

# Fulmer

A large, industrial-looking projector or light fixture. It has a prominent red and black frame with vertical slats. A large, circular lens is visible on the right side. The background is a dark, solid color.

review  
1984



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# CHAIRMAN'S FOREWORD

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Once again Fulmer has notched up a record year in financial terms. Group income reached £4.743M, an increase of 15% over the previous year. Profit, after allowing for all contingencies, was also a new record at £370,000.

It is especially pleasing, when unemployment among skilled technical staff is still so high, to report a further increase in staff numbers to 269.

Substantial progress was made in many of the rapidly growing areas of technology with which Fulmer is strongly identified. In sensor technology a range of PVdF based ultrasonic transducers has been developed which show many superior characteristics over the conventional ceramic based product. Focused and planar transducers with active areas from 5mm to 25mm diameter have been produced with a very broad band response. They also allow single pulse operation and hence improved resolution. The first applications for these transducers will be in the NDT and medical fields.

Using one of these probes a new type of scanning acoustic microscope has been developed for ultrasonic inspection to a resolution not available from conventional equipment. Our microscope produces full colour magnified images of internal features in solids of many types and is also capable of characterising diffusion bonds and material variation in such diverse materials as composites and engineering ceramics. The system was featured on BBC Television "Tomorrow's World" programme during the year.

A registration system for quality assured firms, YQAF, has been established by Yarsley Technical Centre in the building and construction industry. Under this scheme Yarsley audit a firm's quality management system against the national standard BS 5750.

The magnetic tape abrasivity monitor is now becoming accepted as standard equipment by many tape users and manufacturers. Its derivative, the fluid abrasivity monitor, is approaching commercial status.

One of the major technological achievements of the year was the successful completion of the development and manufacture of the first uranium target module for the SERC Spallation Neutron Source at the Rutherford Appleton Laboratory. This enabled them to produce their first neutrons on Sunday, 16th December and demonstrate that the United Kingdom now has the most powerful neutron source for condensed matter research, including examining the basic structure of engineering materials.

The MIDAS semi-solid casting process has moved closer to commercial operation. The range of aluminium alloys which can be cast with suitable structures has been extended. It has been shown that components can be injection cast and heat treated without impairment of surface appearance.

The first Vacuum Generator's Superhipper designed by Fulmer has been installed at RSRE, Malvern.

The Yarsley Technical Centre has developed for Martin Roberts Ltd. a range of pressed metal doors and door frames of radical new design that allow rapid and controlled expansion of the door leaf so that it seals itself within the frame, thereby preventing the spread of fire. These "Guardian" doors are the first ever single point latching door sets to be granted Fire Officers' Committee approval and have recently been further recognised with a 1985 Building Innovation Award.

Exports rose by 10% during the year to £600,000, being particularly strong in USA, Europe and Southern Africa. Fulmer skills in technology transfer were recognised by a contract to develop a TT laboratory in Syria.

The Singapore operation, now concentrating entirely on metallurgical services, has moved closer to commercial viability.

All commercial organisations, especially ones like Fulmer, depend upon the loyalty and dedication of our staff, which I am always most happy to acknowledge. It is pleasing to report that in 1984 their quality was recognised by two significant awards to one member of staff; the Gold Award in the Metaserv metallography competition and the essay prize of the Institution of Mechanical Engineers/Esso Tribology Award.



Sir Ieuan Maddock

**Frontispiece:** The front cover illustrates the complexity of the uranium target module produced for the SERC Spallation Neutron Source at Rutherford Appleton Laboratory. The target contains 23 uranium discs encapsulated in zircalloy-2. Hot isostatic pressing was used to produce a diffusion bond between the uranium and the zircalloy-2. The target module was constructed using electron beam welding to give an assembly with minimum distortion.

The successful completion of the manufacture of this target using the most advanced metal bonding techniques illustrates Fulmer's capability in this field.



# FACTS ON FULMER

**F**ulmer Research Institute is an independent contract research, design and development organisation mainly concerned with the science and technology of engineering materials, processes for their manufacture, and products and components making the optimum use of material properties. Current projects include:

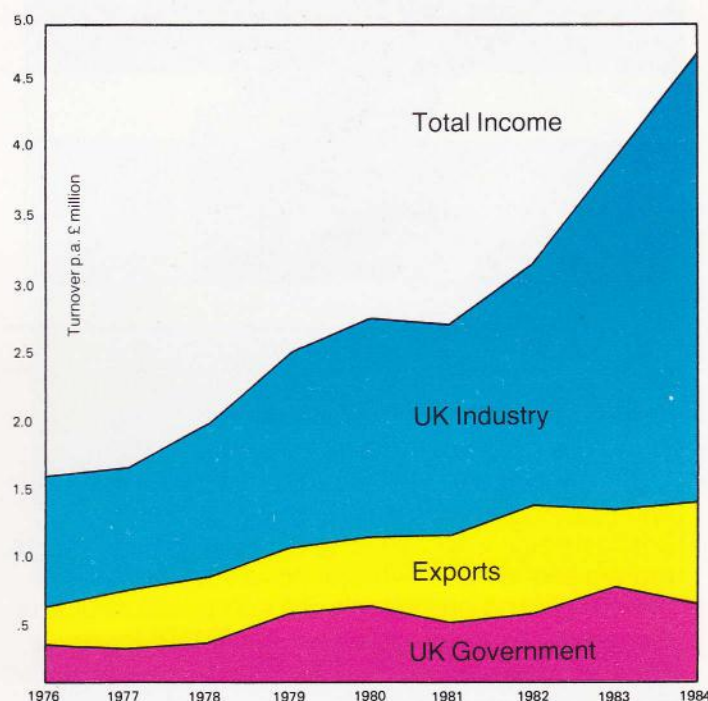
- Evaluation of markets for established metals and for novel materials such as engineering ceramics.
- The development of new materials such as high strength, tough, wear resistant steels for arduous applications in deep mines.
- New magnetic alloys for the electronics industry.
- Tailored polymers for critical applications in health care.
- Devices incorporating new materials such as PVdF transducers and low voltage field emission cathodes for a wide range of industrial applications.
- The development of new material shaping processes particularly for the motor, food and packaging industries.
- The application of robotics and automation, particularly in storage and sorting applications.
- Novel energy conversion and storage systems.
- New types of coating and their means of application.
- The development, testing and certification of building materials for internal and external use.
- The manufacture of special chemical compounds and components.

In this review 1984 achievements in our main areas of activity are described and illustrate how Fulmer can assist clients throughout all stages of the development and manufacturing process.

Consultancy and Technical Services assignments include a full quality assurance and design audit service, novel non-destructive testing technology, materials selection, failure diagnosis, as well as routine testing and analytical services. Technical advice is available relating, for example, to patent and other forms of litigation, technical/economic studies and market surveys.

Fulmer was founded in 1946, and since 1965 has been owned by the Institute of Physics. The Company and its subsidiaries employ 270 people, including 110 professionally qualified scientists, technologists, and engineers. Fulmer is fully self-supporting financially and the operating surplus is used to finance further development. Ownership by the Institute of Physics guarantees that Fulmer is completely independent of any commercial or industrial affiliation. The main proportion of Fulmer's income comes from U.K. industry. Exports accounted for about 14% of the 1984 income of £4.74M, and contracts from Government sources approximately 16%.

**Fulmer Income Distribution 1976 – 1984**



## GROUP TRADING REPORT

Fulmer Research Laboratories.  
(including Fulmer Technical Services)  
Yarsley Technical Centre Ltd.  
Fulmer Components Ltd.  
Reform Manufacturing Co. Ltd.  
Fulmer Singapore  
GROUP TOTAL (less Inter-Company trading  
and minority interests)

Turnover, £		Profit (Loss), £	
1983	1984	1983	1984
2,150,000	2,620,000	184,500	298,500
1,763,000	1,883,000	230,500	99,500
335,000	343,000	12,000	2,000
25,000	29,500	(8,000)	(5,500)
46,500	72,000	(63,500)	(29,500)
4,111,500	4,743,500	349,000	370,000



# NEW MATERIALS AND PROCESSES

In February 1985 the UK Government published a report entitled "A Programme for the Wider Application of New and Improved Materials and Processes" (NIMP). This report contained the findings of a Department of Trade and Industry Committee which had met under the chairmanship of Mr. John Collyear of Associated Engineering. The report pointed out that new materials and processes were essential to the development of advanced industrial products. It also pointed out that the lead time for the introduction of these new materials and processes into industry could be very long.

From its foundation in 1946 much of Fulmer's activities have been devoted to NIMP and the major past successes, ranging from new alloys for land and air transport to new polymers for health care application, have been described in previous Annual Reviews. Among the materials highlighted for study in the Collyear Committee Report were composites, engineering ceramics, electronic materials and surface coatings. The major processing technologies recommended were near net shape forming and new joining methods. Fulmer is at the forefront of many of the programmes recommended, as the advances made in 1984 will demonstrate.



*A prototype bearingless main rotor element*

## COMPOSITES

The most advanced composites being developed are those based on carbon, Kevlar and glass fibre with thermosetting and thermoplastic resin matrices. Fulmer has applied these materials to spacecraft, aircraft, ships, cranes and armour. A major advance in 1984 was the design and production of a composite structure for use in a bearingless main rotor (BMR) for a helicopter. Advanced analytical methods were used to specify the design of the composite material to meet the exacting dynamic requirements of a BMR which connects the helicopter rotor blades to the driveshaft and allows the pitch of the blades to be altered.

The trial element illustrated above was made and tested at Fulmer. Mechanical test results were in very close agreement with predicted values.

While thermosetting resins have been the preferred matrix materials to date, increasing interest for automotive and general engineering applications has been shown in the inherently tougher thermoplastic resins.

## ENGINEERING CERAMICS

Using chemical vapour deposition technology, of which Fulmer was an early pioneer, many engineering ceramics such as silicon nitride and silicon carbide can be produced in either solid or coating form. Fulmer has shown in previous work how a CVD process can be used as the final stage of the manufacture of engineering components to seal up residual surface porosity and close defects which otherwise could be dangerous crack initiators.

The major emphasis during 1984 has, however, been the continuing development of a range of components in boron nitride. This is an important material used in equipment for producing low dimensional structures by molecular beam epitaxy, a technique which is gaining increasing importance in fabricating electronic devices. Boron nitride crucibles are also used for crystal pulling in gallium arsenide, which is becoming increasingly recognised as a possible intermediate successor to the ubiquitous silicon chip. The range of shapes available as standard items from Fulmer is illustrated below. A move onto a new factory site dedicated to the manufacture of boron nitride is now underway.



*A range of boron nitride shapes*



# NEW MATERIALS AND PROCESSES

## NEW ELECTRONIC MATERIALS

One of the major requirements for new electronic materials is in sensor applications with the increasing emphasis on quality assurance, condition monitoring, continuous process control and non-destructive testing. Polyvinylidene fluoride (PVdF) with its piezo and pyroelectric properties has a potential use in all of the above fields. In 1983 Fulmer overcame one of the major previous obstacles to its widespread use by installing at Yarsley Technical Centre a process for the continuous production of consistent high quality film.

In 1984 the second major obstacle has been overcome, that of the attachment to, and incorporation of, the film into useful devices. Using this newly established technology under contract from Cogent Limited, for the protection of whose property rights patents are now being applied for, a range of ultrasonic transducers has now been produced. The features of these transducers are indicated below together with an illustration of the many types now available.

**Broadband Frequency Response.** Unlike conventional piezoelectric materials, polymer films have a very broadband frequency response. Single cycle pulses can therefore be produced which provide improved resolution for non-destructive testing and thickness gauging.

**Acoustic Impedance.** The acoustic impedance of polymer films is much lower than that of ceramics, and is close to that of water. This better match results in improved coupling with a water medium, and therefore greater energy transfer.

**Uniformity.** The continuous production techniques used to manufacture polymer films results in greatly improved transducer uniformity.

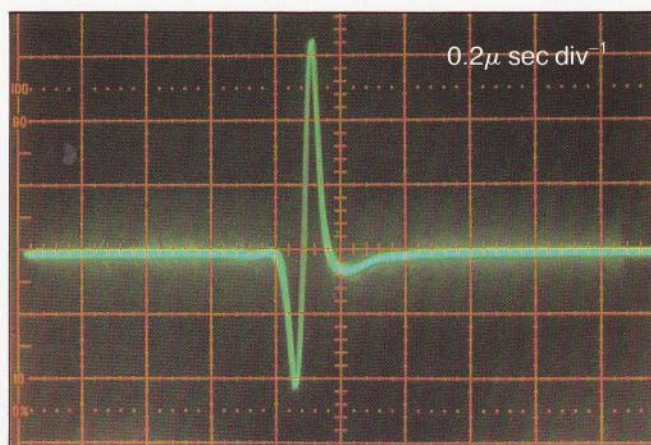
**Large Area.** The ability to produce polymer films in sheet form enables much larger transducers to be manufactured than presently possible using conventional materials.

**Selective Activation.** Complex arrays of transducers can be formed and independently addressed on a single sheet of film.

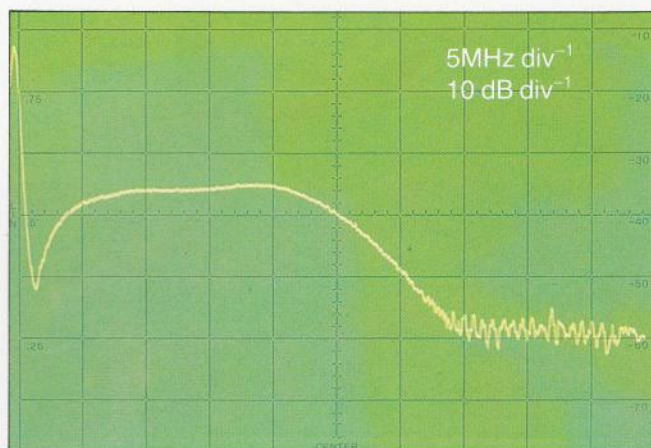
**Stacking Capacity.** Multiple-layer stacking of polymer films can be used to increase the power output and receiving sensitivity of the transducer.



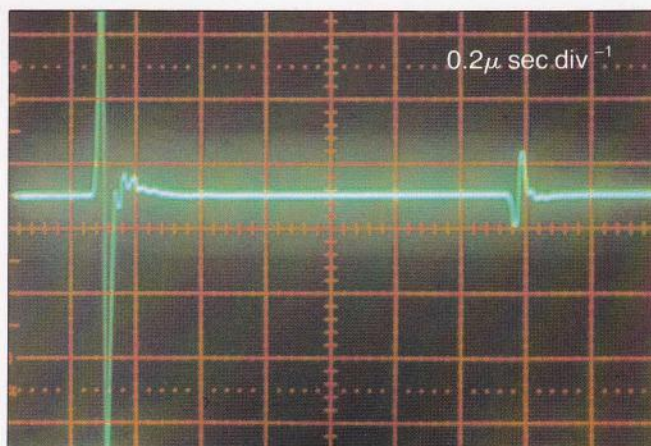
The range of PVdF transducers now available



Single Cycle Pulse Shape 1" planar transducer



Broad Frequency bandwidth 1/2" focussed transducer



Thickness gauging 3 mm Zircalloy 1/4" planar transducer showing the accuracy achieved by single cycle pulses



# PROCESS AND PRODUCT DEVELOPMENT

## SEMI-SOLID METAL FORMING

**T**he MIDAS (Metal Injection into Dies as Semi-solid) process made further advances in 1984.

This process illustrates one of the other recommendations of the Collyear Report, the need for more advanced technology in traditional industries and especially for the development of near net shaping operations which reduce the expense of traditional casting, forging and machining. In mature industries new product innovation tends to be slow because of the conservatism of established markets. Hence the major technological advances must be concentrated on reducing product cost to maintain competitive advantage.

The MIDAS process, although originally conceived as an improved diecasting operation, will undoubtedly demonstrate its potential, initially, as a replacement for forging and gravity die-casting of light alloy components. This is because the metal injection operation produces non-porous products which can be heat treated without blistering. This is not possible with conventionally diecast metal. The illustration below shows bicycle cranks normally produced in forged material which have been made by MIDAS at a cost substantially less than that in the conventional forging route.

During the year the range of alloys conventionally cast into bar stock for the MIDAS process has also been extended and the speed of the continuous casting process itself improved.



*Bicycle cranks made by MIDAS*

As well as producing new materials and processes for general product development in industry, Fulmer is engaged in helping companies develop specific new products using existing technology and also in developing its own range of products for manufacture and sale. Being at the sharp end of its own development, therefore, Fulmer increases its credibility toward assisting clients with their own project.

Two such activities during the year were the development for Martin Roberts Limited of a new design of fire door and further advancement of the Fulmer wear debris monitor.



*The Guardian fire door. Courtesy Martin Roberts Ltd.*

## "GUARDIAN" FIRE DOORS

**M**artin Roberts Limited collaborated with Yarsley Technical Centre to produce the first ever single point latching door sets to be granted FOC (Fire Officers' Committee) approval. They have also received the 1985 Building Innovation Award. The radical new design of pressed metal doors and door frames allows rapid and controlled expansion of the door leaf so that it seals itself within the frame, thereby preventing the spread of fire. The design was based upon the requirement that the door set should not rot, warp or twist, it should have a high degree of security, provide good aesthetic appeal and meet with major worldwide authorities' requirements for fire resistance up to four hours.

Following production of the door sets the product was evaluated and passed by Yarsley to BS 476, Part 8 "Fire Resistance Test". The product is now achieving worldwide sales.

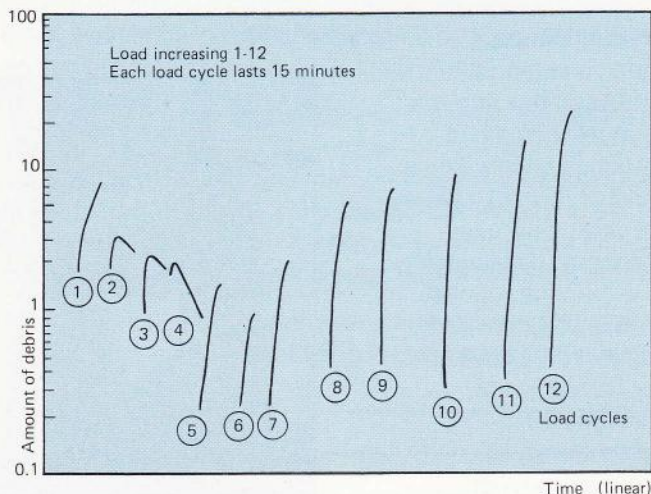


# PROCESS AND PRODUCT DEVELOPMENT

## WEAR DEBRIS MONITOR

**T**his equipment has been developed for detecting small quantities of fine particles in fluids. The sensor consists of a thin metallic film. When fluid is directed onto it the film is abraded by the particulate material and its electrical resistance increases. The rate of increase of resistance, which is related to particle concentration and characteristics, is computed in a microprocessor unit. The monitor has been used successfully to indicate the end of the running-in stage of gear teeth during a standard FZG test.

The diagram below shows how the rate of change of resistance is altered during twelve stages of increasing load on gear teeth. By stage 4 the amount of debris being generated has decreased substantially, indicating the end of the running-in phase. With further increases in load from stages 5 to 12 the amount of wear debris generated during each load cycle of 15 minutes duration shows a progressive increase indicative of increase in wear.



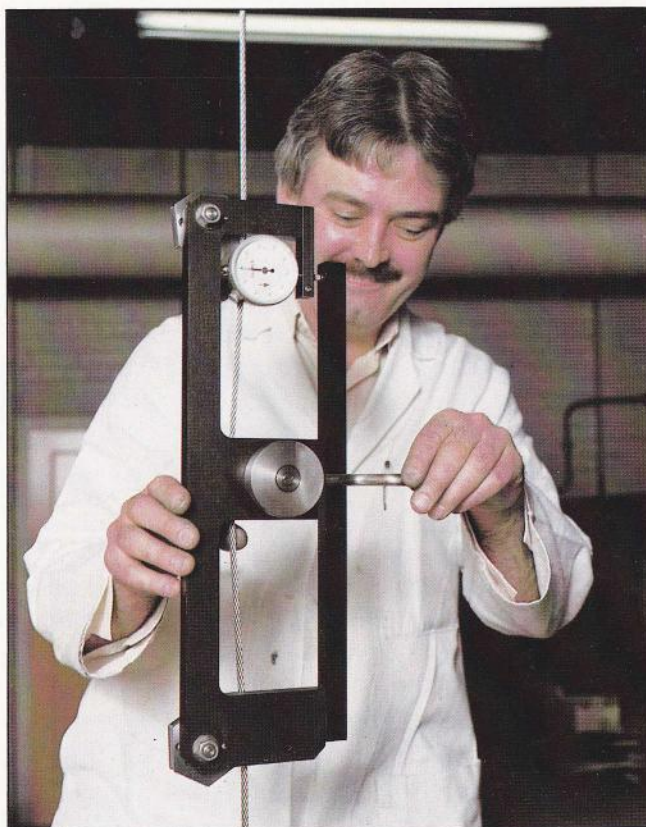
FZG Test. Courtesy of Ethyl Petroleum Additives Ltd.

## POLYMER PROCESSING FACILITIES

Yarsley's facilities have been expanded by the addition of a Battenfeld BSKM 800/220S CNC injection moulding machine, which provides an improved capability for pre-production mould proving trials, prototype mould development and short run production. In 1984 the Battenfeld was used on a variety of projects, ranging from explosive containers, incubator components and new toiletry products to engine components and specialised laboratory equipment. Precision work undertaken for trade moulders is particularly facilitated as a closed loop control system provides control over all injection unit and clamp unit parameters and enables a continuous simulation of the operating conditions to be found in the moulder's own processing environment.

## ROPE TENSION METER

**T**his instrument, illustrated below, enables the tension in a wire, rope, or stay to be measured in situ. The meter frame is clipped into position along the line whose tension is to be measured, the line is then deflected by a rotating cam and the tension determined by the deflection of the tension meter beam, as shown. This meter is now standard equipment for the tensioning of radio masts, lift cables, etc. and is available from Fulmer Components Limited, whose other standard items include a magnetic tape monitor, delay units for computers and accessories for electron microscopes.



The Rope Tension Meter



The Battenfeld BSKM 800/220S CNC injection moulding machine.



# TECHNICAL CONSULTANCY

**T**echnical Consultancy on product development and improvement is forming an increasingly important part of Fulmer's business. The capacity to provide an integrated multidisciplinary approach which includes mathematical analysis, materials selection and design, prototype manufacture and testing, places Fulmer in a unique market position among consultancies.

Typical technological consultancy projects in 1984 have included:

- Failure analysis of a coin dispenser in an automatic vending machine
- Materials selection and design for RF insulators
- Materials selection for novel automotive water pumps
- Loft ladder design optimisation
- Materials selection and design for battery cells
- Analysis of thermal breaks in double glazing systems

## Fatigue Failure of Coin Payout Unit

A supplier of a coin payout unit was experiencing premature failures of a solenoid plunger which formed part of the mechanism. The solenoid operated a bell-crank which in turn acted on a spring-loaded slider. Metallurgical investigations and a fracture mechanics analysis indicated a largely tensile fatigue failure mechanism and a stress fracture of  $\approx 360\text{MPa}$ . Loadings on the plunger were analysed, and it was concluded that the only means by which this stress could occur was by the impact of the solenoid on its stop following energisation. The compressive impact stress wave was reflecting at the section changes in the plunger resulting in a complex stress pattern containing high tensile peaks. Modifications to this plunger geometry, which would reduce these tensile stresses, were suggested, although a more-favoured solution was to reduce the severity of the initial impact by means of a compliant element between the plunger and stop.

## Materials Selection for Design of RF Insulators

A manufacturer of equipment for radio towers and masts identified the need for a novel design in base insulators. The insulators should be capable of withstanding high compressive loads and high tensile loads (from bending) whilst insulating against specified voltages at radio frequencies. A 20 year lifespan with minimum maintenance was required.

A brainstorming approach was used to produce a series of novel design and materials choice possibilities and the customer participated at this stage.

Fulmer evaluated all the possibilities and a novel design, which, in principle, meets all the requirements of the specification was produced. The design involves some changes in materials used but the ceramic insulating block is retained.

## Automotive Water Pump

A customer needed to uprate an automotive water pump whilst achieving reductions in component and assembly costs. The customer approached Fulmer with a conceptual design and requested a programme to explore materials and detailed design options for the new concept.

The Fulmer team recommended a novel combination of materials to meet the technical and economic requirements. They made further design recommendations to reduce the number of components in the pump and simplify manufacture.

## Ladder Design Optimisation

A manufacturer of domestic aluminium loft and extension ladders approached Fulmer with a requirement to optimise the design of ladders so that they met relevant performance and safety standards whilst minimising the cost in terms of section area and thickness.

Fulmer carried out a theoretical design analysis using Strength of Materials formulae and mathematical modelling techniques, and produced a series of short computer programmes enabling the manufacturer to evaluate stress and deflection values for specified ladder designs, or alternatively to optimise section dimensions for a given stress and deflection.



Loft ladder

## Battery Cells

Sealing and insulation problems sometimes exist at the joint between the cell cap and can on high quality nickel cadmium batteries.

A customer commissioned Fulmer to explore the possible changes in design or materials choice which would alleviate the problem.

After evaluation of the alternatives the Fulmer team recommended that either design changes or changes in the choice of materials could be used to solve the problem.



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# TECHNICAL CONSULTANCY

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## Thermal Efficiency of Window Frames

Fulmer were approached by a manufacturer of double glazed window units. His requirement was to optimise the thermal performance of the window frame, particularly in respect of the geometry of the frame sections and the location of the insulating thermal break.

Using a CRAY super-computer, Fulmer carried out a finite element analysis of the heat flow through the manufacturer's current design of frame, giving a map of isotherms for various ambient conditions. The overall 'U' value of the frame was also calculated. A number of modifications to the geometry, location and material of the thermal break were investigated on the computer, and the result was a series of design recommendations for improving the U value substantially, whilst retaining mechanical integrity and architectural styling.



*Double glazed windows*

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## QUALITY ASSURANCE AND PRODUCT CERTIFICATION

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**C**onfidence in the reliability and commitment of a firm to produce "fit for purpose" goods and services is important to the specifier and vital to the supplier if his services or products are to be selected. Until recently, and despite Government interest, (as evidenced by the 1982 White Paper on "Standards, Quality and International Competitiveness") the usual commercial demonstration of an effective quality manufacturing system has been a company's product reliability record, a "catch 22" situation for many suppliers. There is a growing interest in many industries in the establishment of a register of firms that have a proven capability to manufacture their products to an agreed standard.

In 1984 Yarsley Technical Centre has taken the initiative in relation to the building industry by the establishment of a Yarsley Quality Assured Firms Scheme, which has the financial support of the Department of Trade and Industry. Called YQAF (Yarsley Quality Assured Firms) the scheme consists of the assessment of the applicant firm against the appropriate part of BS 5750, Quality Systems, and the relevant technical supplement. A certificate of registration is issued to the firm on completion of a successful assessment. Periodic surveillance visits are undertaken by Yarsley to ensure that the quality assurance system is being maintained and implemented.

Assignments in 1984 have been carried out across a wide range of industry, including a major chemical company, a die casting and injection moulding organisation and a manufacturer of control instrumentation.

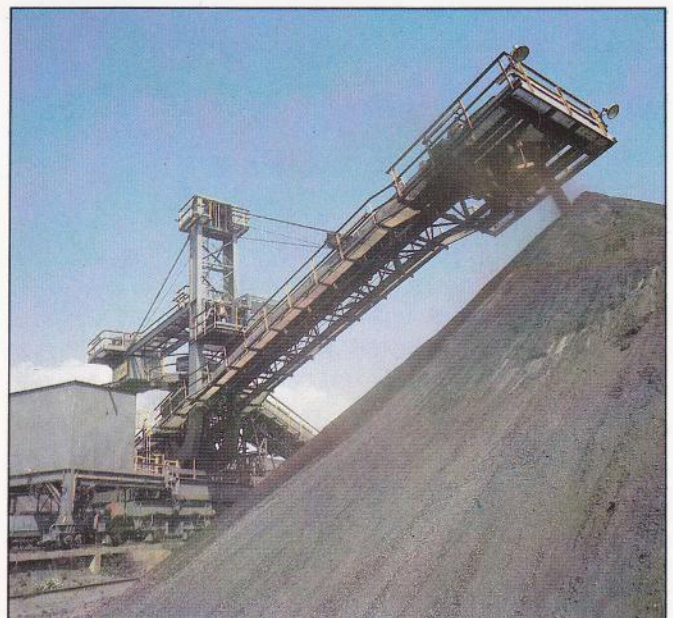
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## DESIGN AUDIT

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**D**esign Audits have been undertaken by the Yarsley Quality Assurance Department, providing a comprehensive engineering consultancy for management organisations in the U.K. and overseas. Headed by the Q.A. Department, over 20 professional Yarsley staff, technical specialists and practical engineers, are on call to make a team approach to each contract. Specialisms within the group range from Design Engineering to Materials Technology and Control Engineering.

Starting in 1984, the department has already carried out successful audits for a number of clients, including the design assessment of material handling/loading equipment at an international airport and other materials handling plant where criteria for the prevention of continuing failure were identified; and the evaluation of a consumer product packaging machine where recommendations were made to facilitate future mass production and sub-contracting.



*Boom stacker – a critical part of a bulk materials handling plant.*



# MATERIALS AND PRODUCT TESTING

**B**oth Fulmer Technical Services and Yarsley Technical Centre are listed in the NATLAS Directory of Testing Laboratories, registration numbers 0050 and 0036 respectively. Yarsley is also fully approved by a number of other agencies, including the British Calibration Service and the Civil Aviation Authority.

Both laboratories specialise in standard and non-standard testing of all types of engineering materials and the products and components manufactured from them. A wide range of facilities is available for mechanical testing, chemical analysis, wear and corrosion testing, fire testing, and determination of thermal conductivity properties. Testing can be carried out under conditions of controlled humidity and temperatures, and special test rigs are built for reproducing in-service conditions. Investigation of material and product failure problems are undertaken together with general technical consultancy. These facilities are continually being increased and extended, often by the use of special equipment designed and constructed in our own workshops.

## THERMAL CONDUCTIVITY

Of particular note during the year was the production of a small guarded hot plate apparatus for the measurement of the thermal conductivity of liquids. Available for manufacture to customers' requirements or for in-house testing, the apparatus is a 130 mm diameter single sided, double guarded hotplate, conforming to the latest revision of BS 874 (which is currently being circulated for comment). It is suitable for measurement of any non-hazardous liquids or polymer melts at mean temperatures between  $-10$  and  $+150^{\circ}\text{C}$  and is typically used for the measurement of the heat transfer properties of liquids such as oils used in cooling systems and for waxes.



Guarded Hot Plate liquid cell

## ON-SITE TESTING

As well as its in-house facilities, Fulmer also offers an on-site service where it is more convenient to move equipment or expertise to the product to be examined. On site metallography has been a feature of this service for many years and has been particularly advantageous in obviating what would otherwise be expensive shut downs on industrial sites such as oil refineries.

The Yarsley Technical Centre specialises in the investigation of building defects, particularly in modern structures such as those with a large glass-covered area. Water penetration of windows is always a particular problem in these structures and laboratory tests are generally performed in accordance with BS 5368 1980, Part 2 "Watertightness Tests under Static Pressure". Water is applied to the surface by water sprays at a regulated distance and rate and with the application of simulated wind gusts and rain sprays at various degrees of pressure. Approved adaptations of this laboratory test are undertaken to facilitate on-site testing and the photograph below shows the Yarsley staff inspecting the concrete and windows of a five storey structure prior to such weather and watertightness tests.



Window Testing on site

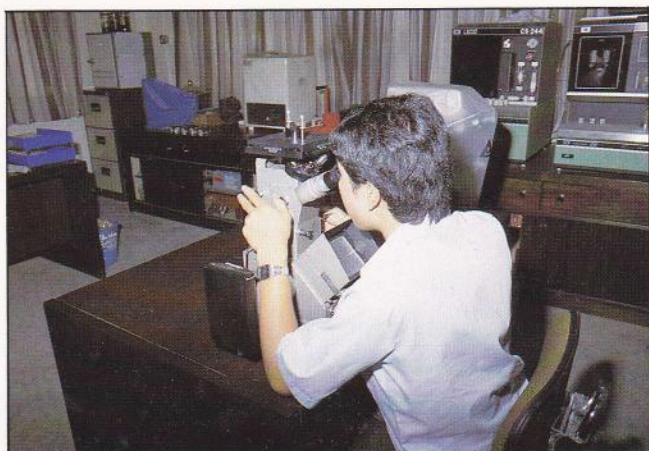


# FULMER RESEARCH AND DEVELOPMENT (SINGAPORE)

**1**984 was a year of significant progress for Fulmer Singapore, despite the fact that it was necessary to close down the company's Polymer Engineering Division, to enable resources to be concentrated on the development of the metallurgical activities. Income from metallurgical testing and consultancy increased by over 300% with an expanding client base.

## Laboratory Testing

Tensile, compression and U-bend tests up to 600 kN  
Charpy Impact Test to 300J  
Hardness Measurements: Vickers, Brinell & Rockwell  
Chemical Analysis  
Welding Procedure Tests  
Welder's Qualification Tests



*A view of the Singapore Laboratory*

## Metallurgical Consultancy

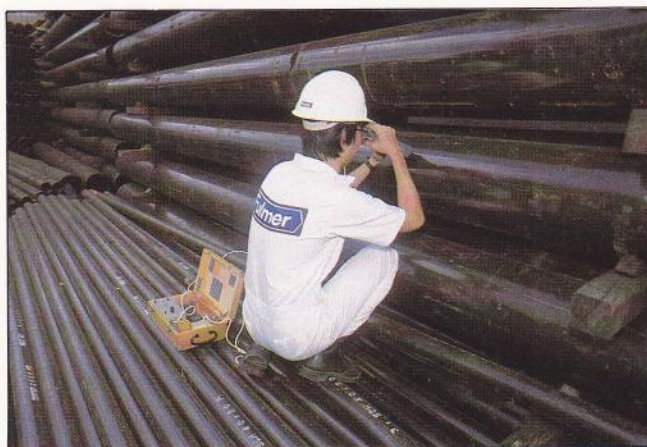
Failure Investigation  
Materials Evaluation  
Materials Selection



*Jeffrey Jee, Michael Tang, Dr. Peter Loh, Zania Amat, Rowena Lee and William Chew.*

An agreement was reached with the Singapore subsidiary of the Dutch Company Van Leeuwen Pipe and Tube Ltd. to sub-let premises in the industrial area of Jurong. This has allowed a substantial increase in the range of facilities that can be offered to our clients in South East Asia.

## On-site Testing & Investigation



*In situ chemical analysis of steel pipes*

In-situ Metallography  
Metal Identification  
Independent Third Party Inspection



*Staff leaving for on site assignment*

FRDS is backed-up by the extensive expertise available from Fulmer U.K., and staff are seconded as necessary. With the emphasis on the development of skills-based industries in Singapore and the other ASEAN countries, the demand for the highly professional services being provided by FRDS will continue to increase. The company will be expanded to meet these demands, both in terms of facilities and staff with the necessary skills and expertise.



Fulmer Research Institute Limited is the holding company of the four main operating divisions in the United Kingdom and the part-owned Singapore and Southern African companies. Fulmer was founded in 1946, and since 1965 has been owned by the Institute of Physics. The Company and its subsidiaries employ 270 people, including 110 professionally qualified scientists, technologists and engineers. Fulmer is fully self-supporting financially and the operating surplus is used to finance further development. Ownership by the Institute of Physics guarantees that Fulmer is completely independent of any commercial or industrial affiliation.

### Fulmer Research Laboratories

Dr. W.E. Duckworth  
Stoke Poges, Slough, SL2 4QD  
Tel: Fulmer (02816) 2181 Telex: 849374

The facilities and expertise cover all aspects of research, development and evaluation of metals and advanced engineering materials, including composites, the structures and components manufactured from them, and the processes used. Advanced facilities include chemical vapour deposition equipment for special ceramic coatings and components; comprehensive X-ray and electron microscopic investigation equipment; novel non-destructive testing methods; ballistic facilities; radiation testing; advanced metal processing plant and production engineering expertise, including robotics and automation. Prototype equipment manufacture is undertaken as are energy studies and other types of technological surveys. Technology training is provided.

### Yarsley Technical Centre

M.A.P. Dewey  
Trowers Way, Redhill, Surrey, RH1 2JN  
Tel: Redhill (0737) 65070  
Telex: 8951511

The Street, Ashted, Surrey, KT21 2AB  
Tel: Ashted (03722) 76391  
Telex: 8951511

The facilities and expertise cover all aspects of the development and evaluation of non-metallic materials, and products and components which use plastics, rubbers, composites, paints, adhesives, timber, thermal insulating materials, floor coverings, building materials. Particular expertise exists in "tailored" polymer technology, including polymer design and synthesis, coatings, film technology and composite materials. Small scale manufacture of special polymers and organofluorine compounds is also undertaken. Special test facilities include fire testing, pollution monitoring, mechanical and chemical testing, thermal conductivity testing. Materials test equipment and special processing machinery are also designed, developed and manufactured.

### Fulmer Technical Services

Dr. W.H. Bowyer  
Stoke Poges, Slough, SL2 4QD  
Tel: Fulmer (02816) 2181 Telex: 849374

Testing and consultancy on all aspects of advanced engineering materials, particularly metals and advanced composites. The services include mechanical and non-destructive testing, chemical analysis, corrosion testing, failure diagnosis and trouble shooting, materials information and selection, physical property assessment, litigation, and technical management services.

### Fulmer Components Limited

Dr. G.I. Williams  
227 Berwick Avenue, Trading Estate, Slough, Berks. SL1 4QT  
Tel: Slough 35996 Telex: 849374

Product manufacture including abrasivity monitors, special sensor systems, pyrolytic boron nitride in the form of crucibles, tubes and coatings for crystal growth of ultra high-purity semiconductors, and plates for heat transfer in travelling wave tubes; delay units for computers. High precision engineering items such as specimen stages for electron microscopy and filament repair service. Small batch production of engineering items such as automatic paint spray unit and 'clip-on' meter for measuring tension in ropes and stays.

### Fulmer RESEARCH & DEVELOPMENT (SINGAPORE)

Dr. Y. Kam  
Fulmer R & D (Singapore) Pte Ltd  
Unit 06-01, 6th Storey,  
520 Balestier Road, Singapore, 1232.  
Tel: 250 1082 Telex: 23988 Kampmas

M.A.P. Dewey  
Fulmer Research Institute Ltd,  
Stoke Poges, Slough, SL2 4QD  
Tel: Fulmer (02816) 2181  
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Provides a service on engineering metallurgy, including failure investigation, corrosion protection consultancy, and process development. Materials testing and analysis of metals and polymers. Materials and machinery selection studies.

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