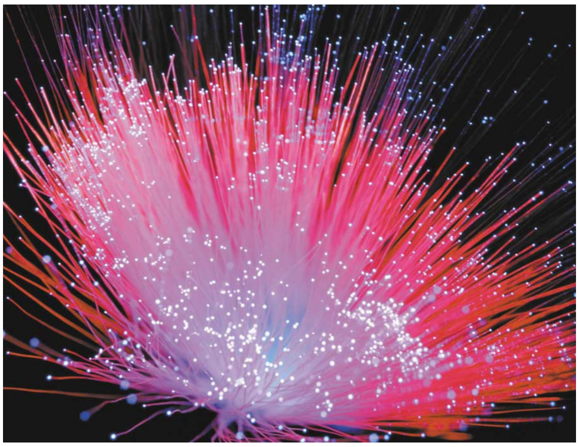
FIBRE OPTICS

- UK physicist's principle leads to research and development of fibre optics
- The UK has played a large role in improving fibre-optic technology for the medical and communications sectors over the last 50 years
- Cambridge researchers have just developed a device needed for future quantum networks – allowing future generations ever-faster communication tools

What is it

For thousands of years people have wanted to send messages over long distances. Over time we have tried many different ways, including smoke signals and drums. But the Egyptians were the first to use mirrors to reflect the Sun and send flashes to communicate. Since then light has been a useful communication tool, and as we have moved forward technologically, so has our use of light.

Flash-forward to the recent past, when researchers came up with the idea of "light through a pipe". They wanted a solution to the problems they faced in using light to communicate over long distances. The curve of the Earth's surface, plus the effects of dust and so on in the air, meant that light could only be clearly seen up to a certain distance.



The creation of optical fibres changed communication forever, as well as many other areas of technology. These strands of very pure glass, about the diameter of a human hair, let light pass through them. The light will always try to travel in one direction, but as the fibres bend round curves, the outer walls act like mirrors reflecting the light back inwards – so the light continues to travel down the fibres until reaching the other end. This is termed total internal reflection.

Over the last 50 years or so, many uses for fibre optics have been found. As well as communication, the technology also appears in medical imaging, mechanical-engineering inspection, traffic management, television and closed-circuit television (CCTV).

Significant research efforts and early manufacturing investments came from many UK-based companies including Standard Telephones and Cables (STC – now Nortel Networks), British Telecom (BT), Plessey and GEC in the 1980s. The early development of the fibre-optics industry owed much to BT, which pioneered the development of modern "singlemode" fibre optics in the 1970s, and R&D support programmes from the Department of Trade and Industry (DTI) nurtured the industry's growth.

Today the world market for fibre-optic components is estimated at £15 bn, while the market for optical communications systems is approximately £40 bn. Both are forecast to grow, driven by the tremendous increase in data traffic arising from the Internet and telecommunications generally. Within Europe, the UK is the largest fibre-optics supplier, with nearly 50% of European output.

The science

Work in this area first began back in 1870, when Irish physicist John Tyndall demonstrated that light follows the curve of a stream of water pouring from a container. It was this simple principle that led to the study and development of applications for this phenomenon.

At this time, the properties of the spun glass caught the eyes of Charles Vernon Boys, a demonstrator of physics at the Royal College of Science in London. In 1887, Boys invented a way to make thin glass fibres by building a miniature crossbow and fastening a needle to a piece of straw a few inches long. This "arrow" was stuck to one end of a glass rod with sealing wax and the glass was heated until it softened. When fired it pulled a fibre tail from the molten glass. He worked further in this area, but not so far as to include light in his research.

Moving forward, Scottish inventor John Logie Baird patented a method of transmitting light in a glass rod for use in an early colour TV, but the optical losses inherent in the materials at the time made it impractical to use.

It was in the 1950s and 1960s that more research and development took place that led to fibre optics as we know it today. Separate scientific teams across the world worked on solving problems, including finding a way to amplify the light so it could travel further.

A big leap was made in 1966, when engineers Charles Kao and George Hockham were working at STC's research lab in Harlow, UK. They proposed the transmission of information over glass fibre, also realizing that to make it practical, much lower losses in the cables were essential. This was the driving force behind the developments to improve the optical losses in fibre manufacturing.

The introduction of optical amplifiers (discussed overleaf) meant optical signals could be used far more widely. The explosive growth of bandwidth being demanded by telecommunications services requires the use of ever-greater portions of the optical spectrum making developments in this sector ever more profitable.

Fibre-optics timeline

1870	Irish physicist John Tyndall demonstrates that light follows the curve of a stream of water pouring from a container. This simple principle leads to the study and development of applications for this phenomenon.
1925	UK engineer John Logie Baird presents the first demonstration of television. He later goes on to register more than 178 patents including sending an image through an array of parallel tubes, transparent rods or clear fibres, which could be bent or curved.
1951	Developments in fibre optics start to gain momentum, with separate research groups led by van Heel and Hansen (the Netherlands), Brian O'Brien (US) and Hopkins and Kapany (UK).
1954	First prototypes of fibre optics begin appearing.
1966	UK engineers Charles Kao and George Hockham focus on transferring information over glass fibres, and develop the concept of total internal reflection.
1977	Transmission of television signals using optical fibres is achieved.
1978	AT&T and the British Post Office announce 10 year plans to develop transatlantic fibre cable; it is successfully launched in 1988.
1986	Fibre-optic cable across the English Channel goes into service.
1991	A Japanese researcher sends a signal through 1 million km of fibre
2000	A trio of blind patients receive the world's first "bionic eyes", comprising 3500 microscopic solar cells which act to convert light into electrical impulses.
2003	Japanese scientists develop an optical camouflage system which may be in production by 2008.
2005	Researchers at Toshiba Research Europe in Cambridge announce that they have developed a fibre-optic device needed for future quantum networks, allowing future generations ever-faster communication tools.

Future developments

UK companies and universities continue to carry out research in these areas, since it is obvious that the "information generation" will need ever-faster connections. Fibre optics is the only technology that can offer true "broadband" connections greater than 10 Mbit/s, and it is clear that research and development needs to take place in order for fibre optics to improve.

Many UK start-ups are helping push this market forward, along with academic support from collaborations. The last five years have seen two major projects of interest, UPDATES and PHOTON, both supported by the DTI and the Engineering and Physical Sciences Research Council (EPSRC). Ultrafast Photonics for Datacomms Above Terabit Speeds is a £10.5 m collaboration between five universities and seven industrial partners. Based at the University of St Andrews, the project is working on generating the technology required for the development of the next generation of photonics with the aim of operating at speeds in excess of 100 Tbit/s (1×10^{14} bits of data per second). The £5 m PHOTON project (Physical-Layer High-Speed Optoelectronics for Tomorrow's Optical Networks) will perform basic materials and device research to enable this goal. Six universities and seven companies are principally involved.

Benefits and applications

Today's fibre-optics industry has brought about many benefits across a range of industries. Its low-loss, high-bandwidth properties make it perfect for today's world, where we would be lost without phones, e-mail and broadband Internet access. Fibres' light weight and small size allowed them to take over for old copper cables; in addition, they are much cheaper to produce.

Other benefits, particularly in the communications sector, include less signal degradation, low power use, more security, non-flammable properties, immunity from electromagnetic interference (making the technology perfect for communications in hostile environments) and flexibility.

Optical amplifiers

An optical amplifier is a device that amplifies an optical signal directly, without the need to first convert it to an electrical signal, then amplify it electrically before reconverting it to an optical signal.

The creation of optical fibres changed communication forever.

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