Thermal Insulation

The thermal insulation property of insulating blinds has been assessed in comparison and in conjunction with both single and double glazed windows. The results showed that the blinds were of similar efficiency to a second sheet of glass in reducing heat lost through a single glazed window. The most effective system tested involved two sheets of glass and three blinds. Very extensive facilities exist at YTEC, Redhill, for determining the insulating properties of a large range of materials.



Photographed by courtesy of Automatic Liquid Samplers Ltd.
Demonstration Model of Insulating Blinds

Surface Coating Technology



Examples of Electroless Gold Plating on Plastic



Mechanical Plating Laboratory

Electroless Gold Plating

An improved technology for producing high integrity gold coatings has been developed at Fulmer Research Laboratories and is currently being used for the production of specialised gold plated components. Gold is deposited by an aerosol spray technique which, by the use of multiple spray heads, leads to rapid and complete coverage of complex shapes. The coating thicknesses are approximately 1000 Å and the process can be applied to conducting and to non-conducting surfaces.

Mechanical Plating

Fulmer now has facilities for the mechanical plating of small components such as nuts, bolts and other fasteners. This comparatively new technique is also ideal for complex shapes. A metal powder, suspended in a suitable carrier plus an activator, together with glass beads, is rotated with the components at moderate speeds. Plating occurs by a combination of mechanical adhesion and chemical action. No electrolytic current is used and this results in the avoidance of hydrogen embrittlement problems. A wide range of metals and alloys can now be applied with this technique.

Materials Processing

In the report of the UK Advisory Council for Applied Research and Development entitled 'Technological Change', a key paragraph referred to increasing emphasis on economy in the transformation of raw materials into semi-finished articles and final products. Improved casting and more accurate forming processes were mentioned together with new shaping technologies and increasing use of powder metallurgy. Fulmer Research Laboratories have been working on such new technologies for several years.

Semi-Solid Metal Forming

A programme under the sponsorship of the Mechanical Engineering and Machine Tools Requirements Board, Lucas Industries and International Aluminium Co., has successfully produced metal in a thixotropic state which, if handled gently, remains as a solid, but behaves as a liquid if a shearing force is applied. Aluminium-silicon-copper alloys have been produced as a continuously cast slurry bar. On re-heating to below the solidus, the material is thixotropic and in this state can be handled gently as a solid. If sheared it can be formed in a die to give accurate shapes.

Powder Metallurgy

Fulmer's work on high energy milling and powder metallurgy processes has now reached the stage where it has been necessary to instal our own hot isostatic pressing facilities. We have chosen a Conaway Laboratory Scale Hot Isostatic Press capable of exerting pressures up to 30,000 psi at temperatures up to 2000°C. As well as the consolidation of powder this process will be used for diffusion bonding and pore closure in castings and pre-sintered products.

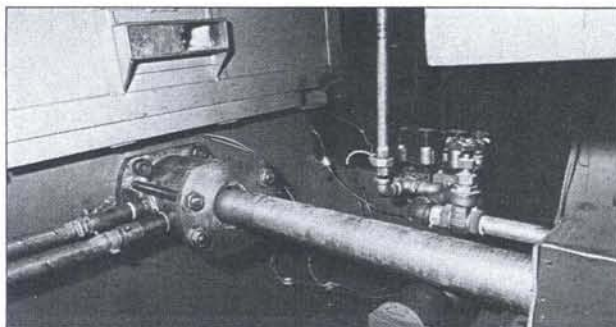
Laboratory Scale
Spray Drier



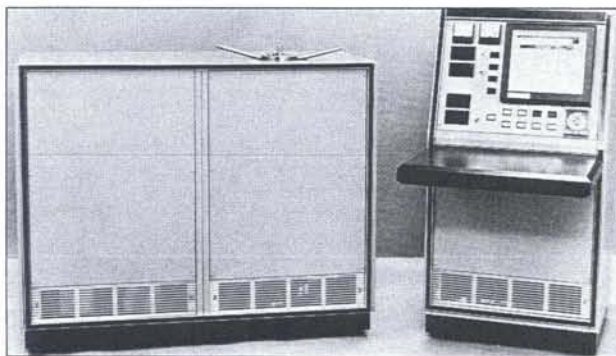
Injection Moulding of Composite Materials

A GKN Windsor HS1 330 injection moulding machine has been installed at Yarsley Technical Centre to complement the already extensive polymer processing facilities.

The HSI 330 is used by Yarsley for process and polymer development involving a wide range of thermoplastic and thermoset materials. A special screw and barrel assembly has been supplied to enable Yarsley to use the HS1 330 machine for injection moulding of composite materials such as heavily loaded glass DMC (dough moulded compound).



Production of Continuous Cast Slurry Bar



Photograph by courtesy of Conaway Pressure Systems Inc.
Hot Isostatic Pressing Facility

Microencapsulation

Yarsley Research Laboratories are developing a process for the microencapsulation of intumescent materials for use in fire-retardant paints. These materials are water-sensitive and it is hoped that by encapsulating them in a polymeric envelope paints with improved water resistance will be obtained.

Encapsulation by spray-drying is the main technique to be used in this project, but expertise is also available on other techniques.



Photograph by courtesy of LPR (Public Relations) Ltd.
GKN Windsor HS1 330 Injection Moulding Machine
installed in the polymer processing workshop at YTEC

Technology Transfer

The Fulmer Industry Education Project

The project originated from our concern for the quality of students entering the engineering profession, the poor image of the engineer and the need to recruit able arts and science students into manufacturing industry. In recognition of our work in this field over the last five years, the Department of Industry provided us with a grant to substantiate our approach to industry-education links.

Six secondary schools in Buckinghamshire and Berkshire reflecting different facets of the education system were selected to take part in the first phase of the work, whose aims were: to demonstrate ways of encouraging school children to become interested in engineering subjects and to develop interests in manufacturing industry through school and company activities, further to influence the attitudes of teachers towards industry, and finally to assist industry to explain its needs to children.

An important ingredient of the project is to give students between the ages of 13 and 18 the opportunity to experience at first hand the world of technologists and engineers. In the classroom this is achieved through highly participative and interactive workshops and seminars. During the 'Technology is Fun' workshop children are introduced to the qualities and skills needed by technologists through examples taken from the world around them; for example by the use of items from a kitchen children are introduced to the 'open ended' nature of technological problems and the necessity for the engineer to be inquisitive, creative and good with people in addition to his technical knowledge.

In a second seminar 'Design the Missing Link' students consider why things look like they do and by practical problems explore the relationship between technology, costs and the market. A third seminar 'School Project - Industry Product' introduces students studying 'O' and 'A' level Design Technology and Nuffield Science courses to a sound methodology and approach to project work in the school and the parallel activities seen in the development of a manufactured product.

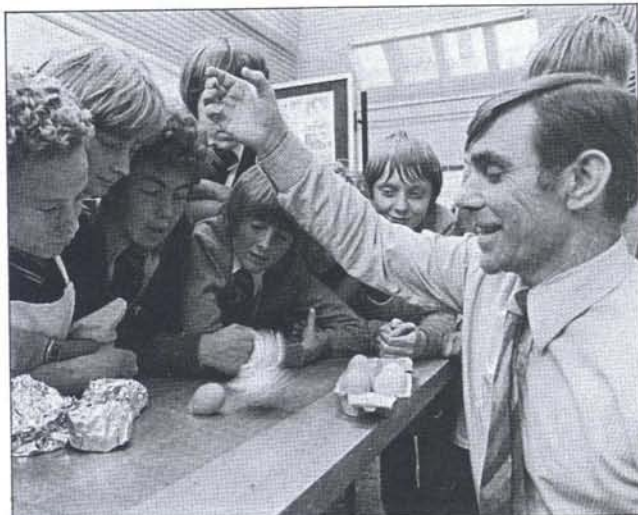
Through the medium of projects obtained from industry, teachers and students are encouraged to use industry as a 'textbook' for the enrichment of traditional curriculum subjects.

New Facilities for Pharmaceutical Intermediates

The 200-litre multipurpose reactor unit for producing fine chemicals used as intermediates in the manufacture of drugs, agricultural chemicals, pesticides, etc, is now fully operational. In addition, the Laboratories' capacity for producing fluorinated aromatic compounds, some of which can be used to produce high temperature polymers, has been trebled.

Many of these fine chemicals are no longer made by the bulk producers because the technology is too demanding for the output required. Yarsley have thus seen the opportunity to meet a world wide need for these chemicals in quantities varying from a few grams to several tons per annum.

Novel processes have been developed which give products with a high degree of purity in high yield. European interest in the Yarsley facilities is



Students testing the design for a packaging material to be used with eggs.



Exploring the Bernoulli principle in the 'Technology is Fun' Workshop

Photographs by courtesy of the Evening Mail

high. A Chinese delegation has visited the plant and enquiries and orders are being received also from North America and Japan.

Market Surveys

Confidential technical and market surveys carried out during the year include: snow clearance systems; rubber-coated fabrics; coatings for non-flammable building materials; rubber-modified polyolefins; applications of carbon fibres in Europe; speciality plasticizers in Europe.

The CURRENT AWARENESS SURVEYS recently started by Yarsley Research Laboratories now serve clients world wide. Amongst the subjects currently covered are engineering plastics, foamed and expanded plastics and adhesives, and functional polymers.

Fulmer**Research
Institute****Fulmer****Research
Laboratories****Fulmer****Technical
Services****Fulmer****Components
Limited****Yarsley****Research
Laboratories****Yarsley****Technical
Centre****Fulmer Research Institute Ltd.**

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Tel: Fulmer 2181: Telex: 849374

This is the holding company of the five main operating divisions. Our activities involve all engineering materials, including metals, plastics, polymers, ceramics, fibres, composites, refractories, glasses and adhesives. The development of new and improved products and components is undertaken, often leading to turnkey projects for the establishment of manufacturing operations. Other projects range from the development of new materials and new ways of processing materials to the evaluation of properties of materials under real or simulated service conditions, using existing or specially developed testing techniques.

Fulmer Research Laboratories Ltd.

Dr. W. E. Duckworth,
Stoke Poges, Slough, SL2 4QD
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The facilities and expertise cover all aspects of research, development and evaluation of metals and advanced engineering materials, the structures and components manufactured from them, and the processes used.

Fulmer Technical Services

Dr. W. E. Duckworth,
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Tel: Fulmer 2181: Telex: 849374

This provides a testing and consultancy service on all aspects of the use of engineering materials, particularly metals and advanced composites. The services include mechanical testing, chemical analysis, microstructural studies, surface analysis, corrosion testing, failure diagnosis and trouble shooting, materials information and selection, physical property assessment, litigation, technical management services.

Fulmer Components Ltd.

(including REFORM MANUFACTURING)

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Slough, Berks, SL1 4QT
Tel: Slough 35996: Telex: 849374

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