ROYAL
ACADEMY OF
ENGINEERING

50 years of the **MacRobert Award** for UK engineering innovation

ROYAL ACADEMY OF ENGINEERING
MACROBERT AWARD
50th ANNIVERSARY

50 years of the **MacRobert Award** for UK engineering innovation 1969 to 2019

With thanks to The MacRobert Trust

Royal Academy of Engineering
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www.raeng.org.uk

↓A FINAL INSPECTION IS MADE OF THE MACROBERT MEDAL, WHICH IS CAST AT THE ROYAL MINT

CONTENTS

HRH The Duke of Edinburgh with representatives from the two winning teams of the first MacRobert Award.

THE MACROBERT AWARD

First presented in 1969, the MacRobert Award for UK engineering innovation is widely regarded as the most coveted in the profession, honouring the winning organisation with a gold medal and the team members with a cash prize of £50,000. Founded by The MacRobert Trust, the award is presented and run by the Royal Academy of Engineering, with support from The Worshipful Company of Engineers.

The award is unique in its celebration not only of outstanding innovation but also tangible societal benefit and demonstrable commercial success. Over the last 50 years, MacRobert Award winning innovations have changed the world, by delivering enormous societal benefit and contributing to the UK economy.

The first award in 1969 was made jointly for two iconic innovations: to Rolls-Royce for the Pegasus engine that powers the Harrier Jump Jet and to Freeman, Fox and Partners for the aerodynamic deck design of the Severn Bridge. Winners have included the engineers behind advances such as catalytic converters, the roof of the Millennium Dome, intelligent prosthetic limbs and the Raspberry Pi microcomputer.

The MacRobert Award has been fortunate to receive strong royal support since its inception. His Royal Highness The Duke of Edinburgh KG KT OM GBE, Senior Fellow of the Academy, presented the award almost every year until 2015 and HRH The Princess Royal KG KT GCVO QSO, Royal Fellow of the Academy, has presented it in recent years.

Over the last 50 years, MacRobert Award winning innovations have changed the world, by delivering enormous societal benefit and contributing to the UK economy.

LADY RACHEL WORKMAN MACROBERT

Rachel MacRobert (née Workman) was born in Worcester, Massachusetts, and initially raised in Germany. After her brother Siegfried died of pneumonia in 1893, Rachel's parents sent her to Cheltenham Ladies' College in England to complete her education.

She studied geology at Royal Holloway College, and spent a further year at the University of Edinburgh studying geology and political economy. She was the first woman to attend the Royal School of Mines. Throughout her career, she researched glacial geomorphology, petrology, and mineralogy in Scotland, Sweden and Norway. She was active in the research community and endeavoured to attend as many scientific meetings as she could, never deterred by the custom that women were not permitted to join learned societies at the time.

Rachel met her husband, Sir Alexander MacRobert, in 1909 and they married two years later. He was a businessman, 30 years her senior, who spent much of his time in India, having founded the British India Company. Together they had three children, Alasdair (1912), Roderic (1915) and Iain (1917). This did not discourage her research career, and she continued to publish her work as she raised her sons.

She became a Fellow of the Geological Society of Stockholm before becoming one of the first female Fellows elected to the Geological Society of London in 1919. Like her mother, she was a suffragette, and often attended events and meetings supporting the movement.

Notwithstanding Rachel's contributions to the study of geology and to gender equality in the geosciences, her greatest legacy is the creation of The MacRobert Trust.

A HISTORY OF THE MACROBERT AWARD

Between 1943 and 1950, Lady MacRobert set up a series of trusts to reflect the interests of her husband, and foster ideals and spirit in young people after her three sons died in aviation accidents, two within five weeks of each other during World War II. In response to these tragedies, she donated £25,000 to the RAF to fund a Stirling bomber, called *MacRobert's Reply*, and then a further £20,000 to provide four Hurricanes to the RAF, one named after each son and one in her name. The MacRobert Trust remains active today, supporting charitable causes and maintaining the MacRobert family estate in Aberdeenshire, which includes Douneside House (now a country house hotel) and Alastrean House (originally set aside by Lady MacRobert for rest and recuperation for RAF pilots, it is now run as a care home for all).

In 1967 the Board of the Trust was looking for new ways to distribute its charitable funds. Donald Heughan HonFREng, an engineer and Trustee of the MacRobert Trust, was keen for the Trust to make a significant mark. He wrote "I believe the Trustees should be searching for a project which sparks their imagination. It must surely meet the purposes of the various Trust deeds and yet, at the same time, should provide a positive sense of purpose and be of benefit to the country on a wide scale."

The MacRobert Award was established to recognise outstanding innovation and tangible societal benefit in engineering, and the Trustees later added proven commercial success as an additional judging criterion. There was no similar prize for engineering anywhere in the world, and at the time, the £25,000 award was more than the Nobel Prize. HRH The Duke of Edinburgh presented the first award at Buckingham Palace in May 1970, to teams from Rolls-Royce for the Pegasus engine and to Freeman, Fox and Partners for their design of the deck of the Severn Bridge.

In 1993, the award amount was doubled to £50,000. The Royal Academy of Engineering took over the management of the award in 1997, with support from The Worshipful Company of Engineers since 2014.

The MacRobert Award was established to recognise outstanding innovation and tangible societal benefit in engineering, and the Trustees later added proven commercial success as an additional judging criterion.

THE MACROBERT AWARD GOLD MEDAL

Around the outside of the medal Machin included a quote from Archimedes: "Give me a fulcrum and a lever long enough and I will move the world".

Designed by the artist Arnold Machin OBE, who is most famous for designing the relief of the Queen's Head used on Royal Mail stamps, the gold medal presented to winners of the award is full of symbolism.

The medal was designed shortly after one of humanity's greatest engineering feats – the Apollo 11 mission to land on the Moon. The medal shows a human figure leaping from the Earth – the figure holds callipers, symbolising the reasoning power, measurement and calculation that enables engineers to understand the physical world. Without knowledge, imaginative ideas do not work.

The design illustrates the possibility for humans to create an environment outside our own world. The sun symbolises the life force without which life as we know it is impossible.

MACROBERT AWARD WINNERS

1960s

1969
JOINT WINNERS:
Freeman, Fox and Partners
For the superstructure of the Severn Bridge

Rolls-Royce
For the Pegasus engine used in the Harrier Jump Jet aircraft

1970s

1970
British Petroleum
For techniques enabling accurate surveying through permafrost in Alaska

1971
The Gas Council
For a range of gas manufacturing processes

1972
EMI Limited
For the application of X-ray techniques for diagnosing brain disease

1973
Dunlop
For the Denovo tyre and wheel system

1974
ICI Ltd
For the development and manufacture of high-activity catalysts used in methanol production

1975
JOINT WINNERS:
Westland Helicopters
For the semi-rigid rotor system and gearing of the Lynx helicopter

British Railways Board
For developments in railway vehicle suspensions

1976
No award was made

1977
Royal Signals Research Establishment and Malvern Instruments Ltd
For the Malvern Correlator for measuring the movement of particles or molecules

1978
Pilkington Brothers Ltd
For the Triplex Ten-Twenty laminated windscreen for cars and aircraft

1979
Post Office Telecommunications
For the Prestel viewdata software system

1980s

1980
Johnson Matthey
For the development of catalytic systems for motor vehicle exhausts

1981
Lucas CAV Ltd
For the Microjector, a miniaturised fuel injector for car diesel engines

1982
BP and Kaldair Ltd
For the Indair/Mardair waste gas flare systems used on offshore platforms

1983
Ruston Gas Turbines
For the Tornado and other industrial gas turbines

1984
Netlon Ltd
For the development of high-strength polymer grids used in civil engineering

1985
JOINT WINNERS:
The National Institute of Agricultural Engineering
For forage conditioning machinery

Rolls-Royce
For techniques for high energy X-ray examination of gas turbines during testing

1986
Oxford Instruments Group
For superconducting magnet systems used in medical diagnostic applications

1987
Renishaw Metrology Ltd
For the development of a range of accurate industrial measurement probes

1988
Quantel Ltd
For the Paintbox television graphics system and the Harry video editing system

1989
British Gas
For the 'intelligent pig' for internal inspection of operational pipelines

1990s

1990
The Science and Engineering Research Council
For the James Clerk Maxwell Telescope

1991
JOINT WINNERS:
Rover Group
For the Rover Metro car

Defence Research Agency and GEC Sensors
For the Nightbird night vision system

1992
BP International
For advancing the application of hydraulic fracturing technology used in the exploitation of oil and gas reserves

1993
ICI Klea
For the process and production technology for manufacturing the ozone-benign refrigerant KLEA 134a

1994
Soil Machine Dynamics
For the development of subsea cable and pipeline ploughs

1995
British Gas and Gill Electronic R&D
For the ultrasonic domestic gas meter

1996
Rolls-Royce
For the Trent aero-engine

1997
Whipp and Bourne (a division of FKI)
For the compact, maintenance-free gas-filled vacuum recloser

1998
Norton Healthcare Ltd
For the Easi-Breathe asthma inhaler

1999
Buro Happold
For the roof structure of the Millennium Dome

2000s

2000
Johnson Matthey
For the Continuously Regenerating Trap (CRT™)

2001
Sensaura Ltd
For Sensaura 3D Positional Audio (S-3DPA)

2002
Cambridge Display Technology
For light-emitting polymers

2003
Randox Laboratories Ltd
For Evidence® – a fully automated diagnostic analyser

2004
IBM
For WebSphere MQ business software

2005
CSR
For the single chip BlueCore™ chips, enabling bluetooth devices

2006
Optos
For the Panoramic200 scanning laser ophthalmoscope

2007
Process Systems Enterprise Ltd
For gPROMS advanced mathematical modelling software

2008
Touch Bionics
For the i-limb prosthetic hand

2009
Arup
For the Water Cube (the Beijing Aquatic Centre)

2010s

2010
Inmarsat
For the satellite-based Broadband Global Area Network (BGAN)

2011
Microsoft Research
For the human motion capture in Kinect for Xbox 360

2012
Jaguar Land Rover
For the Range Rover Evoque

2013
RealVNC
For VNC Remote Access Software

2014
Cobalt Light Systems
For the Insight100 airport security liquid scanner

2015
Artemis Intelligent Power
For the Digital Displacement hydraulic transmission

2016
Blatchford
For Linx, the world's most intelligent prosthetic limb

2017
Raspberry Pi
For its inexpensive credit-card-sized microcomputer

2018
Owlstone Medical
For the ReCIVA Breath Sampler, which identifies a range of diseases through a simple breathalyser test

2019
Bombardier
For developing an innovative, resin-infused advanced composite wing that minimises an aircraft's environmental impact

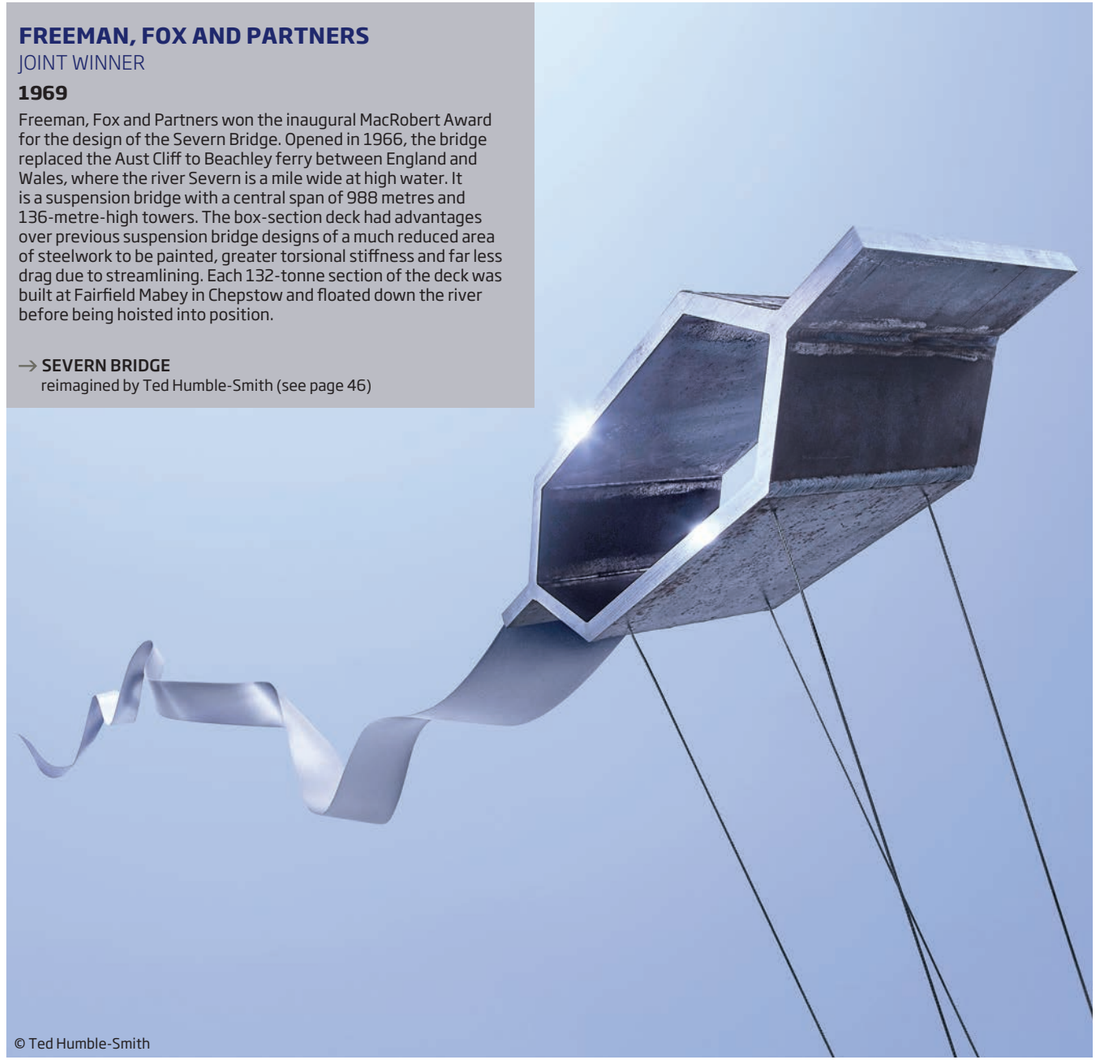
FREEMAN, FOX AND PARTNERS

JOINT WINNER

1969

Freeman, Fox and Partners won the inaugural MacRobert Award for the design of the Severn Bridge. Opened in 1966, the bridge replaced the Aust Cliff to Beachley ferry between England and Wales, where the river Severn is a mile wide at high water. It is a suspension bridge with a central span of 988 metres and 136-metre-high towers. The box-section deck had advantages over previous suspension bridge designs of a much reduced area of steelwork to be painted, greater torsional stiffness and far less drag due to streamlining. Each 132-tonne section of the deck was built at Fairfield Mabey in Chepstow and floated down the river before being hoisted into position.

→ **SEVERN BRIDGE**
reimagined by Ted Humble-Smith (see page 46)



NETLON LTD

1984

Netlon Limited (now Tensar) developed stiff, punched and drawn polymer geogrids for use in civil engineering and construction. The polymer geogrids stabilise granular materials, such as soil, and evenly distribute the loads that are applied to them. They are commonly used to support unpaved roads on construction sites, where they stabilise road construction and allow heavy vehicles to operate on the weakest of soils. Geogrids were originally made by extruding molten plastic into grids, but Netlon developed a production method that gave them extra strength and flexibility, increasing their usage.

← **POLYMER GEOGRIDS**

BURO HAPPOLD

1999

The Millennium Dome featured innovative design and construction methods and is the world's largest dome-shaped tensile structure, with a volume of 2.2 million cubic metres. The building is so lightweight that it weighs less than the air it contains. The dome was built as a set of modular components held together by 70 kilometres of cables and supported by 12 steel masts. While the dome appears curved, it is made entirely of sections of flat fabric supported by straight cables. The building is supplied with air through open doors and air handling units. The outgoing air is extracted by fans built into the masts and vents in the roof.

MILLENNIUM DOME →

CIVIL AND STRUCTURAL

© Arup

ARUP

2009

Arup's Water Cube (the Beijing Aquatic Centre) made revolutionary use of virtual prototyping, changing the way both Arup and the construction industry approached new projects. The Water Cube is effectively an insulated greenhouse – a lightweight structure based on the geometry of soap bubbles and clad in a space-age plastic material called ethylene tetrafluoroethylene (ETFE). With 22,000 individual pieces and 12,000 joints, the polyhedral space frame is extremely energy-efficient and was, at the time, one of the world's most earthquake-resistant buildings. The inventive architecture was matched by engineering innovations in fabrication, materials and environmental management.

↑ **WATER CUBE**

ENVIRONMENT

JOHNSON MATTHEY

1980

Johnson Matthey pioneered the development and commercialisation of autocatalysts to cut emissions from petrol-powered vehicles. The three-way catalytic converter simultaneously turns unburnt hydrocarbons, carbon monoxide and nitrogen oxides into carbon dioxide, water and nitrogen. The catalytic converter was fitted to most American cars by 1982 and was adopted as the standard for gasoline powered cars around the world. Today, Johnson Matthey autocatalysts are fitted to a third of the world's cars, preventing 40 tonnes of pollutants from entering the atmosphere every minute of every day.

← **CATALYTIC CONVERTER**

LUCAS CAV LTD

1981

The CAV Microjector was a miniaturised fuel injector for diesel car engines. It made use of the entirely new concept of an outward opening nozzle valve in contrast to the inward opening valves of conventional injectors. This design enabled the Microjector to be considerably smaller than the usual nozzles and a quarter of the weight. It helped to reduce emissions while maintaining fuel efficiency, and new diesel cars that used the injector were also quieter than other models.

MICROJECTOR

THE NATIONAL INSTITUTE OF AGRICULTURAL ENGINEERING

1985

The National Institute of Agricultural Engineering improved field drying processes with forage conditioning machinery. Part of its work was in applying physical, engineering and mathematical expertise to agricultural processes, including forage conditioning to increase its drying rate and yields, vital to providing feed over winter for livestock. Before harvesting can start, the machine helps to reduce the moisture content by cutting the crop and leaving it to dry in swathes in the field, which improves the drying process.

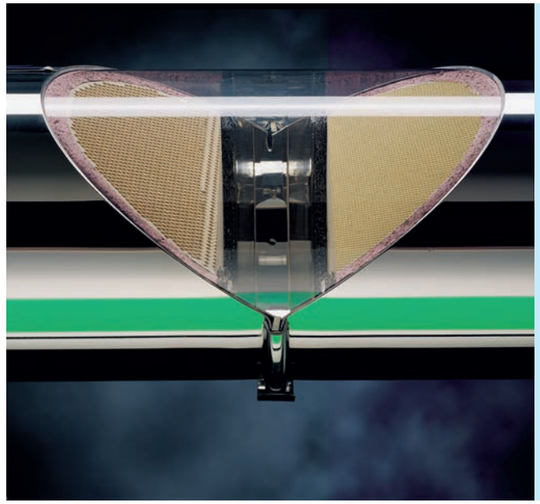
FORAGE CONDITIONING MACHINERY

ICI KLEA

1993

ICI developed a technology to manufacture KLEA 134a, an ozone-benign substitute for chlorofluorocarbons (CFCs), which contribute to ozone depletion, on which global action was agreed in the 1987 Montreal Protocol. ICI developed the process and production technology in record time for KLEA 134a, which provided a safe, energy-efficient and cost-effective CFC replacement for use in low-temperature refrigeration and air conditioning applications. While Klea 134a is now being replaced by more modern refrigerants, its part in helping to protect the ozone layer demonstrated the power of concerted global action.

↑ **BENIGN REFRIGERANT MANUFACTURE**
reimagined by Ted Humble-Smith (see page 46)



JOHNSON MATTHEY

2000

The Continuously Regenerating Trap (CRT®) technology controls pollution from heavy duty diesel vehicles using an advanced filter that traps and destroys the tiny carbon particles. A normal catalyst could not remove the particulates but the CRT® filter system removed more than 90% of the soot, hydrocarbons and carbon monoxide through its two-stage process. First the exhaust gases pass through a monolith substrate, which catalyses the removal of carbon monoxide and hydrocarbons and the production of nitrogen dioxide. The gases and the soot then go into a ceramic trap, which retains the carbon particles while the gases flow through the porous walls. The nitrogen dioxide flow enables the carbon to burn.

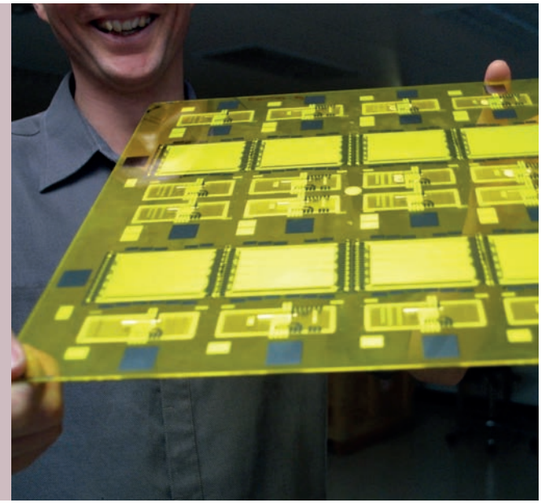
← **CRT DIESEL PARTICLE FILTER**

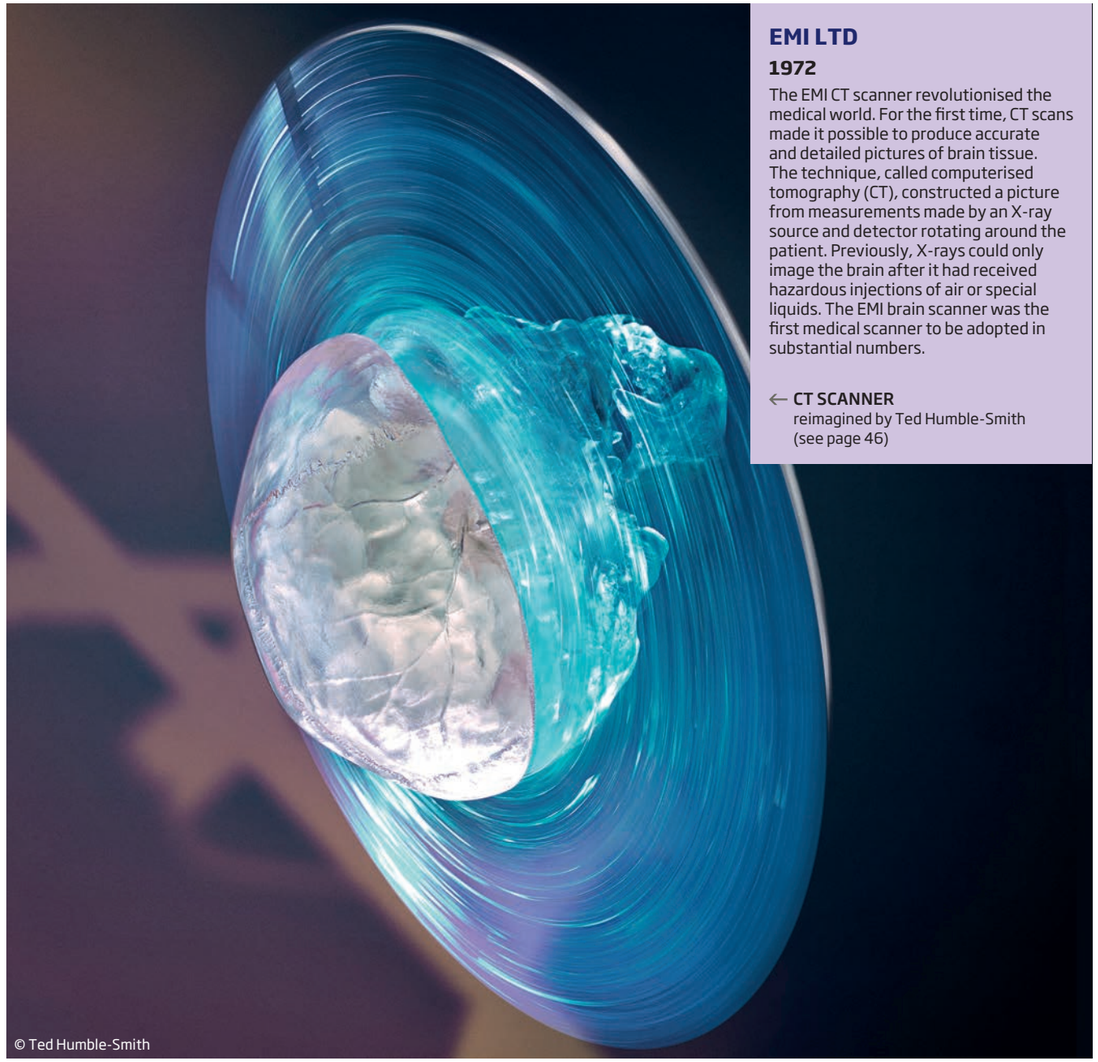
CAMBRIDGE DISPLAY TECHNOLOGY

2002

Passing an electric current through certain polymers makes them emit light. Cambridge Display Technology (CDT) was formed to commercialise the technologies that evolved from this discovery. Polymer organic light-emitting diodes (P-OLEDs) offer the potential of a true flat-screen TV or computer display. Displays can be created on one sheet of glass or, ultimately, plastic so they could be rolled up. They offer many advantages over the liquid crystal displays and plasma displays used in conventional flat panel displays, including lighter weight and lower energy use.

LIGHT-EMITTING POLYMERS →





EMI LTD

1972

The EMI CT scanner revolutionised the medical world. For the first time, CT scans made it possible to produce accurate and detailed pictures of brain tissue. The technique, called computerised tomography (CT), constructed a picture from measurements made by an X-ray source and detector rotating around the patient. Previously, X-rays could only image the brain after it had received hazardous injections of air or special liquids. The EMI brain scanner was the first medical scanner to be adopted in substantial numbers.

← **CT SCANNER**
reimagined by Ted Humble-Smith
(see page 46)

The technology is an integral part of MRI scanners, a revolutionary and non-invasive way of generating images of the human body.

OXFORD INSTRUMENTS GROUP

1986

Oxford Instruments researched and commercialised superconducting magnet technology. The company developed a new generation of superconducting magnets that generated a field strength that was unachievable with natural magnets. A superconducting magnet is made up of a large coil of wire that produces a strong magnetic field when electricity is passed through it. Crucially, the coil must be supercooled to less than 2.2 degrees Kelvin using liquid helium to maintain its enormous magnetic field – but once charged it does not require constant power, unlike an electromagnet. The technology is an integral part of MRI scanners, a revolutionary and non-invasive way of generating images of the human body.

SUPERCONDUCTING MAGNETS

NORTON HEALTHCARE LTD

1998

The Easi-Breathe asthma inhaler simplified the asthma pump by automatically releasing a measured dose of drugs when the patient inhaled. Unlike previous inhalers, it didn't require patients to coordinate the two actions of pressing and breathing. The patient only had to open the inhaler, breathe and close. In the UK, 1 in 12 adults and 1 in 11 children suffer from asthma, accounting for nearly 10 million people. Of these, in 1998, 70% reported having difficulties in operating conventional 'press and breathe' inhalers, especially under the stress of an asthma attack.

EASI-BREATHE ASTHMA INHALER →

RANDOX LABORATORIES LTD

2003

Evidence® is a fully automated diagnostic analyser that uses biochip array technology to diagnose potentially life-threatening conditions more quickly and accurately in a single test. Evidence can perform up to 30 times more blood tests an hour than conventional methods. The biochip design is a 9mm² support with an array of test sites. Each site acts as a small biochemical laboratory running a test for a specific protein or compound. Randox's analyser could then measure the presence and amount of each of these compounds in a sample in a single, automated run.

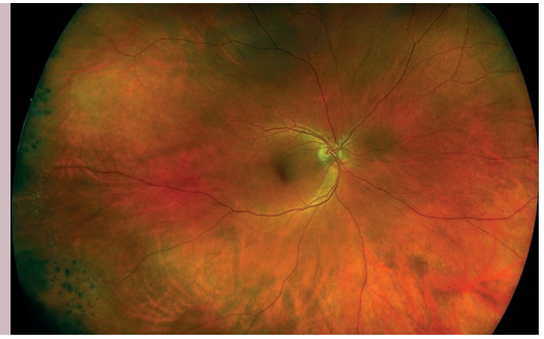
← EVIDENCE® LAB-ON-A-CHIP DIAGNOSIS

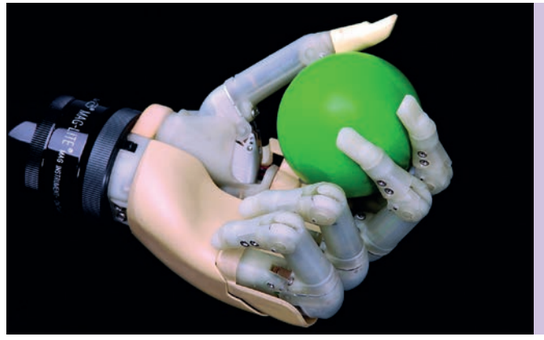
OPTOS

2006

The Panoramic 200 was the world's first scanning laser ophthalmoscope that could non-invasively capture a high resolution digital image of over 80% of the retina. It used low-powered lasers, manipulated by ellipsoidal mirror technology, to maximise the visible area of the retina. An optomap image provides a bigger picture and more clinical information, facilitating early detection, management and effective treatment of disorders and diseases evidenced in the retina such as retinal detachments, glaucoma, diabetic retinopathy and macular degeneration.

LASER RETINAL SCANNER →





TOUCH BIONICS

2008

Touch Bionics' i-limb hand was the world's first commercially available bionic hand. The key innovation behind it was the individually powered digits, with each finger having its own mini gearbox that allowed people to carry out tasks such as turning a key in a lock or picking up a pen. The i-limb was developed using leading-edge electronic and mechanical engineering techniques and manufactured with high-strength plastics. It responds to tiny electric pulses from contracted muscles in the remaining limb and allows wearers to use varying degrees of force.

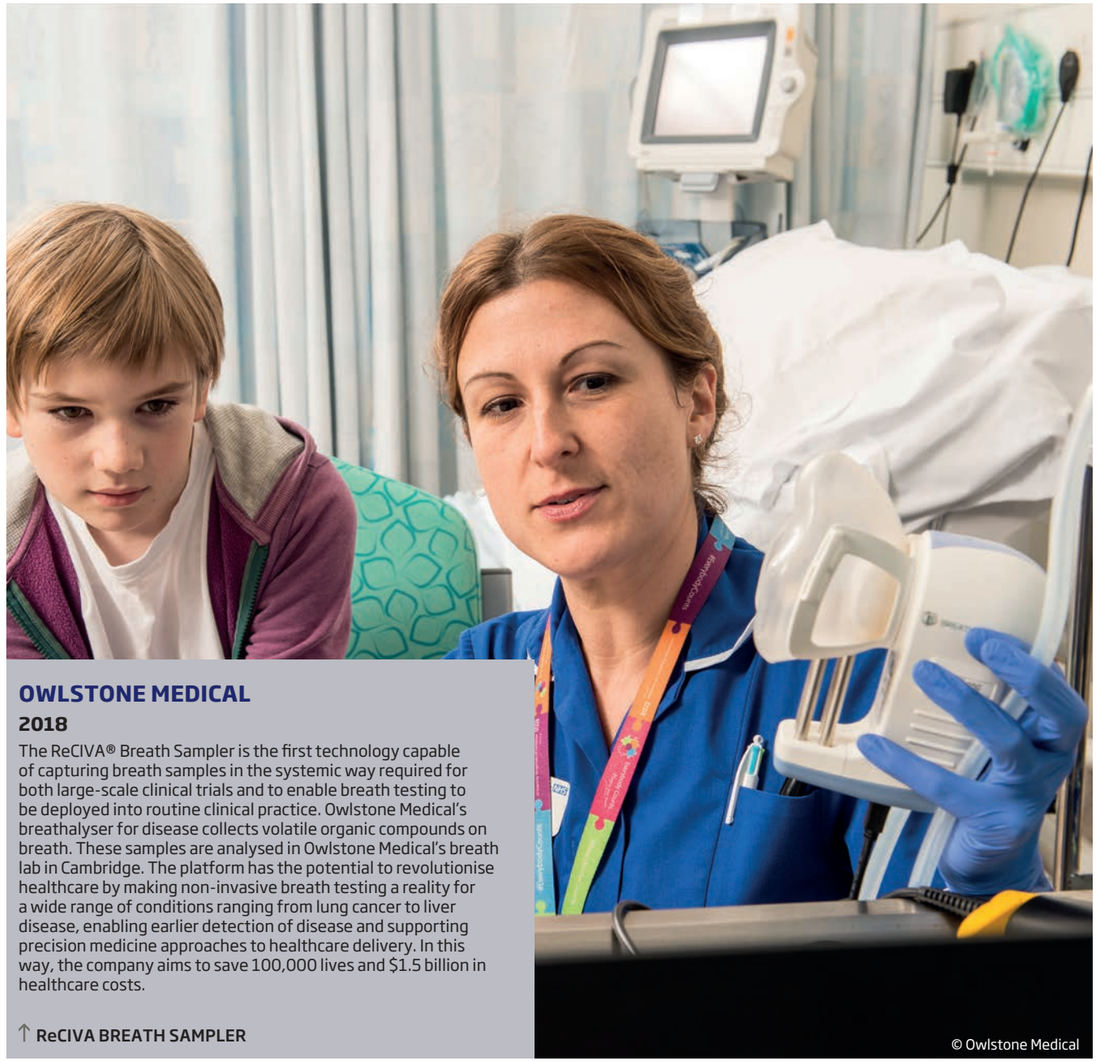
← I-LIMB BIONIC HAND

BLATCHFORD

2016

The smart robotics in the Linx limb system constantly monitor and adapt to a prosthetic leg wearer's movement, automatically adjusting to their environment. It uses a network of sensors across both the knee and foot, which simulates biological senses in the limb, continuously collecting data on the user's activity, environment and terrain. An additional central computer acts like the Linx's brain, adapting the limb's response using a pioneering control paradigm called MI2. This means the user can walk confidently, knowing that their prosthetic limb will operate at the right speed and provide the required support level at all times.

↑ LINX LIMB



OWLSTONE MEDICAL

2018

The ReCIVA® Breath Sampler is the first technology capable of capturing breath samples in the systemic way required for both large-scale clinical trials and to enable breath testing to be deployed into routine clinical practice. Owlstone Medical's breathalyser for disease collects volatile organic compounds on breath. These samples are analysed in Owlstone Medical's breath lab in Cambridge. The platform has the potential to revolutionise healthcare by making non-invasive breath testing a reality for a wide range of conditions ranging from lung cancer to liver disease, enabling earlier detection of disease and supporting precision medicine approaches to healthcare delivery. In this way, the company aims to save 100,000 lives and $1.5 billion in healthcare costs.

↑ **ReCIVA BREATH SAMPLER**

ROLLS-ROYCE | JOINT WINNER

1969

One of the inaugural joint winners, the Rolls-Royce Pegasus engine powers the Harrier, the world's first short take-off and vertical landing aircraft. Generating up to 23,000 pounds of thrust, Pegasus was developed in Bristol for the prototype Kestrel aircraft, which later became the Harrier. The fan and core air flows pass through four nozzles that can swivel to provide thrust for either lift or forward propulsion. Over 1,200 engines were made, accumulating over two million flying hours. Although Pegasus is no longer in production, it still powers the Harriers that remain in service with the US Marine Corps.

↓ **PEGASUS ENGINE**
reimagined by Ted Humble-Smith (see page 46)

It was the first helicopter in the world to take advantage of advances in materials technology.

WESTLAND HELICOPTERS | JOINT WINNER

1975

Westland Helicopters created a completely new and much simplified rotor system for the Lynx helicopter. The traditional system connecting the rotor blades was articulated in three different ways, whereas the new design replaced the complex articulation with flexible titanium forgings and fixing the blades directly to the rotor-head. The Lynx also featured conformal gears, which spread the load and made it possible to transmit high power with a smaller and simpler gearbox. It was the first helicopter in the world to take advantage of advances in materials technology.

LYNX HELICOPTER

BRITISH RAILWAYS BOARD | JOINT WINNER

1975

The tilting train was a major advance in suspension that allowed trains to navigate turns at a faster speed. British Rail Research first demonstrated the system with the Advanced Passenger Train Experimental (APT-E). It was the pioneer of the active tilt to negotiate tight curves at higher speeds than previous passive tilting trains. Three prototypes went into service on the Euston-Glasgow line and, although the original project was halted, it paved the way for modern high-speed trains including Eurostar and the Pendolino, Virgin's flagship train on the West Coast Main Line.

TILTING TRAIN SUSPENSION →

The Nightbird night vision system effectively doubled the time that aircraft could be flown.

DEFENCE RESEARCH AGENCY AND GEC SENSORS | JOINT WINNER

1991

Nightbird night vision for military aircraft enabled fast, low-level flight at night and in poor visibility. The system revolutionised the night-time operational effectiveness of aircraft such as the Harrier and Tornado – effectively doubling the time that they could be flown. The system used a forward-looking infrared sensor to present a thermal image of the terrain ahead on a pilot's head-up display. Coupled with helmet-mounted night vision goggles, this increased the operational effectiveness of military aircraft.

NIGHTBIRD NIGHT VISION SYSTEM

ROVER GROUP | JOINT WINNER

1991

The Rover Metro represented a significant advance in small cars. It had two principal engineering innovations – its interconnected suspension system and the new Rover K engine. For the first time, a car's suspension system now incorporated features to optimise the separation of the pitch from the bounce and roll control modes, designed to create a flat 'big car' ride. The K engine series was all-aluminium, had four cylinders and was available in 1.1 and 1.4 litre, 8- and 16-valve, fuel injected and carburettored derivatives. The Rover Metro achieved sales of over £1.1 billion in its first 18 months.

← ROVER METRO

ROLLS-ROYCE

1996

The Rolls-Royce Trent engine is one of the world's most powerful and efficient aircraft engines. Its wide-chord fan blades, each a metre long, are made from two layers of titanium and a titanium inner membrane that is 'blown' to produce a hollow blade with a strong support structure. This has the dual effect of giving the blade greater strength while making the whole fan lighter, contributing to Rolls-Royce's weight advantage over competing engines. At the time, the engines were used for 35% of the world engine market, worth around £3.5 billion in exports for the UK.

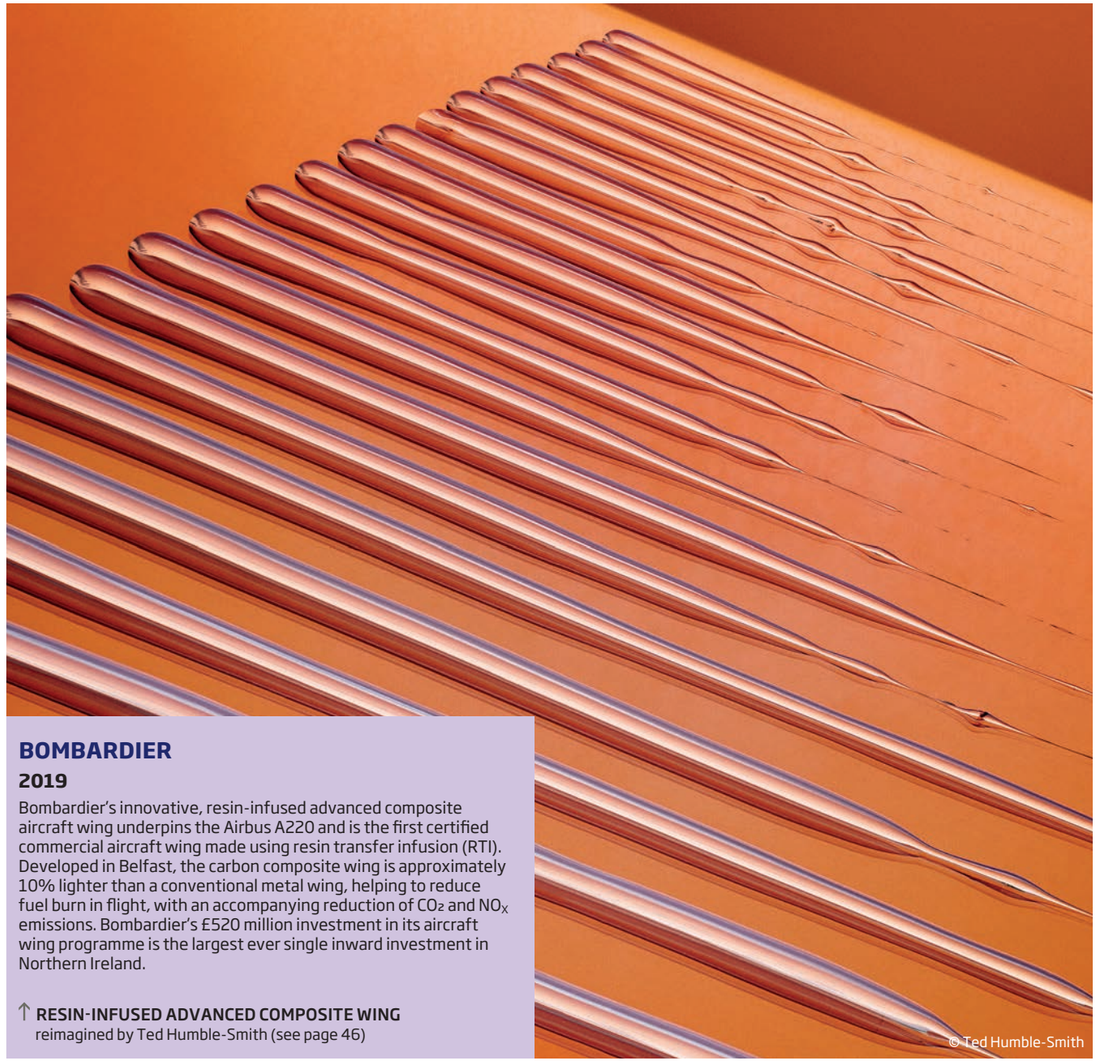
TRENT AERO-ENGINE →

JAGUAR LAND ROVER

2012

The Range Rover Evoque is a striking concept car that still retains the ground clearance necessary for all-terrain capability. To maintain the original low-profile design, Jaguar Land Rover's engineers packaged the under-floor components, the front and rear suspension systems, new chassis frame and fuel tank with millimetre accuracy. Safety and weight-saving technologies are built throughout its bodyshell and chassis, including an advanced steel frame that is reinforced with ultrahigh-strength boron steel. The car has a slim profile without compromising strength or safety.

← RANGE ROVER EVOQUE



© Ted Humble-Smith

BOMBARDIER

2019

Bombardier's innovative, resin-infused advanced composite aircraft wing underpins the Airbus A220 and is the first certified commercial aircraft wing made using resin transfer infusion (RTI). Developed in Belfast, the carbon composite wing is approximately 10% lighter than a conventional metal wing, helping to reduce fuel burn in flight, with an accompanying reduction of CO_2 and NO_X emissions. Bombardier's £520 million investment in its aircraft wing programme is the largest ever single inward investment in Northern Ireland.

↑ **RESIN-INFUSED ADVANCED COMPOSITE WING**
reimagined by Ted Humble-Smith (see page 46)

The correlator gave research and engineering a powerful new analytical tool for the analysis of a wide range of flows.

ROYAL SIGNALS RESEARCH ESTABLISHMENT AND MALVERN INSTRUMENTS LTD

1977

The Malvern Correlator measures the movement of particles or molecules in fluids. Specifically, the instrument used photon correlation in conjunction with laser scattering spectroscopy to measure the movement of particles or molecules. The correlator gave research and engineering a powerful new analytical tool for the analysis of a wide range of flows. These include gaseous and liquid flows, flames, combustion, turbulence studies, and internal combustion engine analysis.

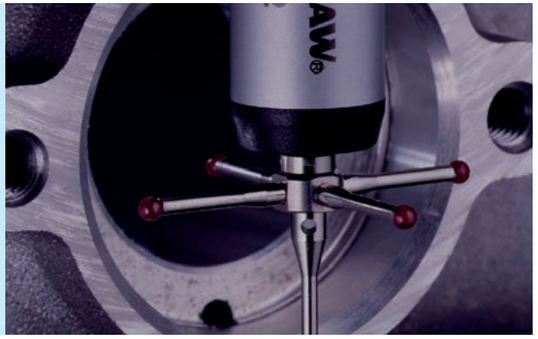
MALVERN CORRELATOR

RENISHAW METROLOGY LTD

1987

Renishaw's Three Axis Touch Trigger probe was an outstanding contribution to the speed and accuracy of engineering measurement and industrial metrology. The touch trigger probes could provide real-time, three-dimensional measurement of a component to a repeatability of one millionth of a metre, by lightly touching the workpiece and giving a signal. Modified versions of the probes could also check the features of a component while they were being manufactured and provide data to correct any error during the manufacturing process.

THREE AXIS TOUCH TRIGGER PROBE →



The meters allow lower-cost and more accurate remote meter readings.

BRITISH GAS AND GILL R&D

1995

The ultrasonic domestic gas meter provided more accurate and intelligent readings. The meter measures the flow rates of gas using bursts of very high frequency sound, or ultrasound. Sound waves travel faster when they move with the flow and slower when against, so the meter transmits bursts of sound both with and against the gas flow. The difference between the transmission times is used to work out the flow rate. The meters allow lower-cost remote meter readings and can be linked to tiny modems allowing access to cable communication channels.

ULTRASONIC DOMESTIC GAS METER

BP

1970

BP's exploration of Northern Alaska enabled the discovery of the North Slope oil fields. The company began working in Alaska in 1959, drilling the confirmation well for the Prudhoe Bay oilfield in 1968 and in the mid-1970s helped to build the 800-mile Trans-Alaska Pipeline. BP began producing oil from Prudhoe Bay in 1977. The giant oilfield – the most prolific in US history – has to date produced over 13 billion barrels of oil and is estimated to have the potential to produce more than one billion further barrels. The entire Alaska operation has recently been sold to Hilcorp Alaska, subject to regulatory approval.

← ALASKAN GEOLOGY

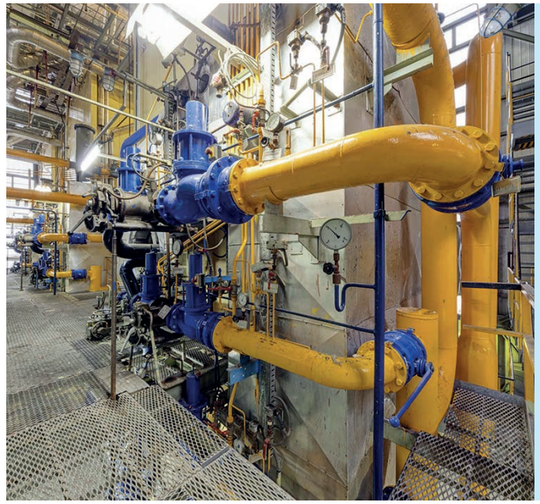
THE GAS COUNCIL

1971

The Gas Council developed the most economical and adaptable gas manufacturing process. In 1971 the Gas Council licensed its Catalytic Rich Gas process to Kellogg in the USA, which at the time was forecasting a daily shortage of around 10 billion cubic feet of gas by 1975. The hydrocarbon reforming process helped to plug that gap. In the UK, North Sea gas was already revolutionising the gas industry and by the late 1970s the existing infrastructure had been converted to carry natural gas instead of town gas.

GAS MANUFACTURING PROCESS

In the UK, North Sea gas was already revolutionising the gas industry and by the late 1970s the existing infrastructure had been converted to carry natural gas instead of town gas.



ICI LTD

1974

ICI developed the high-activity catalysts used in methanol production. Methanol is a vital ingredient in the manufacture of many materials, from plastics and paints to adhesives and fibres. Most of the world's methanol is used in the chemical industry but it is increasingly used as a fuel as the demand for clean energy increases. ICI filed a patent for the first Low Pressure Methanol (LPM) process and commissioned the first plant based on this technology. In this process, methanol is produced over a copper zinc oxide and alumina based catalyst via a multi-step chemical conversion.

← METHANOL CATALYSTS

BP AND KALDAIR LTD

1982

Kaldair created a new, safer gas flaring system for offshore platforms. Flaring of flammable gases is an essential feature on oil rigs, but flaring of gas from a simple pipe can create excessive smoke, drift of the flame and problems in windy conditions. The Kaldair flare ensures adequate air entrapment and mixing thus improving the oxygen supply. The resultant flame is smokeless, emits a low level of heat radiation and is stable in high wind speeds. Today, flaring is recognised as an environmental problem, and the World Bank has set a target of zero gas flaring by 2030.

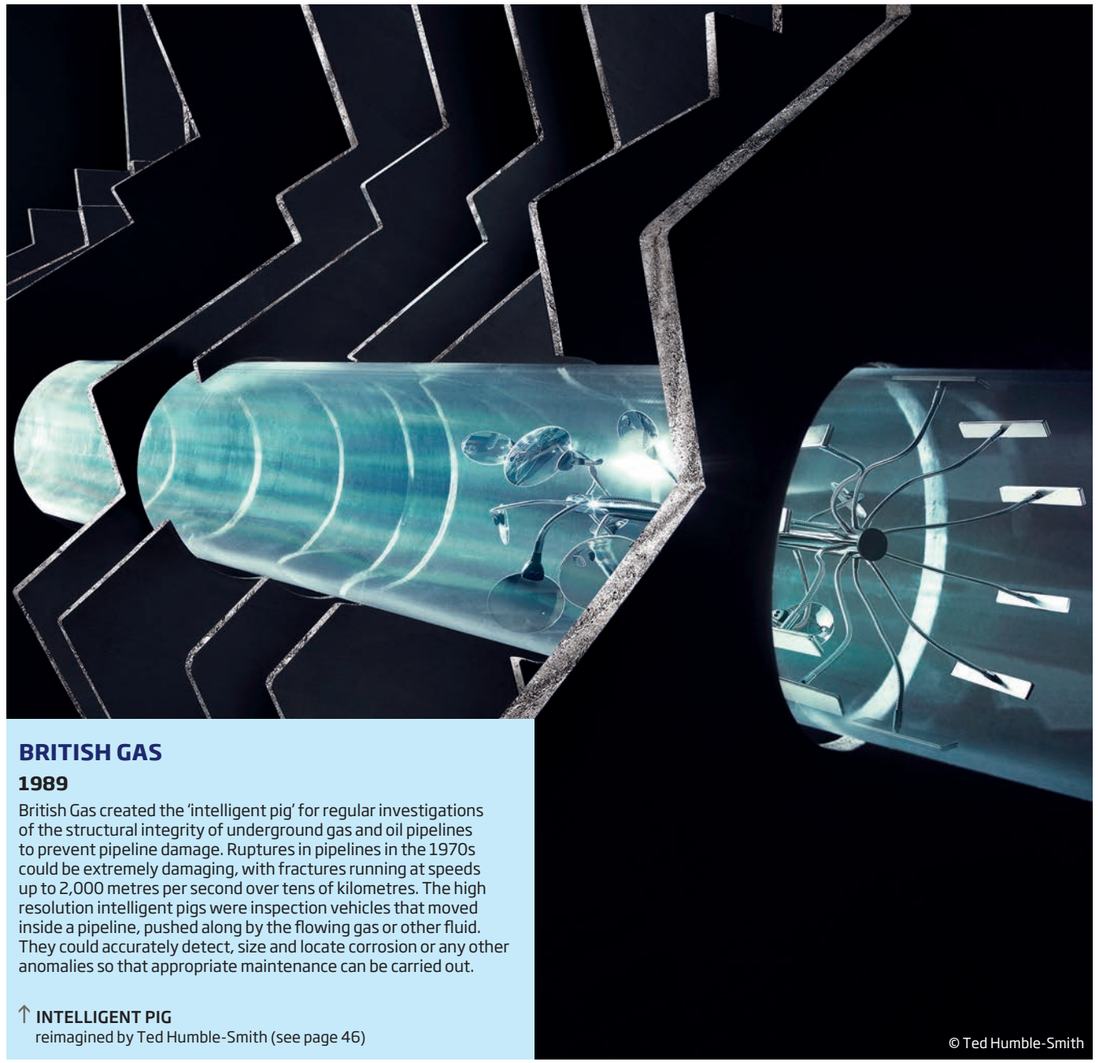
GAS FLARING SYSTEM

RUSTON GAS TURBINES

1983

Ruston Gas Turbines (now owned by Siemens) created the Tornado, an efficient and compact gas turbine that combined new technology, metallurgy and design. It was a refinement of proven technology that improved efficiency and reduced fuel costs. The Tornado marked a turning point for turbines as it was built to meet operators' varied needs with minimum modification. It came as a compact packaged set and was designed with accessibility for rapid servicing in mind. Its operation was controlled by the 'Rustronic' control system based on microprocessor technology, a forward-thinking feature in the early 1980s.

TORNADO GAS TURBINE



© Ted Humble-Smith

BRITISH GAS

1989

British Gas created the 'intelligent pig' for regular investigations of the structural integrity of underground gas and oil pipelines to prevent pipeline damage. Ruptures in pipelines in the 1970s could be extremely damaging, with fractures running at speeds up to 2,000 metres per second over tens of kilometres. The high resolution intelligent pigs were inspection vehicles that moved inside a pipeline, pushed along by the flowing gas or other fluid. They could accurately detect, size and locate corrosion or any other anomalies so that appropriate maintenance can be carried out.

↑ **INTELLIGENT PIG**
reimagined by Ted Humble-Smith (see page 46)

© 2005 BP PLC

BP INTERNATIONAL

1992

BP improved existing hydraulic fracturing techniques used in the exploitation of oil and gas reserves to increase the flow rates from oil or gas wells. BP's team used extensive research and testing to implement wider fractures and S-shaped drilling, which significantly improved the flow of oil and gas. The method enhanced the applicability of hydraulic fracturing to areas where the costs associated with drilling wells are very high, such as the North Sea and Alaska. It also made wells significantly more productive, reducing the number of wells required.

← **HYDRAULIC FRACTURING**

WHIPP AND BOURNE

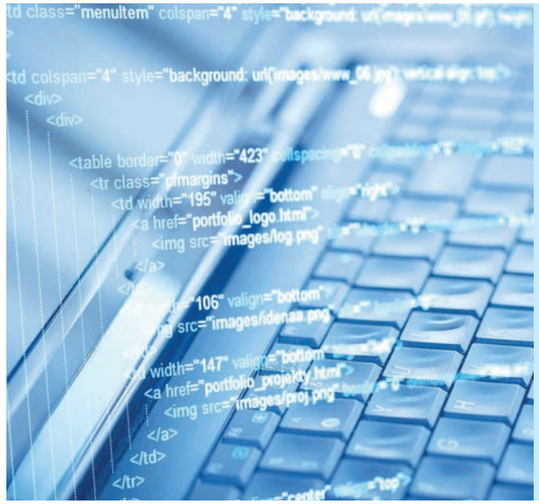
1997

Whipp and Bourne invented an innovative circuit breaker for overhead power lines, the gas-filled vacuum autorecloser. If there is a fault on a power line, a recloser interrupts the power supply, safeguarding electrical equipment connected downstream to the system. Autoreclosers installed at power junctions allow it to disconnect only the branches affected by the fault, safeguarding the rest of the system. Whipp and Bourne completely redesigned the autorecloser to deliver an almost maintenance-free product with a low number of moving parts and independence from the grid. It was a third of the weight of its competitors.

GAS-FILLED VACUUM AUTORECLOSER

Whipp and Bourne completely redesigned the autorecloser to deliver an almost maintenance-free product with a low number of moving parts and independence from the grid.

ENERGY AND CHEMICAL



PROCESS SYSTEMS ENTERPRISE LTD

2007

Process Systems Enterprise's gPROMS is advanced mathematical modelling software that allows engineers across the process industries to provide real-world solutions by building and solving complex process models in silico. The software allows the user to focus on the physical and chemical phenomena that take place in large reactors. The modelling technology is transforming the process industries – from large-scale chemicals industries to food and pharmaceuticals – by allowing companies to explore the decision space rapidly and take better, faster and safer design and operating decisions. The technology has also been used for design and operability analysis of carbon capture and storage projects.

← **gPROMS**

ARTEMIS INTELLIGENT POWER

2015

Artemis pioneered the Digital Displacement® power system, which dramatically improves power capacity for wind turbines. The smart, modular system has digitally controlled hydraulics and overcomes the significant reliability issues associated with existing wind turbines. The company is also applying the same technology to reduce the fuel consumption of commuter trains and buses. A regenerative braking energy-storage system based on Digital Displacement® can be retrofitted to existing diesel commuter trains, reducing fuel consumption by some 10%. The system also generates less noise and cuts exhaust emissions within stations.

DIGITAL DISPLACEMENT POWER SYSTEM →

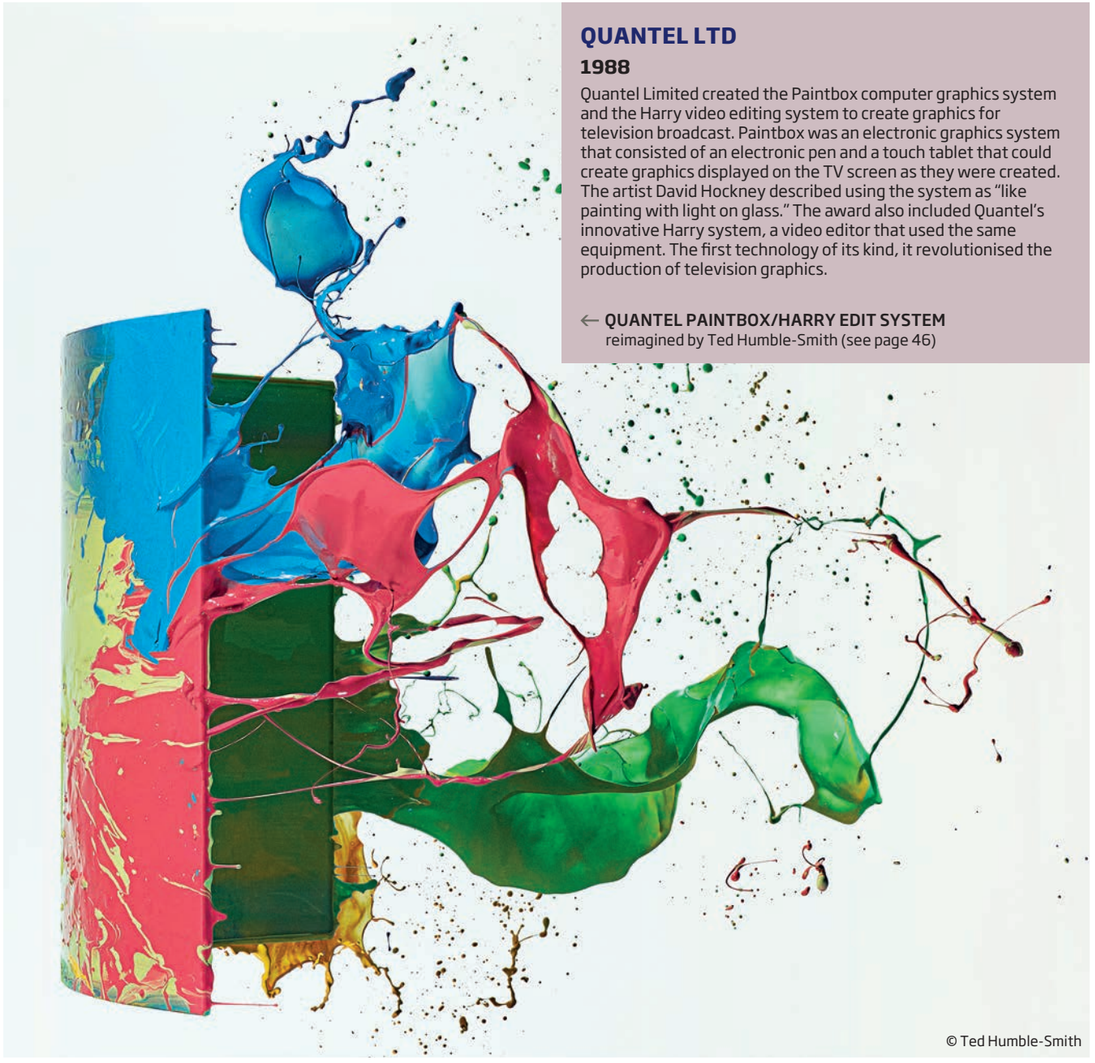
DIGITAL AND COMPUTING

QUANTEL LTD

1988

Quantel Limited created the Paintbox computer graphics system and the Harry video editing system to create graphics for television broadcast. Paintbox was an electronic graphics system that consisted of an electronic pen and a touch tablet that could create graphics displayed on the TV screen as they were created. The artist David Hockney described using the system as "like painting with light on glass." The award also included Quantel's innovative Harry system, a video editor that used the same equipment. The first technology of its kind, it revolutionised the production of television graphics.

← **QUANTEL PAINTBOX/HARRY EDIT SYSTEM**
reimagined by Ted Humble-Smith (see page 46)



Prestel was the world's first data view service. It linked a home TV set, telephone and computer to provide instant access to 150,000 pages of advice and information.

POST OFFICE TELECOMMUNICATIONS

1979

Prestel was the world's first data view service. It linked a home TV set, telephone and computer to provide instant access to 150,000 pages of advice and information from news agencies, companies and government departments. Unlike teletext, it was a two-way system and could host far more information but, crucially, it was more expensive. At its height in 1987, the service had over 75,000 terminals in the UK and overseas, increasing at 1,000 sets a month. However, Prestel never cracked the British home market and it was overtaken by other services and ultimately by the world wide web.

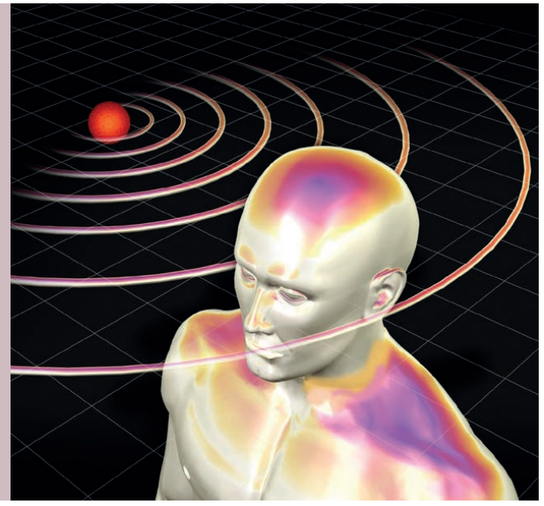
PRESTEL

SENSAURA LTD

2001

Sensaura created three-dimensional audio technology on stereo speakers or headphones. It duplicated the directional sensation that humans get listening to a live event. It was originally developed to enhance classical music recordings, invoking the all-enveloping experience of music in the concert hall. However, Sensaura soon realised that computers were a much bigger market and licensed it as 'surround sound' software for game-players and music listeners through conventional stereo speakers from their PC. The system was then applied to game consoles, and Sensaura technology was incorporated in the Microsoft Xbox™ system.

SENSAURA 3D POSITIONAL AUDIO →



Websphere was designed to help organisations running a large number of incompatible information systems. IBM came up with the simple idea that the solution was to connect existing systems instead of replacing them.

IBM

2004

WebSphere provides a failsafe means of exchanging business-critical information between computer systems, irrespective of their location and regardless of the hardware, programming language, operating system or communication protocol they used. It was designed to help organisations running a large number of incompatible information systems. IBM came up with the simple idea that the solution was to connect existing systems instead of replacing them. It integrated servers, back office systems and databases, reliably handling hundreds of millions of messages every day. It supported 40 different computing platforms, filing over 120 patents.

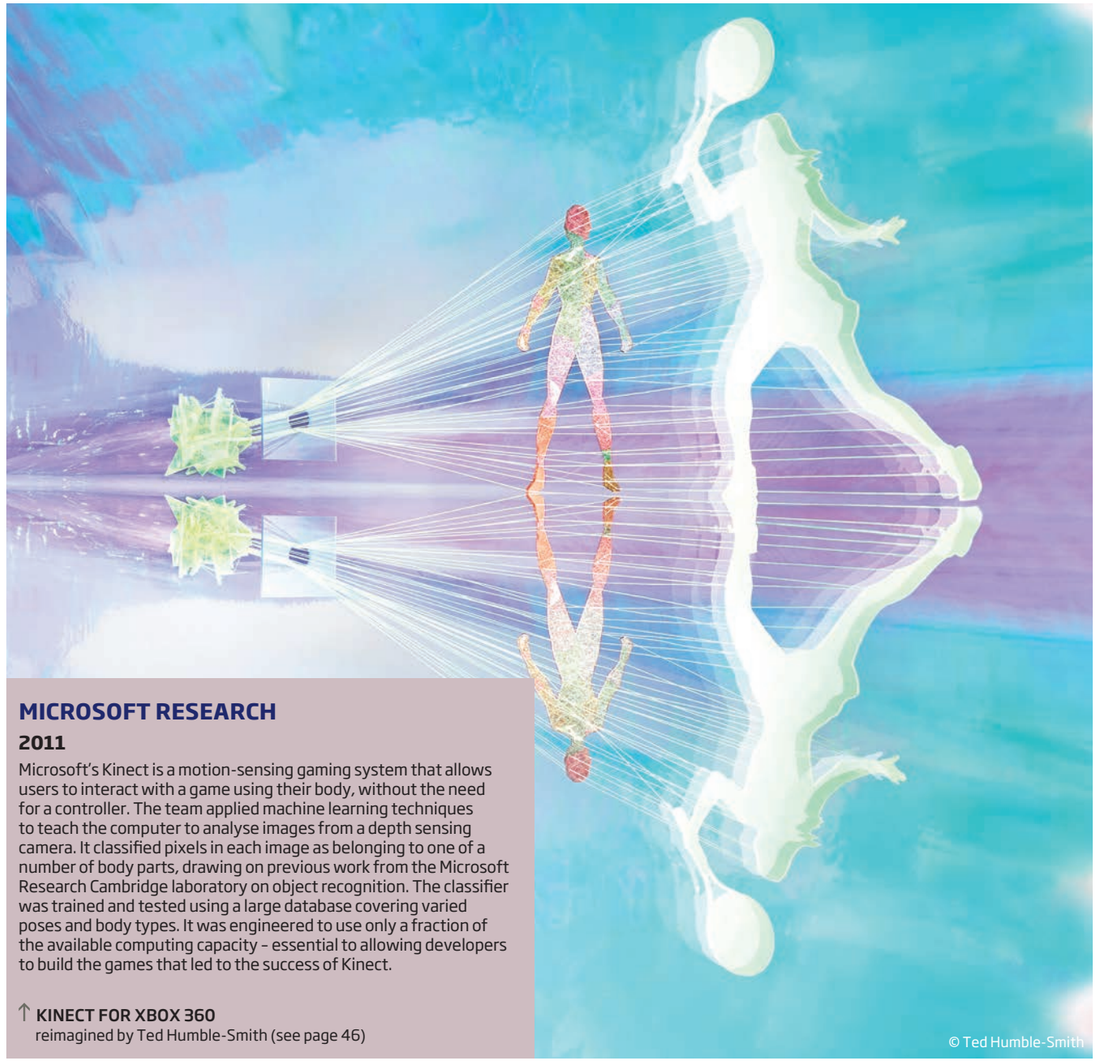
WEBSPHERE MQ

CSR

2005

The BlueCore™ family is a revolutionary group of silicon chips incorporating a radio transmitter/receiver that has helped fuel the inexorable rise of Bluetooth wireless products, from mobile phones to medical devices. The technology was a major breakthrough in bypassing the 'noise' produced by electrical signals crossing the small chip, which would normally swamp a radio receiver working with micro-volt signals. Frequency planning enabled the radio component to communicate through the noise of the chip's digital traffic. Since 1999, CSR have designed over 30 different BlueCore™ chips and in 2005 the company was ranked number one in every Bluetooth market segment. CSR was acquired by Qualcomm in 2015.

BLUECORE →

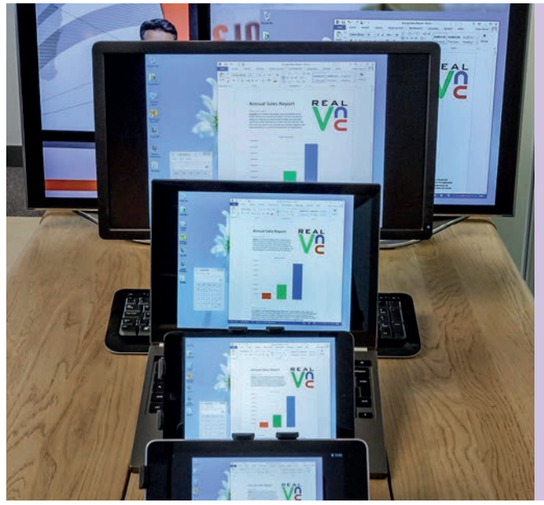


MICROSOFT RESEARCH

2011

Microsoft's Kinect is a motion-sensing gaming system that allows users to interact with a game using their body, without the need for a controller. The team applied machine learning techniques to teach the computer to analyse images from a depth sensing camera. It classified pixels in each image as belonging to one of a number of body parts, drawing on previous work from the Microsoft Research Cambridge laboratory on object recognition. The classifier was trained and tested using a large database covering varied poses and body types. It was engineered to use only a fraction of the available computing capacity – essential to allowing developers to build the games that led to the success of Kinect.

↑ **KINECT FOR XBOX 360**
reimagined by Ted Humble-Smith (see page 46)



REALVNC

2013

RealVNC's technology gives computer, smartphone, and other device users the power to 'take over' another device remotely from anywhere in the world. This means IT workers can solve problems without having to leave their own desk, for example. The technology uses specially designed algorithms to send data only about the parts of a screen that are changing, rather than all of it, which minimises the amount of data transferred and ensures that sharp images are sent quickly. It has already been built directly into millions of Intel chips so laptop users do not even have to download the software, and computers can be controlled remotely even if they are faulty and unresponsive or hibernating.

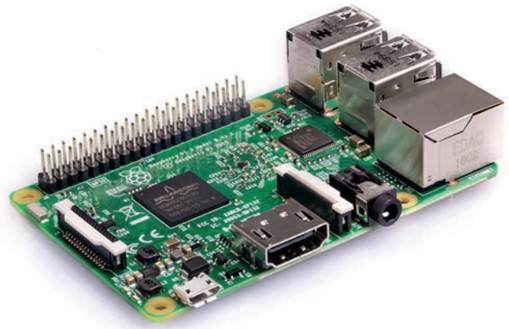
← **VNC REMOTE ACCESS SOFTWARE**

RASPBERRY PI

2017

The credit-card-sized Raspberry Pi is the world's smallest and most affordable desktop computer, originally developed to interest more students in programming. To maximise its applications, the Raspberry Pi had to have video and audio capabilities and a wide range of inputs and outputs. A printed circuit board with multiple layers allows components to be decoupled from one another, increasing the flexibility with which the board could be designed. Since 2012, nearly 30 million Raspberry Pis have been sold to a dedicated community of makers, schools, and an increasing demand from industry for use in control systems. The surplus generated by the commercial arm is used by the charitable Raspberry Pi Foundation to help teach people about computing.

MICROCOMPUTER →



DUNLOP

1973

Dunlop created the world's first fail-safe tyre system. The Denovo flat radial tyre and wheel was the first system of its kind to give drivers total long-distance and high-speed control, even following punctures or blowouts. Denovo would allow motorists to continue driving with a flat tyre with little effect on the handling of the car, thanks to a fluid inside that cooled and partially reinflated the tyre. The innovation, which was designed to take the danger out of high-speed blowouts and the inconvenience out of punctures, increased public interest in road safety features.

← DENOVO FAIL-SAFE TYRES

PILKINGTON BROTHERS LTD

1978

Pilkington Brothers Limited created the Triplex Ten-Twenty 'superlaminated' windscreen, one of the biggest advancements in windscreen safety in the 1970s. Most vehicle windscreens at the time were made of either toughened or laminated glass. Triplex Ten-Twenty combined the best of both kinds, producing a windscreen that would crack but remain in place in the event of an accident, reducing the risk of injuries from broken glass.

TRIPLEX TEN-TWENTY WINDSCREEN →

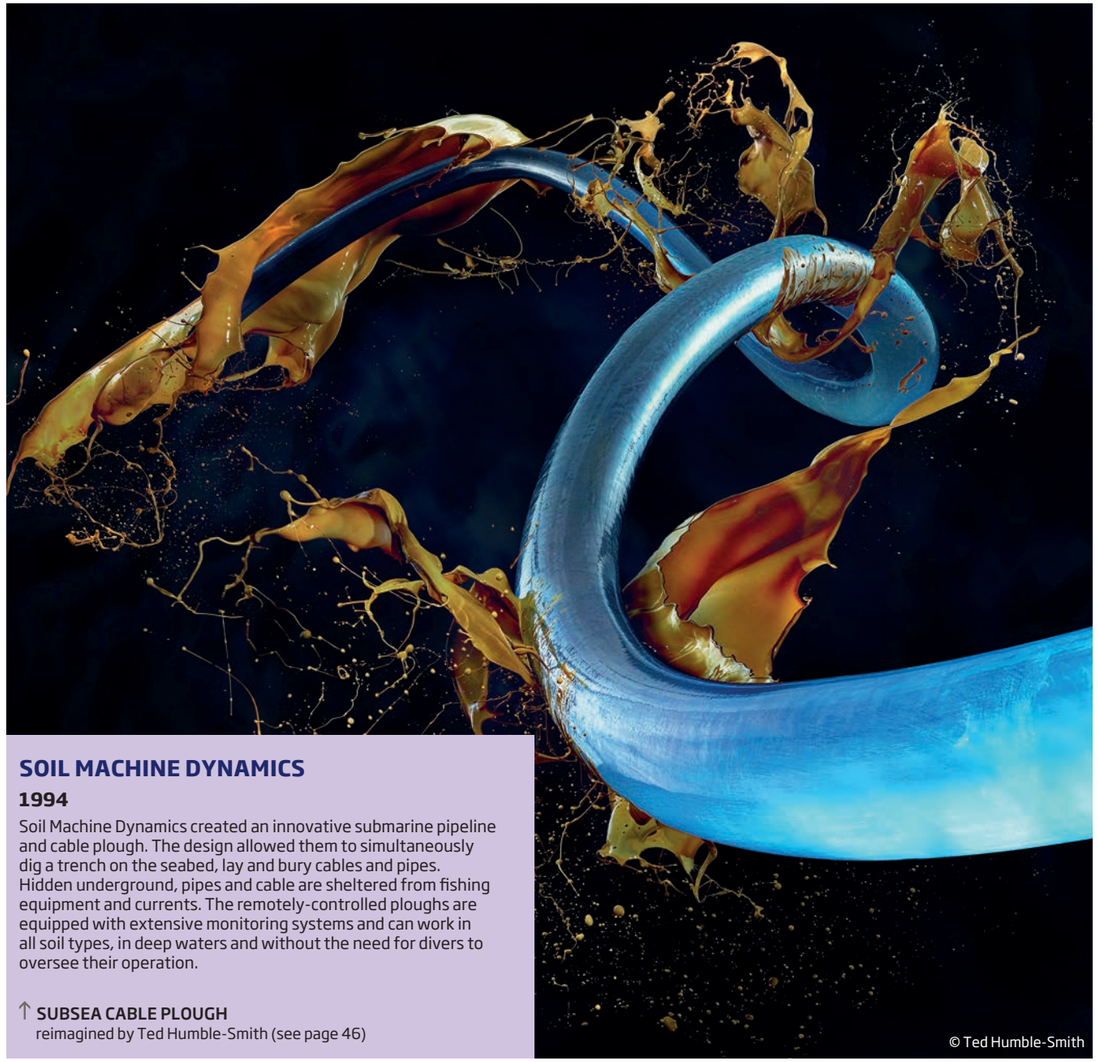
Rolls-Royce developed techniques and equipment to generate and process X-ray images of aircraft engines safely.

ROLLS-ROYCE

1985

The Rolls-Royce X-ray Examination System was a non-invasive means of measuring and making live images of metal components within gas turbines. Rolls-Royce developed new techniques and transportable equipment to generate and process the X-ray images safely. It took meaningful images of the moving parts and measured them through the opaque metal walls of the casings. This enabled engineers to reduce the development time and cost of engine programmes, and to improve their reliability and efficiency.

X-RAY INSPECTION OF TURBINES

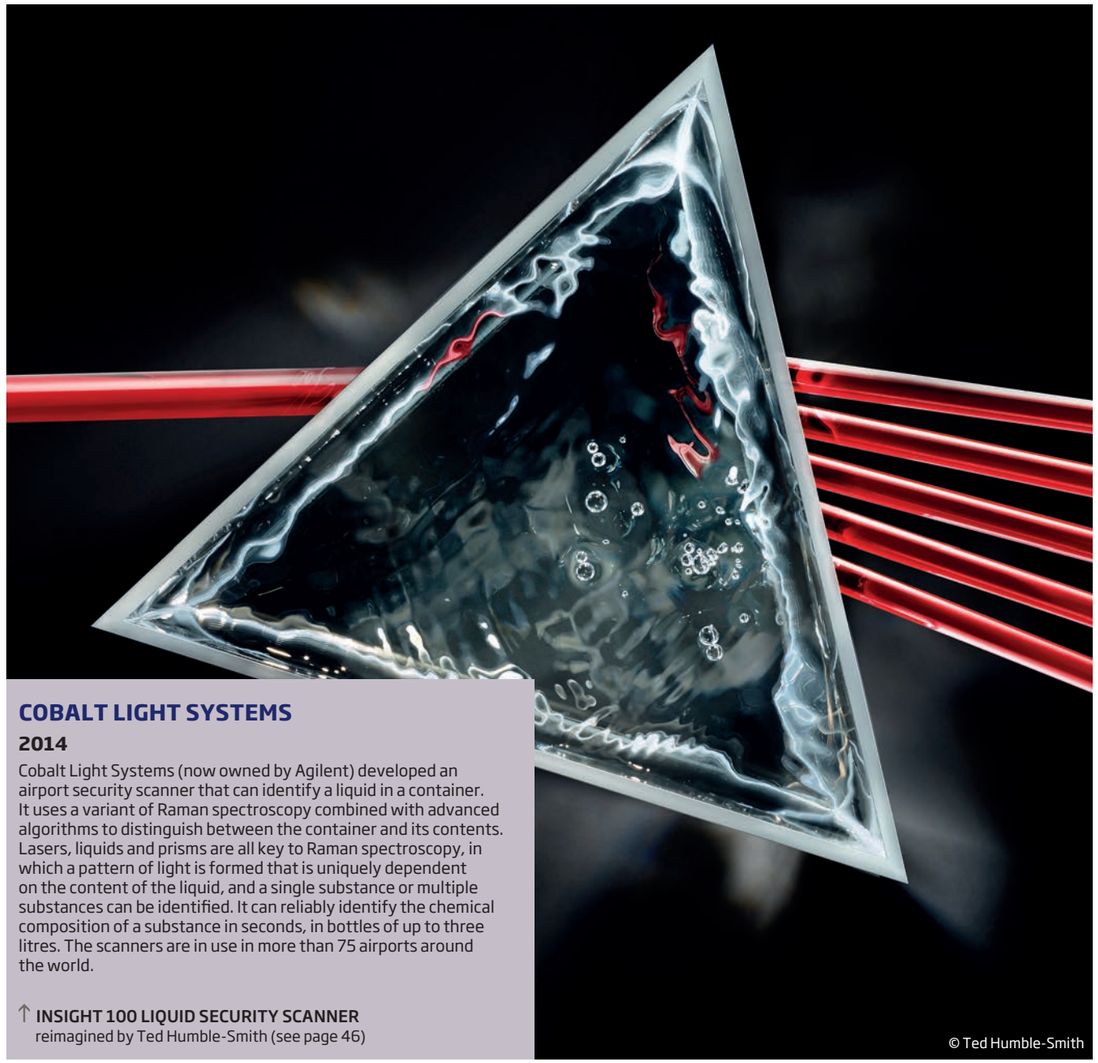


SOIL MACHINE DYNAMICS

1994

Soil Machine Dynamics created an innovative submarine pipeline and cable plough. The design allowed them to simultaneously dig a trench on the seabed, lay and bury cables and pipes. Hidden underground, pipes and cable are sheltered from fishing equipment and currents. The remotely-controlled ploughs are equipped with extensive monitoring systems and can work in all soil types, in deep waters and without the need for divers to oversee their operation.

↑ SUBSEA CABLE PLOUGH
reimagined by Ted Humble-Smith (see page 46)



COBALT LIGHT SYSTEMS

2014

Cobalt Light Systems (now owned by Agilent) developed an airport security scanner that can identify a liquid in a container. It uses a variant of Raman spectroscopy combined with advanced algorithms to distinguish between the container and its contents. Lasers, liquids and prisms are all key to Raman spectroscopy, in which a pattern of light is formed that is uniquely dependent on the content of the liquid, and a single substance or multiple substances can be identified. It can reliably identify the chemical composition of a substance in seconds, in bottles of up to three litres. The scanners are in use in more than 75 airports around the world.

↑ **INSIGHT 100 LIQUID SECURITY SCANNER**
reimagined by Ted Humble-Smith (see page 46)

THE SCIENCE AND ENGINEERING RESEARCH COUNCIL

1990

The UK Science and Engineering Research Council developed, designed and built the James Clerk Maxwell Telescope close to the summit of Maunakea, Hawaii, at an altitude of 4,092 metres. With a 15-metre diameter reflector, it is the largest astronomical telescope in the world built to operate at submillimetre wavelengths. The telescope's primary reflector comprises 276 individual lightweight panels, each made of a thin aluminium skin bonded to an aluminium honeycomb. The alignment of these mechanical panels can be continually monitored and adjusted to compensate as gravity distorts the antenna as it tips to different elevations. The whole 450-tonne building can rotate fully in ten minutes. Now part of the East Asian Observatory, it is used to study the Solar System, interstellar and circumstellar dust and gas, and distant galaxies.

← **JAMES CLERK MAXWELL TELESCOPE**

INMARSAT

2010

Inmarsat created the groundbreaking Broadband Global Area Network service through its Inmarsat-4 satellite. This satellite broadband service was the world's first global 3G mobile network, providing internet connectivity anywhere on earth and used by business, government, broadcasters, aid and relief agencies, and emergency services. The Inmarsat-4 satellites providing the service are in geostationary orbit 35,786 kilometres above the Earth. Each satellite can generate over 200 focused beams (which provide the cells, as in ground mobile network communications), plus 19 regional, and one global beam for detection and switching.

BROADBAND GLOBAL AREA NETWORK →

MACROBERT AWARD FINALISTS

2019

Darktrace
For Darktrace Antigena: an AI-powered cybersecurity system

M Squared
For SolsTiS: Creating the world's purest light for science and industry

OrganOx
For metra: a world-first device for maintaining livers for transplant at body temperature

2018

Oxford Space Systems
For the new generation of origami-inspired, innovative and cost-competitive satellite antennas and structures

Williams Advanced Engineering and Aerofoil Energy
For Aerofoils, an aerodynamic shelf-edge technology that significantly reduces energy consumption in supermarket and convenience store fridges

2017

Darktrace
For the Enterprise Immune System, which learns what is 'normal' for an organisation's computer network and uses this information to detect and fight back against emerging threats

Vision RT
For the development of AlignRT: the tracking of a patient in 3D during radiotherapy

2016

Jaguar Land Rover
For the design and manufacture its own engines for the first time

Siemens Magnet Technology
For making a step-change in MRI technology that enabled earlier diagnosis of diseases such as Alzheimer's and improved drug development

2015

Endomag
For its system to improve the diagnosis of cancer spread in breast cancer patients

Victrex
For its creation of new materials to bring modern technology advances to life

2014

OptaSense
For the 'Earth's Nervous System', technology that can turn existing fibre-optic cable into a highly sensitive real-time microphone

Rolls-Royce
For the world's first short take-off and vertical landing system for a supersonic aircraft

2013

Concrete Canvas Ltd
For Concrete Canvas, a fabric that enables rapid, innovative and adaptable concrete infrastructure

Oxford Instruments
For the X-Max large area detector for energy dispersive spectroscopy for electron microscopy

2012

Andor Technology
For the Neo sCMOS scientific digital camera that captures high-resolution pictures of single cells and molecular structures with greater accuracy

JBA Consulting
For JFlow, a flood risk modelling system using low-cost supercomputing

2011

Dstl and NP Aerospace
For developing a new modular ceramic armour system for armoured military vehicles

Jaguar
For the new lightweight aluminium XJ body, the first production car to be made using aerospace cold joining technology

Radio Design Ltd
For the radio frequency filter that allows mobile phone operators to share their networks

2010

Chas A Blatchford & Sons Ltd
For the Echelon hydraulic ankle-foot, the world's first self-aligning prosthesis for amputees

Cobham Technical Services
For the Minehound dual sensor landmine detector, which increases the efficiency of clearing a minefield

Lucite International UK Ltd
For the Alpha process, a cheaper, greener way of making for methyl methacrylate

2009

Orthomimetics Ltd
For engineering medical implants that enable natural regeneration of bone and soft tissue

QinetiQ
For the Tarsier, an automatic foreign object debris detection system

Rolls-Royce
For developing the Trent 900 gas-turbine engine, providing efficient power for the Airbus A380

2008

Johnson Matthey
For the compact catalysed soot filter for diesel cars

Owlstone
For chemical sensors on a silicon chip, a miniature detection system for trace amounts of chemicals

The Automation Partnership (TAP)
For the Polar, automated ultra-low temperature robotic storage for medical research

2007

Intelligent Orthopaedics Ltd
For the Staffordshire Orthopaedic Reduction Machine that helps surgeons reduce fractures

Roger Bullivant Ltd
For the SystemFirst solution, a guaranteed foundation for homeowners

Transitive
For QuickTransit, which allows software to run on different central processing units

2006

Airbus UK
For its A380 Integrated Wing Design

Brinker Technology Ltd
For mechanical platelets that locate and seal oil and water pipeline leaks

Davy Process Technology Ltd
For an environmentally-friendly ethyl acetate production process

2005

Agilent
For the Access7 location system, enabling mobile phone operators to locate individual users.

OHM
For controlled source electromagnetic sounding

Southampton Photonics Ltd
For highly-efficient, ultrabright fibre lasers

2004

Delphi Diesel Systems
For the E3 electronic unit injector advanced fuel system, reducing harmful emissions

Pilkington
For Pilkington Activ™, the world's first self-cleaning glass

Sharp Laboratories of Europe
For 2D-3D displays, enabling airport staff to see realistic 3D images from X-ray equipment without glasses

2003

Oxford Instruments Superconductivity
For the Discovery 900 MHz superconducting magnet

FT Technologies Ltd
For the FT702 Acoustic Resonance Anemometer, a small, durable and reliable wind sensor

Rolls-Royce
For the sophisticated propulsion system for future UK/UK Joint Strike Fighter aircraft

2002

STS
For plasma process silicon-etching equipment

Mott MacDonald
For three full-size interstate highway tunnels

Innovene High Productivity Gas Phase Technology
For the innovation of an improved method of manufacturing polyethylene

2001

Southern Water
For the deHoxar spiral separator

Bombardier Aerospace
For natural blockage thrust reverser for a turbofan engine nacelle

2000

BAE Systems Sensor Systems Division
For the CAPTOR radar for the Eurofighter

New Transducers Ltd (NXT)
For its flat panel transducer technology

Thermomax
For the evacuated heatpipe and direct flow solar hot water systems

1999

British Aerospace Systems and Equipment
For the Silicon VSG in-car gyroscope

Carbospars Ltd
For the AeroRig® carbon fibre sailing rig

NDS Limited
For developing digital terrestrial television

1998

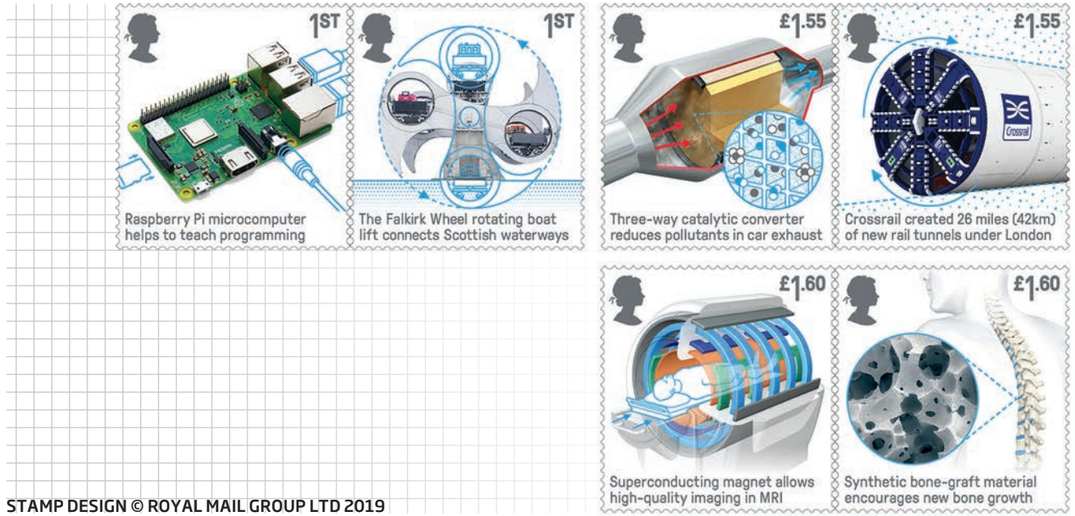
Alstom Engines, Paxman
For the VP185 series of high-performance diesel engines

Mott MacDonald Group
For the Tsing Ma Bridge, Hong Kong

Psion Computers
For the Series 5 handheld computer

Before 1998, finalists were not selected, only the winners were announced.

ROYAL MAIL STAMPS AND THE MACROBERT AWARD



In May 2019, Royal Mail launched a set of commemorative Special Stamps to celebrate the range of British engineering innovation over the last 50 years.

The set of six stamps features three past winners of the MacRobert Award. It includes the 2017 winner Raspberry Pi, the three-way catalytic converter developed by 1980 winner Johnson Matthey, and 1986 winner Oxford Instruments' superconducting magnets that enable MRI scanning. The stamps also feature the Falkirk Wheel, the world's only rotating boat lift, and Crossrail's massive tunnel excavation beneath the streets of London. A synthetic bone-graft material developed at Queen Mary University of London and used in orthopaedic treatment around the world completes the six-stamp set.

An accompanying miniature set sheet of four additional stamps issued by Royal Mail features the Harrier Jump Jet, celebrating 50 years since it entered RAF service. The Harrier was the first operational jet fighter in the world to use revolutionary vertical short take-off and landing technology, powered by Rolls-Royce's Pegasus engine, joint first winner of the MacRobert Award in 1969.

The Harrier, powered by Rolls-Royce's Pegasus engine, was the joint first winner of the MacRobert Award in 1969.

INSPIRING ENGINEERING: REINTERPRETING MACROBERT AWARD INNOVATIONS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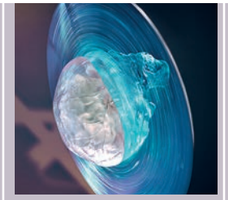
2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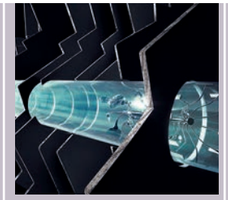
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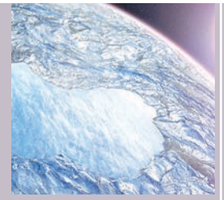
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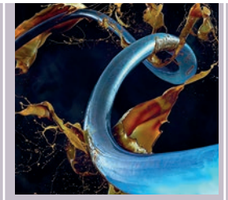
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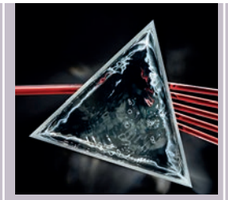
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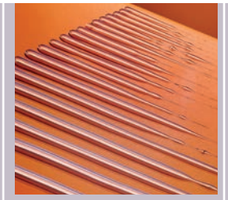
10

To mark the 50th year of the Royal Academy of Engineering MacRobert Award, the Academy commissioned conceptual photographer Ted Humble-Smith to create a series of special images to celebrate the anniversary.

Ted Humble-Smith works across a range of sectors from luxury fashion to car manufacture. He uses his imagination and technical expertise to produce vibrant images that push the boundaries of commercial photography. Ted talked to the engineers who developed the concepts behind 10 former winners. The results capture a sense of the thought process behind the breakthroughs, and are featured throughout this book.

The project was generously supported by the UK Intellectual Property Office. The following MacRobert Award innovations were captured in the photography series.

Rolls-Royce (1) were joint winners of the first MacRobert Award in 1969 for the Pegasus engine used in the Harrier aircraft. Ted was inspired by the balance of the thrust of the engine and the directional airflow of the swivelling nozzles that allowed the Harrier to hover and, famously, to dip its nose. His 3D sculpture of the airflow translates into a shadow of the iconic aircraft.

Freeman, Fox and Partners (2) designed the deck of the Severn Bridge to be aerodynamically favourable to wind forces hitting the bridge side on. It reminded Ted of a box kite, which when flown with a tail would demonstrate the problem and the solution that was used to design the deck.

EMI (3) won the MacRobert Award in 1972 for the application of X-ray techniques. The CT scanner takes images of slices of the head that are combined to create a composite image. Ted created a 'slice' in a transparent skull model and inserted a set of serrated discs that overlapped and rotated around the skull to show the spinning motion of the original CT scanner.

Quantel (4) won the MacRobert Award in 1988 for the Paintbox television graphics system. Ted took his inspiration from the original screen colours available and created a striking image by throwing red, green and blue paint at a piece of curved plastic representing an old computer screen.

British Gas (5) won the MacRobert Award in 1989 for the intelligent pig (pipeline inspection gauge) that travels along inaccessible pipelines to inspect for defects. Ted reimagined the device as almost animal in form, with magnifying glasses closely observing everything as it works its way down the pipe.

ICI (6) won the MacRobert Award in 1993 for the process and production technology, developed in record time, to manufacture the ozone-benign refrigerant Klea 134a. Ted's image reflects on the global emergency posed by chlorofluorocarbons (CFCs) damaging the ozone layer, acknowledged in the Montreal Protocol.

Soil Machine Dynamics (7) won the MacRobert Award in 1994 for the undersea cable plough. Ted was inspired by the plough's ability to simultaneously create a trench, lay and bury fibre optic cable in the extreme conditions on the ocean floor.

Microsoft (8) won the MacRobert Award in 2011 for the machine learning system for human motion capture in Kinect. Ted used a ball of thread to signify the machine absorbing a chaotic mass of data, then learning the form of a basic humanoid shape and finally progressing to tracking its movement.

Cobalt Light Systems (now Agilent) (9) won the MacRobert Award in 2014 for the airport security liquid scanner. Ted was inspired by the prisms and lasers used in Raman spectroscopy by the scanner to create a unique pattern of light that can identify specific substances in liquids, even in non-transparent materials.

Bombardier (10) won in 2019 for an innovative, resin-infused advanced composite wing, currently used on the Airbus A220 aircraft, which minimises its environmental impact. Ted created an image that reflects how the resin is injected into a vacuum within the carbon fibre wing, and is then heated under pressure to form the final shape.

CHAIRS OF THE MACROBERT AWARD JUDGING PANEL

The MacRobert Award judging panel comprises of Fellows of the Royal Academy of Engineering, representing a wide range of engineering disciplines and organisational backgrounds. Over the past 50 years the following distinguished engineers have chaired the judging panel:

Lord Hinton of Bankside OM KBE FREng FRS | 1969-1975

John Duckworth FREng | 1977- 1984

Dr Alex Moulton CBE RDI FREng | 1985-1989

John Osola CBE FREng | 1990-1994

Professor Geoff Hewitt FREng FRS | 1994-1998

Sir John Cullen FREng | 1998-2002

Dr Robin Paul CBE FREng | 2002-2006

Dr Geoffrey Robinson CBE FREng | 2006-2010

John Robinson CBE FREng | 2010-2014

Dr Dame Sue Ion DBE FREng FRS | 2014-2019

Professor Sir Richard Friend FREng FRS | 2019-2023


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