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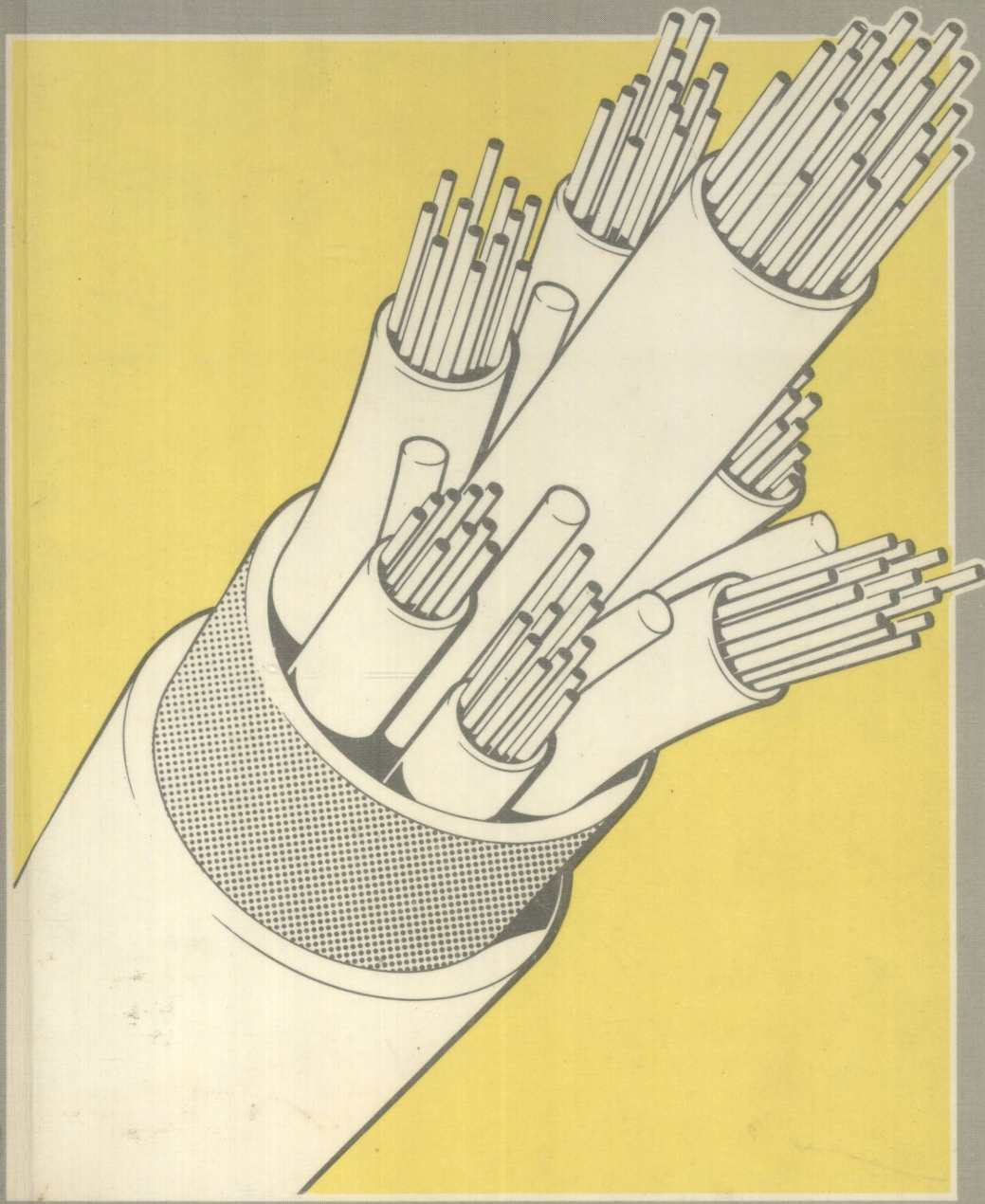
Optical Fibres



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EPO APPLIED TECHNOLOGY SERIES
VOLUME 5

The surveys of this series have been made by the examiners of the European Patent Office at The Hague (The Netherlands) who are most competent in the technology concerned.

The present survey encompasses the most recent developments in the field and rests on a selection made by the authors among the patent and non-patent literature available at the EUROPEAN PATENT OFFICE (EPO).

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Foreword

A long way has been gone since Graham Bell's proposal to send speech over visible light beams, a century ago. Since then, low-loss fibres, high-power LED's and lasers as well as sensitive p-i-n and APD detectors have provided the basis for a new technology, allowing the transition from a laboratory curiosity into operational use. Why is there such an interest in this new communication medium? Let a single example provide the answer.

A copper link between a radar transceiver and its consoles requires 47 cables carrying 375 separate signal lines and five hefty copper wires to help subdue the effects of large earth loops. The copper installation weighs 7 tons and costs $ 1 million. The fibre-cable version requires a single cable of seven strands, weighs 15 pounds and costs $ 30,000.

This is not enough. A fibre-optic link has many advantages, a few disadvantages and many potential applications.

Advantages

- smaller cable size and weight (easier to install, to handle, to store) compatible with integrated-circuit dimensions
- immunity to electromagnetic interference (radiofrequency or electromagnetic-pulse interference)
- eliminates earth loops
- no electromagnetic emission (does not radiate any signals and has no noise emission problems), few cross-talk problems, security against electromagnetic eavesdropping
- much greater bandwidth (accepts wide-band or multiplexed signals), easily upgraded in bandwidth

- free from sparking, safe in explosive atmosphere, no short-circuits, does not attract lightning, freedom to route cable through water, at a high temperature, in a highly electrical field

- handles high voltages without isolation transformers

- potentially lower cost, savings in energy.

Disadvantages

- as a new phenomenon, may need trained personnel familiar with interconnection techniques and suffer customer acceptance problems due to a reluctance to abandon well-proven systems

- not yet standardized, possibly existing inferior-product support

- inherent limitations such as light-launching difficulties, attenuation in sharp bends, reflection noise, backward scattering, etc.

Applications

Earth-based systems

° The "wired city" concept. It is expected that copper cables can be exchanged for fibre-optic cables in a 1 : 1 proportion in existing conventional services (telephony, cable TV, data transmission), ISDN (integrated services digital networks) are in the making.

° Long-haul transmissions with repeaters at a national or international network level (digital and analogous).

° Medium- and short-haul applications such as private signal wiring or printed-circuit board to printed-circuit board signal transfer, cabling in severe environments (nuclear, chemical), computer networks, distributed-data processing.

° Measuring instrumentation.

° Industrial control with optical sensors, signal transfer from rotating parts.

° Submarine cabling.

° Applications in power plants, radar installations, railroad operations, petroleum explorations, motor cars, medicines, robotics.

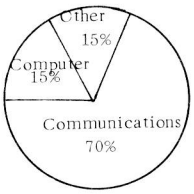
° Avionics cabling with substantial weight reduction.

° Navionics cabling (aboard-ship systems).

Potential Market

The world-wide market share of fibre-optics is estimated at $ 600 million in 1985 and at $ 1,000 million in 1990.

Fibre-optic transmission challenges the satellite links, radio links and all kinds of wire links. In addition to being a replacement of existing services, fibre-optic links compete for applications such as broad-band integrated networks offering new services (alarm, banking, etc.).



Predictions related to fibre-optics production.

In 1985 : 1 million km at $ 0.6 a meter : $ 600 million.
In 1990 : 10 million km at $ 0.1 a meter : $ 1,000 million.

Present Situation

Fibre-production capacity 800,000 km/year, 40 manufacturers of data links, multiplexers and transducers, 15 experimental fibre-optic local networks.

Future of the Fibre-Optic Technology

This new technology will compete with existing transmission technology and probably supersede a great deal of it. In the mean time, many new components such as integrated optics will have to prove that the photon can replace the electron. Right now, it looks that way. Undoubtedly, the new technology will have a great impact on diverse systems, with social and cultural implications.

The Monograph

Such an interest in fibre-optic technology goes along with much research and patent activity. However, we feel that this technology remains a mystery to many engineers and scientists. The aim of the present monograph is to clear up the mystery by explaining the technology from a practical point of view by making use of the latest information disclosed in patent and other literature from all over the world. In particular, this monograph is a survey of such literature to be found in the parts of the systematically arranged search files of the European Patent Office referred to as subclasses C03B, G02S and H04B of the International Patent Classification.

The monograph is divided into three parts : the first one deals with the manufacture of optical fibres, the second describes optical-fibre connectors, terminals and branches, and the third one is concerned with the major optoelectronic components encountered in optical-communication systems.

Since there are thousands of relevant documents, this survey cannot refer to all of them and a selection had to be made. We have eschewed the historical approach and, instead, have chosen those documents which best illustrate the present state of the art in all its variations. Thus, along with selecting documents representing the main aspects, we have also selected those which show, and claim to solve, the various practical difficulties that can arise.

The documents chosen have been abstracted and/or important sections have been quoted. If a particular patent or article is of interest, greater detail and further embodiments can usually be obtained from the full version. Similar or related patents have also been mentioned so as to provide the reader with a basis for further investigation. Furthermore, since many modern patents (US, GB, DE, EP, WO) nowadays publish the citations that have been raised against them, one can quickly build up a detailed picture by looking up these citations.

For convenience, the patent and other documents have been referred to by their number or title.*

It has been assumed that the reader has no previous knowledge of the subject and so, whenever possible, the simplest examples of each aspect have been used. However, no necessary complexity has been deliberately avoided and the survey should mention all the details and techniques required for a comprehensive knowledge of the art presented here.

A monograph of this sort, reflecting current thinking in topical areas of technology, will be useful to research scientists and engineers or patent personnel who are engaged in the field concerned.

It also provides the newcomer with an opportunity to familiarize himself with the specific problems of the technology involved.

Taking into account that patent literature is, in many areas, from five to six years ahead of the final development of its subject, such a monograph provides a working tool much more up to date than traditional books or manuals usually written and published after the final development stage.

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* See "Note on Cited Patent Documents" (opposite page).

NOTE ON CITED PATENT DOCUMENTS

In this monograph, a great number of patents and published patent applications are cited, using an international two-letter country code, *i.e.*:

DE = Germany (Federal Republic)
EP = European Patent Office (EPO)
FR = France
GB = United Kingdom
JP = Japan *)
NL = The Netherlands
SU = USSR
US = United States of America
WO = International Bureau of W.I.P.O. **)

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*) All cited documents are published patent applications (Kokai Tokkyo).

**) Patent applications published under the Patent Cooperation Treaty (PCT).

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MAKING OF OPTICAL FIBRES

CHAPTER I

Manufacture of Optical Fibres

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