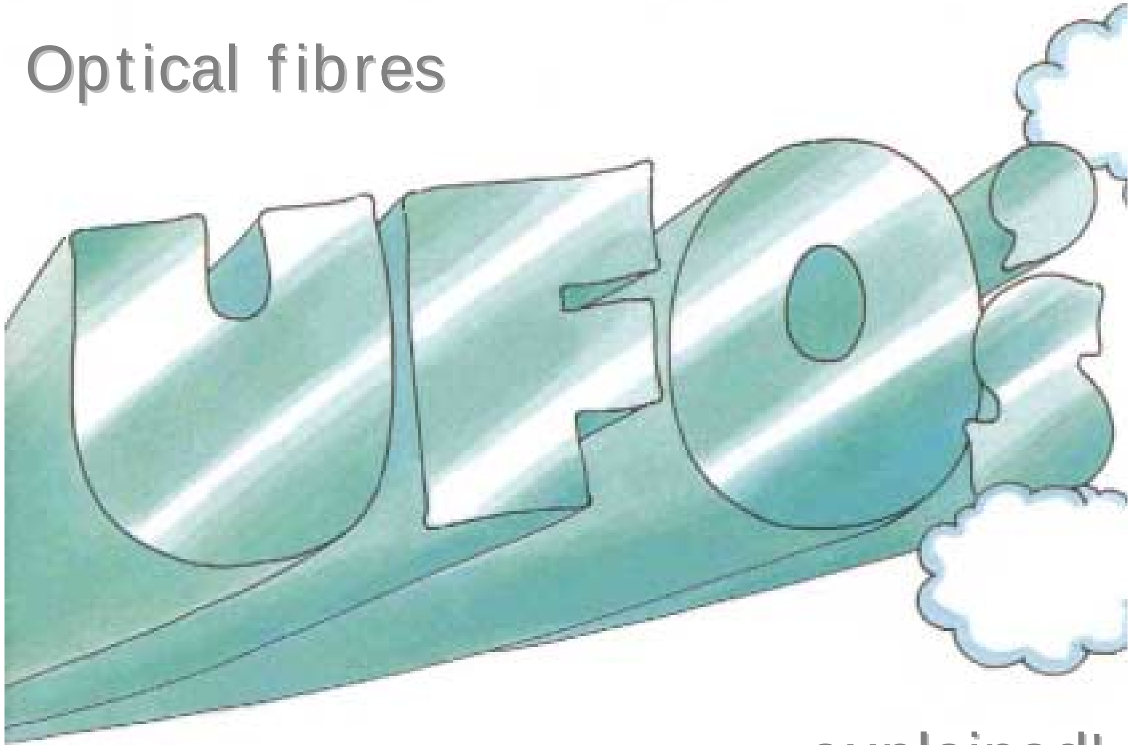
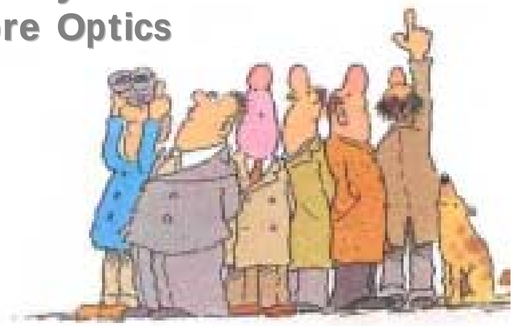
Optical fibres



explained!

Solving the mystery of Unexplained Fibre Optics



FIA
The Fibreoptic Industry Association
www.fibreoptic.org.uk

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UFO's No, they're not over your head.

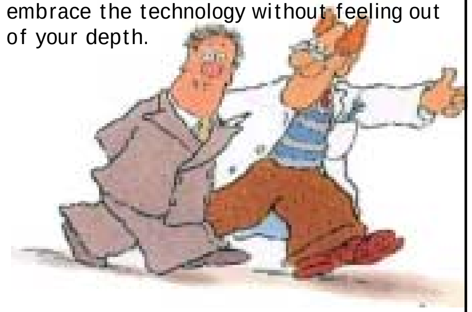
If any mention of fibre optics has you running for the hills, panic not; help is at hand. It's only a mystery because no one has bothered to explain it to you.

Well, that's where this little book, produced by the Fibreoptic Industry Association, can help. It won't make you a world-leading authority, but it will get you on the first few rungs of the ladder and help you to talk knowledgeably on the subject.

And that's important. Sooner or later, you'll want to put fibre optics to work in your own business or industry, so it makes the best possible sense to start learning about it here and now.

You'll be surprised to discover how straightforward and logical it all is. Yes, it's an exciting new technology. And yes, it holds terrific promise for the future. But fibre optics are already here and in widespread use. They're making life easier and a lot more convenient for you right now.

Pick up a 'phone, visit the bank, stop off at a petrol station, and it's almost certain you're in contact with fibre optic technology. So join us as we begin to explore the world of optical fibres. It's so simple, you'll soon feel confident to embrace the technology without feeling out of your depth.



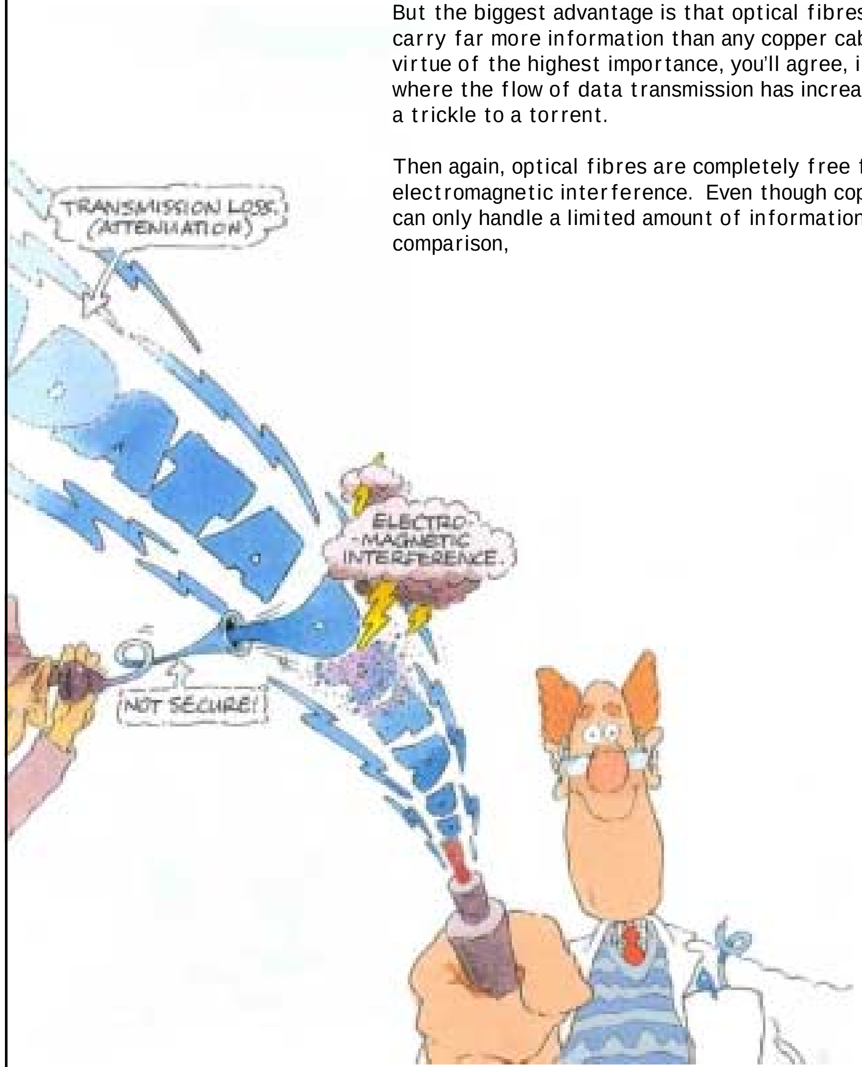
Today's cable,

Fibre optic technology has been with us for several years and has by now proved its superiority. Optical fibre systems offer so many advantages, it's easy to see why copper cables can't compete.

For one thing, optical fibre cables are much easier (and therefore cheaper) to install, being far smaller in size and lighter to handle.

But the biggest advantage is that optical fibres can carry far more information than any copper cable. A virtue of the highest importance, you'll agree, in an age where the flow of data transmission has increased from a trickle to a torrent.

Then again, optical fibres are completely free from electromagnetic interference. Even though copper cable can only handle a limited amount of information by comparison,



tomorrow's cable.

that information is all too easily corrupted due to electrical machinery, thunderstorms or 'noisy' power lines. The problem just doesn't exist for optical fibres.

Security, too, is an important point. Signals carried by optical fibres are practically immune to detection; they're effectively invulnerable to eavesdroppers.

Low attenuation is another key benefit. ('Low attenuation' is a term you'll come across time and time again in the world of fibre optics, so you might as well know what it means from the start). It's simply a way of describing low transmission loss. Which means that a message can be trusted to go long distances from sender to recipient, intact, without needing a boost from regenerators along the way.

You need another good reason? How about safety. Optical fibre cables will not – indeed, cannot – produce sparks. Which makes them highly desirable in areas where a stray spark could result in a big bang.

Information at light speed.

Copper cables carry messages by electricity. Optical cables carry messages by light.

But what's so new about light being used to transmit signals? Our forefathers lit warning beacons when invaders threatened. The Ancient Greeks used the heliograph, a movable mirror that reflected the sun's rays and could flash coded signals across great distances. Lighthouses are still in service, and traffic lights (when obeyed) are still keeping death off the roads.

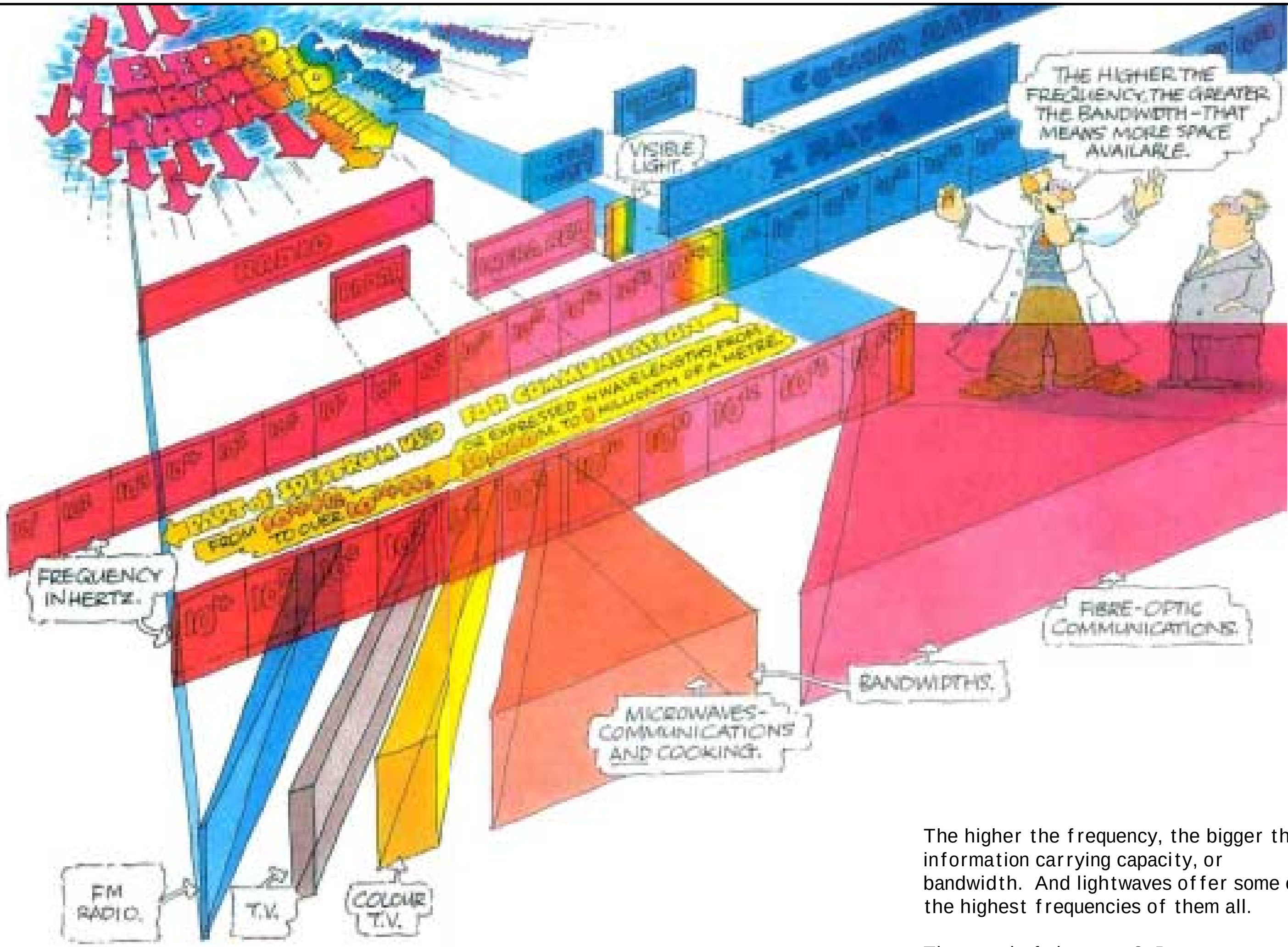
In optical fibres, we're using light in an altogether more sophisticated way. We're also using an altogether different kind of light, but we'll get round to that later.

First, you need to know about radio waves and light waves, and why the latter is a far superior transmitter of data. It all becomes clear as you cast an eye over the electromagnetic spectrum.

You will not be surprised to see radio waves there, but the presence of light waves may puzzle you. The truth is, radio waves, microwaves, infra-red, visible light, ultra-violet, X-rays and gamma-rays are all forms of electromagnetic radiation. Just one big happy family, waltzing along at the speed of light which, as we all know, is 300,000,000 metres (186,000 miles) per second.

There are two ways of measuring these waves –
-wavelength… the distance between waves
-and frequency… the number of waves per second

All waves are different; they have different lengths and frequencies. The shorter the wavelength, the higher the frequency. Now, radio has a long wavelength. Take for instance BBC Radio 1 on 98.9MHz. This means the wave is repeated every 3 metres. Compare that with a visible lightwave which is repeated thousands of times over a single millimetre.



Look again at our model of the electro-magnetic spectrum, and you'll "see the light" even more clearly. Frequency is expressed in hertz (or Hz) -remember we said Radio 1 operates on 98.9MHz, and the part of the spectrum available for communication ranges from 10kHz to over 100,000 million kHz – a range of wavelengths from 30,000m to one millionth of a metre.

You'll notice that particular frequencies have been given different bands. The width of any individual band shows how much information carrying capacity is available at that particular frequency.

The higher the frequency, the bigger the information carrying capacity, or bandwidth. And lightwaves offer some of the highest frequencies of them all.

The moral of the story? Because lightwaves offer such a high bandwidth capacity they have far more space available for signals. We need all this extra room or capacity to handle the thousands of speech channels, multiplicity of TV signals, and reams of data produced by the flood of information technology.

That's why light-carrying optical fibres are set to revolutionise the entire field of communication and data transmission.

The light that's out of sight!

In the last page or two we've learned that optical fibres use light to transmit signals, and we've discovered that lightwaves can carry far more information than radio waves.

We hinted earlier that optical fibres make use of a different kind of light to the ordinary, everyday kind that you're familiar with.

We need a kind of light that can be guided along a solid rod of the finest purity glass advanced technology can produce. Ordinary light wouldn't do at all.

To explain. In fibre optics, messages are first converted from electrical impulses into lightwaves. The lightwaves travel through the fibre (which, as we said, is a rod of extra-ordinarily pure glass) until it reaches the receiving end. At this stage the message is converted back into electricity by a piece of electronic equipment called a 'receiver.'

It turns out that receivers are at their best when dealing with a kind of light called infra-red. It also turns out that the special glass used in fibre optics – about which more later – is also at its best with infra-red.

Fascinating stuff, infra-red. It's invisible to the human eye in the same way that 'dog whistles' are inaudible to the human ear. Yet you can use it to produce highly dramatic colour or black-and-white images on specially sensitised films, using an infra-red filter over the camera lens to black out all other wavelengths.

Gun-sights that 'see in the dark' have been modified to pick out infra-red radiating from target objects. Thermal cameras operate on the same principle to detect heat leaking through an uninsulated roof. Hospital scanners use infra-red to explore possible damage in the deepest recesses of the human body or brain.

And if you have a remote-control television, it's good old infra-red that squirts from your handset to the TV to switch channels or Ceefax.

But it's in fibre optics that infra-red really comes into its own – pumping voice, video and data transmissions down thousands of kilometres of optical fibre – and never an unwanted signal to annoy or confuse.

Mind you, we can find a little job for visible light too. It has it's uses as a guidelight for motorway signs, jazzy advertising displays, and medical endoscopes.

That's enough theory for the moment. Right now, it's time we looked at optical fibres at work today. Join us overleaf…

And you thought fibre optics were new!

In a whole range of communications and data transmission installations, optical fibre cables are already making major contributions. On these pages, we'll run through a selection of applications where optical fibre cables have been chosen – and explain the reasons for that choice.

Data Transmission
Optical fibre cables are the products of advanced technology; designed in and for the computer age. They are better suited for the purpose than older copper-based types. The unique combination of high bandwidth and low transmission loss means higher data rates and more freedom for the user to decide where to locate computers and their peripherals.

Telemetry
Telemetry is the process of monitoring the behaviour of electronically operated machinery over long or short distances by remote control. Here again, high transmission capacity plus low transmission loss are the chief benefits. But there's another big plus point that has particular appeal to industrial users; optical fibre cables are not susceptible to interference from heavy electrical equipment. Signal integrity is thus assured.

Closed Circuit TV
Monitoring a wide range of industrial applications, CCTV cameras often have to operate in harsh or hostile environments. Faultless performance can only be assured by the combination of high bandwidth and zero crosstalk characteristics of optical fibre cables. (Crosstalk refers to unwanted signals caused by adjacent conductors in copper cables).

Telecom
The degree of high bandwidth that only optical fibres can provide is crucially important in the world of telecommunications. But keeping loss of signals down to the barest minimum is equally essential. Optical fibres serve both needs by supporting high transmission capacity with low transmission loss. Of course, cables are often routed through underground ducts where space can be severely limited.

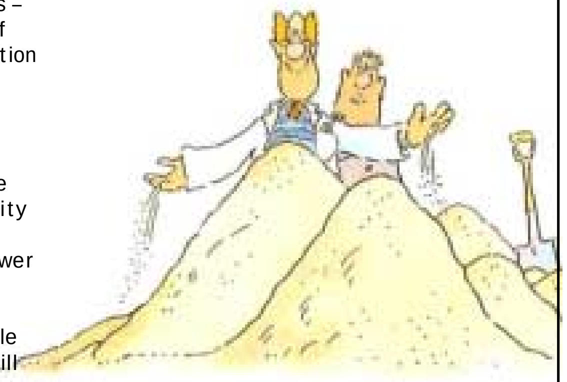
Because of the small physical size of optical fibres, many more can be incorporated into a cable reducing the overall space required in underground ducts.

The emergence of optical fibre technology has enabled both existing telecom operators and newly emerging competitors to build high quality, high capacity networks.

Today telephone companies, cable TV operators, electricity utilities and railway companies all rely on optical fibres in order to carry the majority of their communication services, including telephony, high speed data and television pictures.

Military
Security of communications is a question of prime importance in the military field. Optical fibre cables, offering complete immunity to signal detection, are clearly the ideal solution. The low size and weight of these cables answers the need for compact, lightweight equipment in battlefield conditions. The key benefits of high transmission capacity coupled with low transmission loss pay off in optimum performance under the harshest of operating conditions.

Hazardous Areas
On top of all their other advantages, optical fibres have another inherent benefit that makes them particularly suited for use in hazardous areas such as petrol stations and installation in the oil, gas and petrochemical industries – being non-metallic, they are incapable of producing sparks. Thus, the risk of ignition in fire-prone areas is greatly reduced.



Why now?
The hunger for more information! Take just one area, data transmission. As the swell becomes a tidal wave, the availability of a transmission medium which offers much higher signal capacity and much lower signal losses – amongst the many other advantages – can only increase the effectiveness of the entire process while pushing the limits of technology back still further.

Conventional copper cable systems are hard pressed to keep up with the mounting speed of development in communication and information technology. They were never designed to handle the range of tasks they're now being called upon to perform. In many cases, they've already reached the limit of their operating parameters. Put simply, they just can't cope.

Fibre optics technology, on the other hand, is a child of the high-tech age; born to thrive in the fast-changing world of electronics. It is both an essential part of this rapid advance, and the means by which related user-industries can keep pace.

Cost–effective?
Yes! To begin with, sand (of which more later), the basic raw material of an optical fibre, is cheaper than copper, but more seriously, increased production volume and advancing technology have brought the cost of adopting fibre optics down substantially. The sound financial sense of investing in modern technology with plenty of growth potential, rather than one which is becoming increasingly obsolete, is obvious: more for your money.

Future capacity
Optical fibre cables positively encourage you to install capacity now which caters for future demand. The savings to be made in this way are even more pertinent than present costs. Remember this if you're cabling a new building, or digging a cable trench for the installation of other services

A glass full of light.

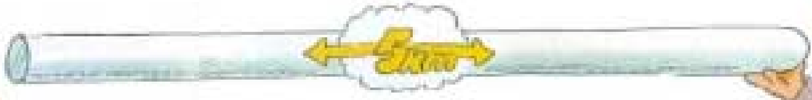
Having read this far, you know more than most people about optical fibre cables. You know that they offer a host of superior benefits. You've seen some of the important contributions they're making in communications and data transmission right now. And you're aware that they offer terrific potential for the future.

Now you're ready to discover just what an optical fibre is, and how it's made.

Put simply, an optical fibre is a solid rod of glass finer than a strand of human hair. The fibre is surprisingly very flexible. In the same way that electricity travels along wires, infra-red light is guided along the fibre in a continuous beam, or as digital on/off pulses.

The finished optical fibre looks simple enough… the making of one is anything but. To begin with, you can't use any old glass. Only glass of the most exceptional purity will do. Glass so pure that a solid block of the stuff 5km thick would be as transparent as a pristine window pane – and without any of the distortions and impurities that cause a sheet of ordinary glass to look green when you examine it edge on.

As already mentioned, the major ingredient is



sand. But, again, not the kind that fills your sandals and sandwiches at the beach. This is a special kind of sand called silica.

Why do we need a silica glass so pure?

Because its purpose is to transmit infra-red light reliably and efficiently over long distances. Ordinary glass would lose the signal beyond recovery within a few metres; impurities would scatter the light in the fibre, rather as light is lost in fog. In the optical fibre, we have at last conquered the problem of 'conducting' light without any hindrance from fog, rain or dust.

The manufacturing process takes place in the driest, cleanest environment that time, money and a heck of a lot of patience can buy. A speck of dust or a stray fingerprint, and the job's destroyed.

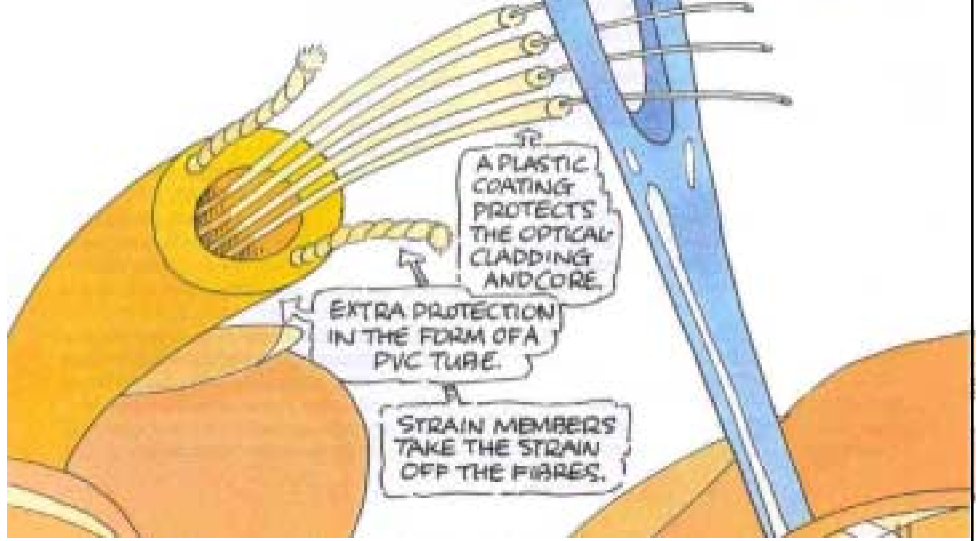
Remember, an optical fibre is the wispiest strand of silica glass, and solid all the way through. Yet things are going on in there that would make the hair rise on your head. You see, light is not merely zipping along in any kind of an orderly fashion. It's positively bouncing and bending, dashing this way and that.

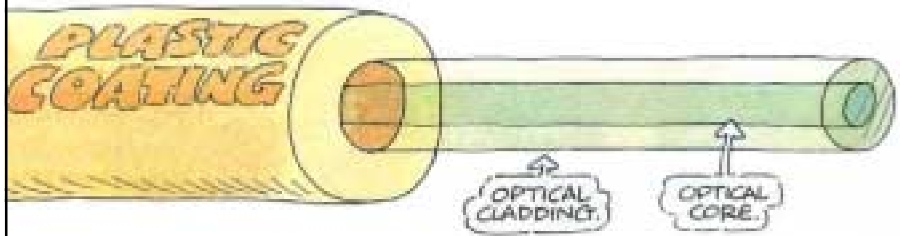
Frantic is the word for it.

Now, mind, it's strictly controlled. Every bounce and bend is predetermined. Let's get to the heart of the matter. The innermost core of the optical fibre is silica glass of the highest density. Infra-red light is guided along the core. Being glass, you'd expect the light to shoot out of it in all directions. But it doesn't, because …

From the core the silica glass graduates to form a slightly less dense outer cladding. Light is reflected back from the outer cladding to the core, and continues its travels, bouncing along from side to side, from cladding to core. Protection is provided by …

A plastic coating, covering the optical cladding and core, preventing external dust particles and moisture from attacking the glass.





Different fibre types.

What the blazes gets into light when it gets inside an optical fibre? What possesses it to go leaping about like a wild thing?

Well it's all done for a purpose. For reasons too technical to go into, light follows a different path along different types of optical fibre. It never get the chance to choose its own path, because it's guided every step of the way from transmitter to receiver. Nothing wild or random about it.

(By the way, if you want to make yourself understood when the talk turns to optical fibres, don't say 'path' - say mode. It means the same thing).

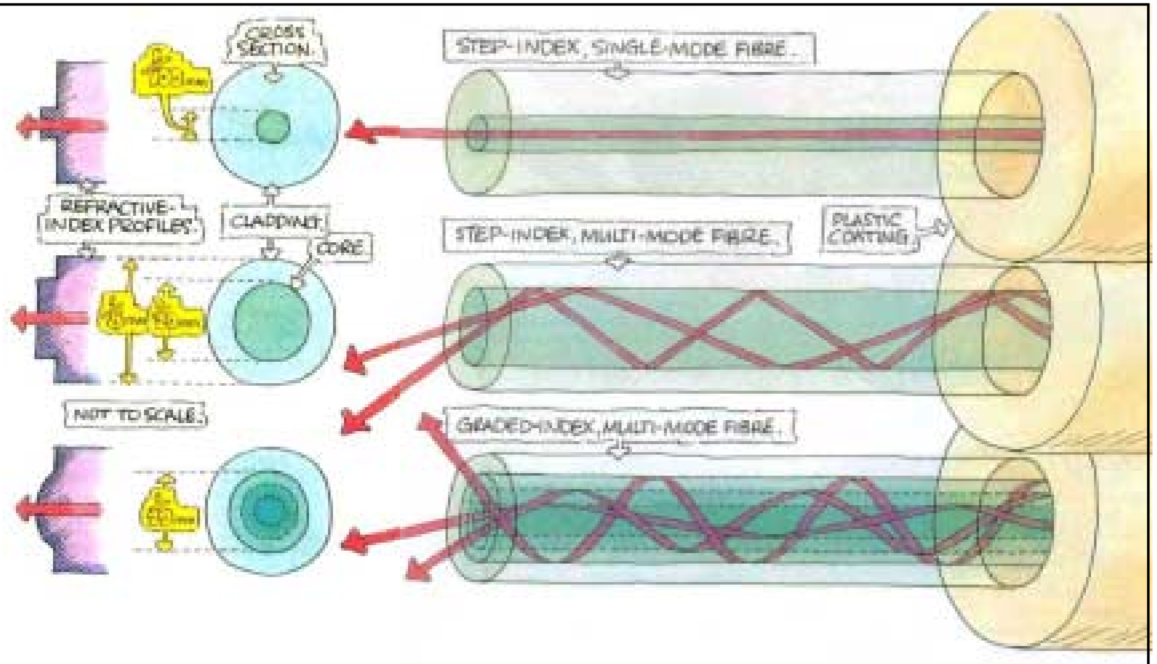
Now, you'll be asking yourself, how do you set about guiding light so it bends and bounces along the right mode? It's all down to that wonderful stuff, silica glass. And the awesome degree of control that goes into forming it into an optical fibre.

The glass itself is given different degrees of optical density at certain points. When the light passes from a high density region into a low density region, it bends or bounces. And vice versa.

In other words, higher and lower densities in the same rod of silica glass control the way light behaves.

Optical engineers, of course, never use plain words like 'bending' and 'bouncing'. They prefer 'refraction' and 'reflection'. It'll do you no harm to learn the difference between the two.

When light hits a reflective surface, like a mirror, it bounces back. That's reflection. When light passes from one medium through to another of a different density, it bends. That's refraction. Pour yourself a nice glass of water, stand your door-key in it, and watch how the key appears to bend as its image passes from water to your eye.



Now we'll look at the different types of optical fibre on the market right now.

First, there's Single Mode Fibre. As the name suggests, light can only follow one mode in this type of fibre. That's because the core is exceptionally narrow. Single mode fibres offer the greatest information carrying capacity of all the fibre types, and can support the longest transmission distances.

Multimode Fibres normally have a wide core and give light a wide choice of modes. There are two kinds to consider…

In Step Index Multimode Fibres, an abrupt and definite change occurs between areas of low and high density. The shift from one level of density to another causes light to bounce.

In Graded Index Multimode Fibres, the change between low and high density areas within the fibre happens gradually. Light is gently bent rather than bounced. This type of fibre offers two advantages over step index multimode: longer transmission distances and higher bandwidth.

When optical engineers talk about these differences, you'll hear them use the phrase 'refractive index profile'. Do not be alarmed. It's simply a way of showing, in diagram form, the different levels/variation of density within the fibre. Which is something you now understand. (Unless you skipped the last three paragraphs).

You may be wondering why we go to all the bother. Why can't we manage with just one kind of optical fibre?

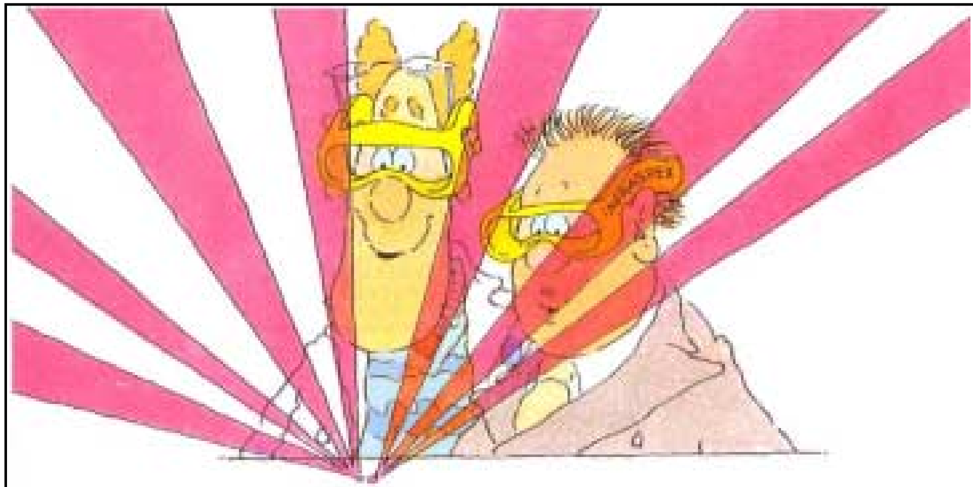
Well, think of all the industries that are either using or are about to use optical fibre systems. Think of the different jobs they'll have to perform.

Computer Engineering, Data Transmission, Remote Control Engineering, High Voltage Engineering, Chemical Processes, Surveillance Systems, High Security Systems, Aviation and Space Technology…

You'd hardly expect areas of such diversity to get by on just one standard fibre type, would you?

That's why the potential user is given a choice of fibres, each one designed to satisfy a particular set of requirements.

(The fact that such a choice is widely available simply underlines what we've been telling you all along; that fibre optics is a well-established, up-and-running technology).



Light sources.

As you know by now, optical fibres are so thin, so fine, you can pass a whole bunch of them through the eye of a darning needle. It follows, then, that the light source used to send light along them also has to be incredibly slender.

In short, we need the minutest light source capable of concentrating the highest amount of power down the fibre.

A light bulb couldn't do it. For one thing, it scatters light far and wide without discrimination.

Fortunately, we have a choice of two light sources (or transmitters) which are eminently suitable for the job. We can use either small light-emitting diodes (LEDs), or LASER 'chips'.

You're familiar with LEDs – the little indicator lights on hi-fi systems, car dashboard indicators, and so forth.

LASER chips, like LEDs, are made from tiny chemical crystals which generate light when excited by electricity. They're a lot more expensive than cheap and cheerful LEDs, and are used only when the very purest infra-red light is needed to provide extra high data-rate performance.

Unlike ordinary light, LASER light can consist of single wavelengths concentrated into a straight beam. The chip itself is no bigger than a grain of sand.

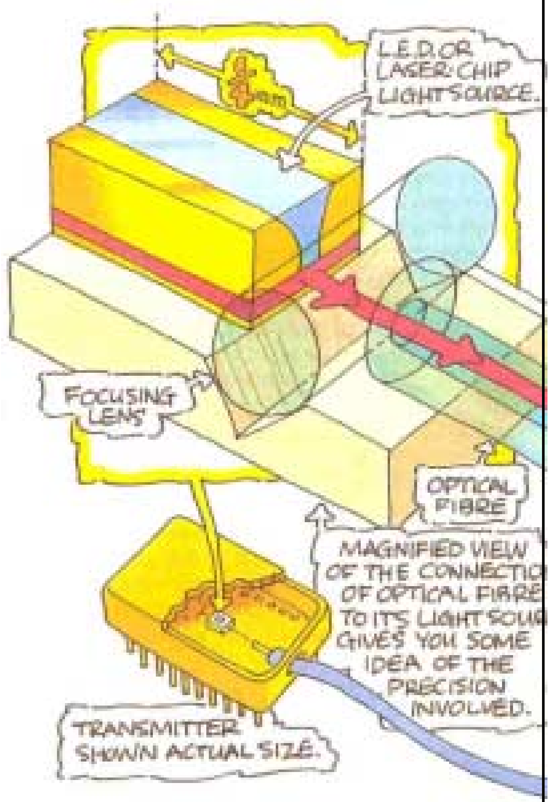
Travelling light

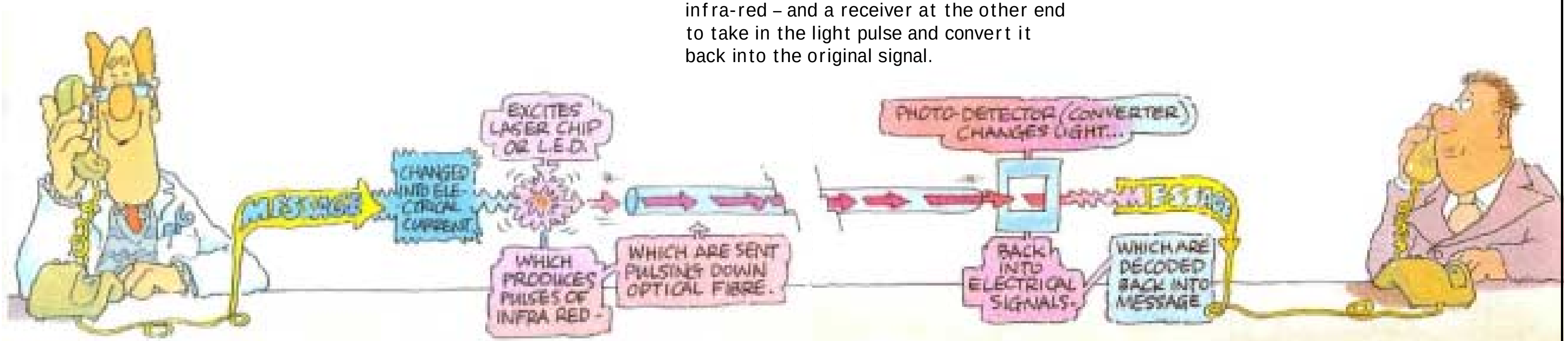
Infra-red, carrying a payload of information, is pulsed at speed down optical fibre. Light becomes a 'pulse' when a light source (transmitter) is switched on and off. LEDs and LASER chips are the only devices available capable of switching on and off fast enough.

Connecting an optical fibre to a LED or a LASER chip is a task that calls for the most critical precision. Alignment must be absolutely spot-on, or the light transmitted will be scattered and lost – along with all the data the light is carrying.

The message starts out as an electric impulse which excites the LED, or LASER chip, into emitting flashes of infra-red. These flashes – more correctly, coded 'pulses' – have to be introduced directly into the optical fibre. These pulses of light bounce along the fibre until they reach journey's end – the receiver. The receiver is a photodetector which converts the transmitted light back into an electronic impulse, which is then decoded back into the original message.

And that's how optical fibre works. A strand of silica glass, pure and fine – a highly concentrated light source pulsing signals through at one end in the form of infra-red – and a receiver at the other end to take in the light pulse and convert it back into the original signal.





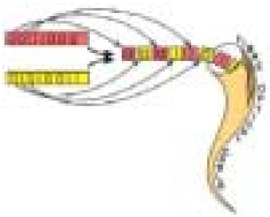
All talking together.

All talking together
Hopefully you now know how we can transmit a single message through our fibre but if we needed a single fibre for each message it would be very expensive. Remember how light is electromagnetic radiation just like radio waves but with a much shorter wavelength? Well just as radio waves can be used to transmit many programmes simultaneously so our optical fibres can carry lots of messages at the same time. In this way we are making use of all that enormous bandwidth that is available in the optical part of the spectrum.

To find out how we can simultaneously send lots of messages (we call this multiplexing) we first need to consider in a bit more detail how we send a single message, such as the spoken voice, into the flashes of light that travel down the fibre. First of all we speak into a microphone which converts our voice into an electrical signal whose strength varies with sound pressure. We then take this signal and 8000 times a second, we sample it and decide which of 256 voltage levels each sample is closest to. Now instead of transmitting the original voltage levels we send the 8 digit binary number that corresponds to it. If for instance it was closest to 56 we would send 00111000. As we do this 8000 times a second this means that for each voice channel we have to send 8 x 8000 = 64,000 ones or noughts (we call them bits) every second.

All this may seem like a lot of trouble to go to but this new digital format can also be used to carry other messages, such as TV signals, and it is of course the way that computers talk to each other naturally. Once in this form it is easy to transmit it on our fibre by simply turning our LASER off and on. As we shall see later it's also possible to decode it almost perfectly in most cases.

Time multiplexing
Now that we have our signal in this digital format if we want to send two signals aneously then we simply interleave the signals as shown. Of course this new message must only take as long to send as each of the original messages so each 'bit' can only be half as long and the transmission speed will be 128,000 bits/s.

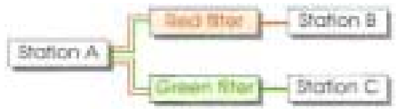


We can keep on doing this and it is not unusual to interleave almost 32,000 channels and to send over 2,500,000,000 bits every second in this way.

Wavelength multiplexing
Our fibres need to carry not just voice messages but faxes, computer messages, TV signals, internet traffic etc. etc. There is now so much demand for capacity (bits) that if we just use time multiplexing each of the bits becomes so small that it is getting difficult to send them without distortion. This has led to a new technique called 'wavelength multiplexing' to be developed.

Instead of just using one we use a number of LASERs, each one of which transmits at a different wavelength (colour). In this way we can increase the capacity of our fibre without making the bits any smaller. By using an optical filter at the decoder we can select which wavelength to listen to, much as we can tune into a particular radio station.

Another big advantage of wavelength multiplexing is that it allows us to route signals to different places without using any electronics.



The picture shows how station A transmits to station B using red light and to station C with green light, with optical filters being used to route the two signals where the fibres split into two

Overcoming transmission loss.

If you remember we said that only the purest glasses were used to make fibres and this meant that 5km of optical fibre is as clear as a normal pane of glass. But what happens if we want to transmit our signal over even longer distances? The equivalent of how many panes of glass (we call this transmission loss) can our signal travel through before it is too weak to be able to be decoded accurately?

The answer can be as great as 400km (the distance from London to Paris) depending upon exactly how much information we want to send. That's a long way for the light from one LASER chip to travel and if we care to make it travel even further then it's going to need a little help. To explain how, we are going to have to understand how our decoder works and to meet the big villain of the piece: NOISE.

Decoding light

You don't need to read a book like this to tell you that it's easier to hear a person near to you than someone who is 10m away. The reason is that the weaker the signal the more it gets lost in all the other everyday noises that are going on around us. Our light decoder has the same problem – it always generates some noise of its own which means it cannot decode any messages that come from too far away.

So how can we overcome the dreaded noise? Well, when we send our messages using pulses of light then, as long as there's not too much noise, we can decode whether a pulse has been sent or not. In fact, with digital signals, we can do this so well that we think there's something wrong if we make even a single error in decoding a billion pulses of light. So one way of overcoming noise is to add something we call a regenerator into our optical fibre just before the signal gets too weak to be reliably decoded. This decodes the message almost perfectly and then retransmits it at a higher signal level using a LASER chip. Because we do this almost perfectly each time, we can continue to do this over and over again and send our signal half way round the world if required. We call this process regeneration.

Optical amplifiers

Regeneration is fine if we are only transmitting a single wavelength of light and we know exactly how many bits per second of information we are sending. It is, however, a complicated process in that we keep having to turn our signal from being optical to electrical and vice versa. This has led to the development of the optical amplifier in which the weak light is amplified directly without the need for the intermediate electronics. Optical amplifiers 'boost' incoming noise as well as signal and even add a small amount of noise themselves so they have to be spaced a bit closer together than regenerators. They are, however, extremely versatile and can amplify many wavelengths at once (we would need a separate regenerator for each wavelength) making them ideal for systems carrying more than one wavelength of light.

Optical fibre cables.

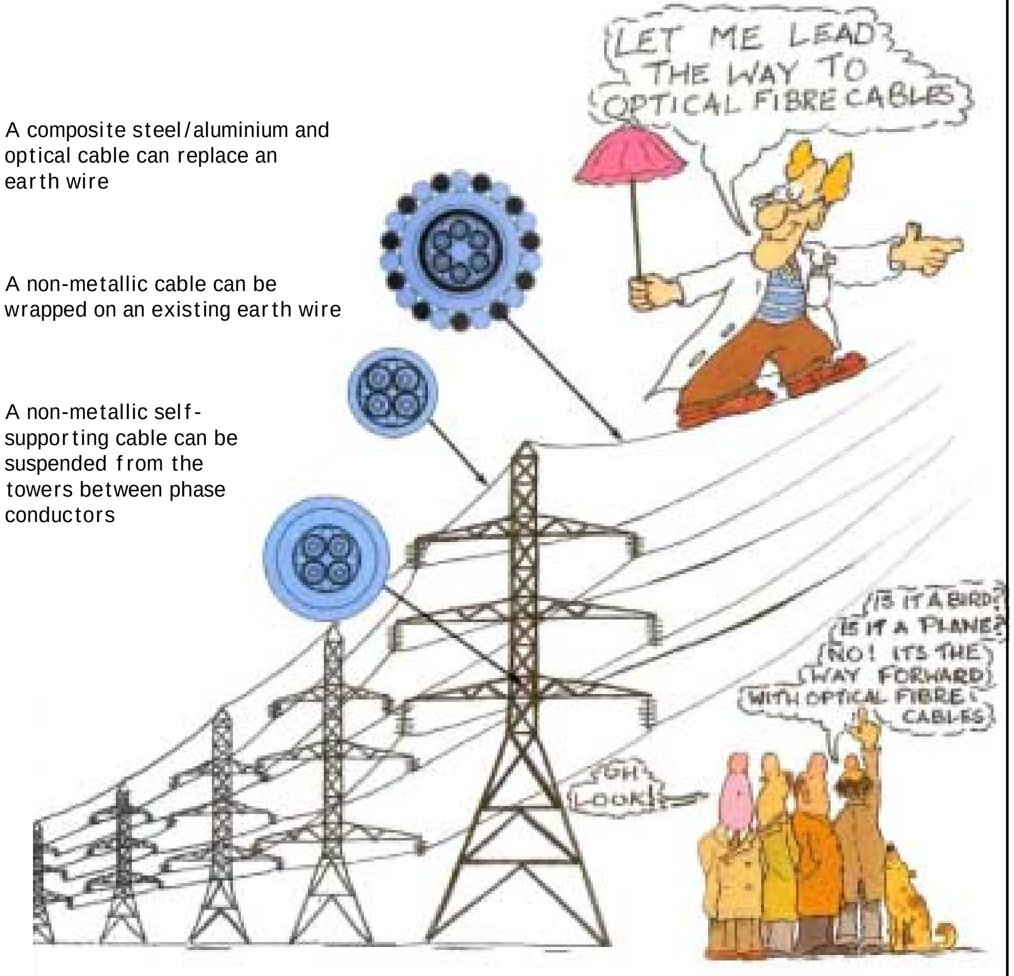
The way forward

Optical fibre cables are now even found on high voltage power lines. These are used for controlling the electricity network and to build telecommunication systems.

A composite steel/aluminium and optical cable can replace an earth wire

A non-metallic cable can be wrapped on an existing earth wire

A non-metallic self-supporting cable can be suspended from the towers between phase conductors



Making an optical cable.

As we told you earlier, the merest touch of a careless finger, no matter how well scrubbed, could ruin the fibre for keeps. It sounds like sacrilege therefore to talk of burying it underground, pushing it through sewers, or laying it on areas where it is likely to be doused with petrol or assaulted by corrosive chemicals.

You're right! It wouldn't be reasonable to send them naked into the field. Protection from rough handling and onerous environments is an absolute must.

The cable-maker builds protection around an optical fibre by building a cable around it. It's rather like cladding a knight in armour, or dressing a fireman in protective gear.

Cables are essential to any activity requiring the use of electrical power. Without a cable to connect powered equipment to a power source, the equipment's redundant and we needn't have bothered discovering electricity.

Now, while fibre optics is a fairly recent technology, cable-making has been a well established activity for over a century. There have been changes, of course; cable-makers are forever introducing new and innovative techniques. But, essentially, most of the materials and techniques used in the making of conventional copper cables can be applied to advanced optical fibre cables.

The cable-maker wants to know what job the cable is expected to perform and what sort of working conditions it's expected to endure. Only then can he/she select the right materials.

It could well be that a special cable type will be required. So every cable-maker worth his or her salt keeps a range of non-standard cables, just in case.

Is the cable to be used indoors or outdoors? Will it be buried underground, or even at sea? Does it need self-suspension qualities for an overhead installation? Will it be subject to vibration, crushing or high pressure? Does it need protection from chemicals, bacteria, rodents? Is a cable needed that generates less smoke and toxic gases in an outbreak of fire? The questions are seemingly endless, but all must be answered if the cable-maker is to select the correct materials and method of construction.

Whatever the challenge, the experienced cable-maker will have the ideal solution in his/her standard or non-standard cable ranges.

The first thing he does when he/she rolls up his/her sleeves is to put a kind of jacket on the fibre. Called in the trade a 'buffer jacket', it's the fibre's first line of defence against the unfriendly elements. There are two basic methods:

Either: Tight Buffers, i.e. plastic coatings drawn over the fibres.

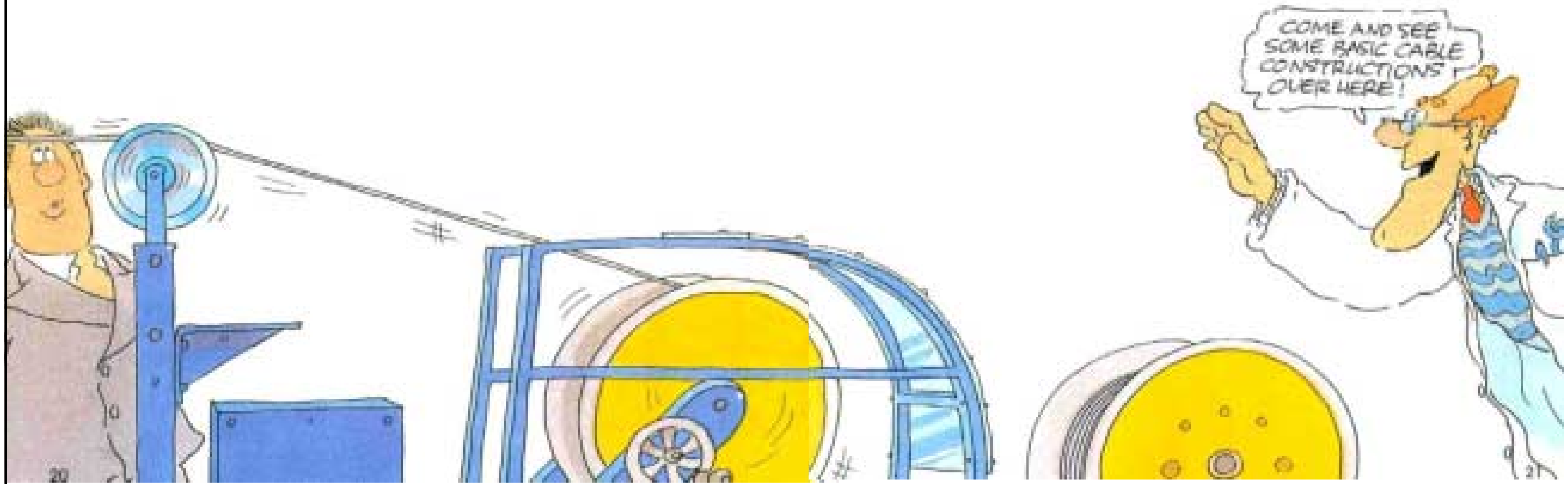
Or: Loose Buffers, i.e. fibre with the freedom to move within a cavity, a common form being a fibre in a loose tube.

To ease any strain on the precious optical fibres, he'll add strain members made of steel, glass or synthetic yarns.

What other materials might we need? Filling compounds, perhaps, to keep water out. Metallic tapes, if a really impenetrable water barrier is called for. Metallic barriers, such as lead, to keep out corrosive chemicals. The cable maker may decide to use binding tapes to bunch a number of cable elements together – carefully used, this method can isolate the cable core from any movement in the outer jacket.

Outer jacket? That's the plastic sheath that covers and protects the innards of a cable. And it's no ordinary plastic, we hasten to add. It could be a flame retardant polymer for indoor use, or polyethylene for outdoors.

Armouring could be essential, especially to provide extra protection for the cable while it's being installed. The most common forms are steel wire and steel tape, which improve the cable's resistance to crushing and an unkind cut from a spade.



You've solved the mystery.

So now you know. Fibre optic technology isn't over your head after all. It never was; you just wanted someone to explain it for you.

And you can't start learning too early. Optical fibre cables are already thoroughly established in industries throughout America, Britain and the rest of the world. Fibre optics is a 'now' technology.

But you're wondering if there's an application for fibre optics in your own field. The answer's a resounding "Yes" if you're involved with computer engineering, data transmission, the oil and petrochemical industries, telemetry, telecoms, surveillance systems, CATV, or aviation and space technology.

In all these areas, the advantages of fibre optics have proved to be far superior to those offered by any other transmission system. The exceptionally large bandwidth, for example, has the potential to carry 100,000 times more information than a coaxial cable.

Voice, data and television signals may all be combined together and transmitted over a single optical link with little loss of signal.

Optical fibres are almost completely immune to all forms of electromagnetic interference, and there's never any crosstalk between fibres.

It's virtually impossible to tap into an existing fibre optic link. This provides a level of security unobtainable with coaxial based systems.

The small size and light weight of optical fibre cables leads to lots of room for extra capacity in underground cables ducts.

In areas where the danger of explosion exists, optical fibre cables are incapable of emitting sparks.

As the input and output circuits connected to a fibre are only optically coupled, no electrical connection takes place. This results in total electrical isolation, making it possible to monitor and control high voltage installations. And since glass does not conduct electricity, there's no risk of adverse effects from a nearby lightning strike.

The end of this book isn't the end of all the help and advice you can get from the **FIA**. We're always ready and willing to share our knowledge, and we'll gladly put you on our mailing list to keep you in the know.

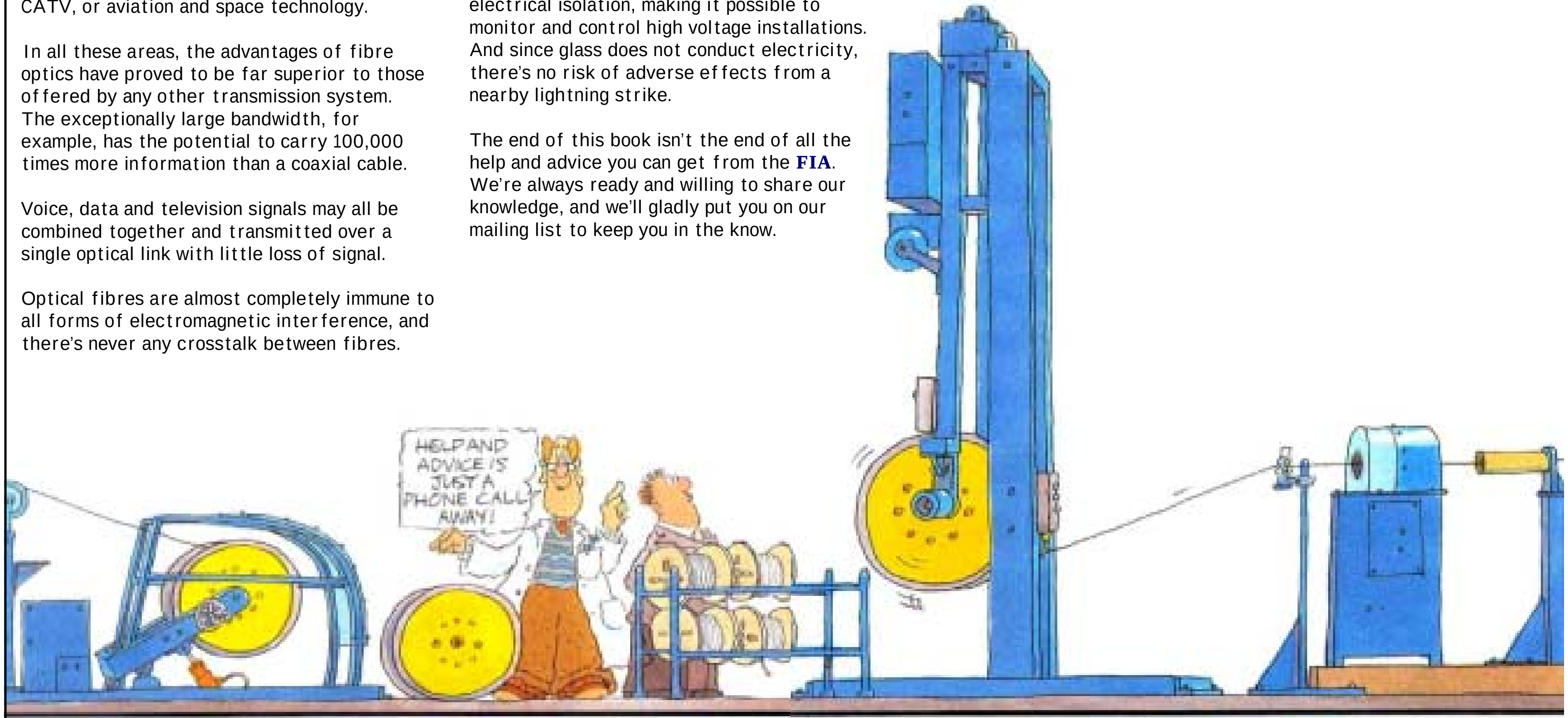
FIA Information sources

Visit the Web-site:
www.fibreoptic.org.uk

e-mail the Secretariat:
jane@fiasec.demon.co.uk

Telephone: +44 (0) 1763 273039

Members are able to access, free of charge, copies of all the FIA Technical Support documents. Non-members are able to purchase the documents from the Secretariat.



How to tell a bifurcator from …

Armour
Extra protection for a cable. Improves resistance to cutting and crushing. The most common form is steel wire.

Attenuation
A term which refers to a decrease in transmission power in an optical fibre. Usually used as a measurement, e.g. 'low attenuation' means low transmission loss.

Bandwidth
The amount of space in a given part of the electromagnetic spectrum needed to carry our communication signals, i.e. 'greater bandwidths' means more usable space.

Bifurcator
An adaptor with which a loose tube containing two optical fibres can be split into two single fibre cables. See Loose Tube.

Buffer
Material surrounding the fibre to protect it from physical damage.

Cladding
The outermost region of an optical fibre, less dense than the central core. Acts as an optical barrier to prevent transmitted light leaking away from the core.

Core
The central region of an optical fibre, through which signal-carrying infra-red light is transmitted. Manufactured from high density silica glass. See Silica Glass.

Electromagnetic
Radio waves and light are waves of energy associated with electric and magnetic fields, and are forms of radiation occurring within the electromagnetic spectrum.

Fibre Optics
It's what this book's all about.

Frequency
The number of times a signal occurs in a given period usually measured in Hertz or cycles per second. See Hertz.

Graded Index
(More precisely, graded index profile.) A term describing how the refractive index of glass used in this type of optical fibre alters gradually from the core to the optically less dense outer cladding. See Core; see Cladding.

Hertz
The unit of frequency, equivalent to one cycle per second, named after the wireless pioneer Heinrich Hertz.

Kilohertz (kHz)	Megahertz (MHz)	Gigahertz (GHz)
One thousand Hertz.	One million Hertz.	One thousand million Hertz.

Infra-Red
A form of light having a longer wavelength than ordinary constituents of white light. Invisible to the human eye.

LASER
A source of exceptionally pure light which can consist of single wavelengths concentrated into a straight beam. Used to transmit infra-red along an optical fibre; employed when high data-rate performance is required.

LED
(Light emitting diode). An electrical component which produces light when stimulated by electricity. The cheapest and most common means of transmitting infra-red along an optical fibre.

Loose Tube
Refers to a type of cable in which one or more optical fibres is/are laid loosely within a tube.

Mode
The path taken by a light ray as it travels along a fibre.

Moisture Barrier
A layer of protection built into a cable to keep water out.

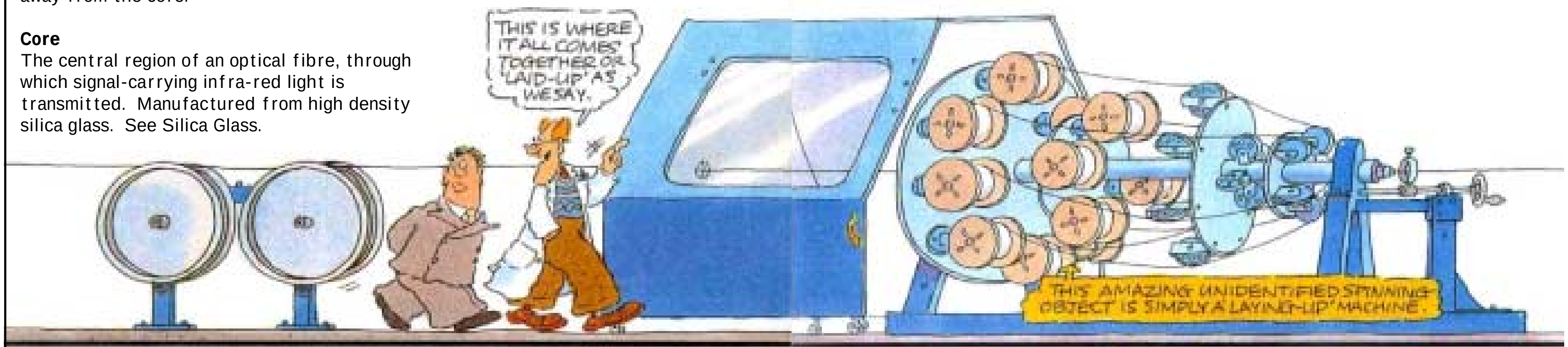
Multimode Fibre
An optical fibre which allows the signal-carrying light to travel along more than one path.

Optical Amplifiers
Devices which boost the optical signal level without converting it to an electrical signal as an intermediate stage.

Photdetector
A device at the receiving end of an optical fibre link which converts light to electrical power.

Primary Coating
A thin plastic coating applied to the outer cladding of an optical fibre. Essential in protecting the fibre from contamination and abrasion.

Refractive Index Profile
A description of how the optical density of an optical fibre alters across its diameter.



A useful glossary of terms

… a strain member

Regenerators
Devices placed at regular intervals along a transmission line to detect weak signals and re-transmit them – seldom required in a fibre optics system. (Often wrongly referred to as 'repeaters').

Sheath
The outer finish of a cable. Usually an extruded layer of either PVC or polyethylene.

Silica Glass
Exceptionally pure glass used to make an optical fibre.

Single Mode Fibre
An optical fibre so constructed that light travelling along the core can follow only one path. (Also called 'monomode').

Step Index
(More precisely, step index profile). A description of how the refractive index of glass used in this type of optical fibre graduates, in a clearly defined step, from the highest density to the lowest. The shift from one level of density to another causes the light to bounce as it travels.

Strain Member
Part of an optical fibre cable which removes any strain on the fibres. Commonly used materials include steel, glass and synthetic yarns.

Tight Buffered
A type of cable in which the optical fibres are encapsulated in a plastic material.

Time Multiplexing
Interleaving digital signals to increase data rates.

Wavelength
A measurement of the length of any electromagnetic wave. The shorter the wavelength, the higher the frequency. S
Frequency.

Wavelength Multiplexing
Using more than one wavelength of light
same fibre to allow greater rates of information transmission.