OPTICAL FIBERS COMMUNICATIONS
——A REVIEW FROM A LAYMAN

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I. A BRIEF HISTORY OF OPTICAL FIBERS COMMUNICATIONS

As early as August 1964, an author in an address to the British Association for the Advancement of Science speculated on the use of light and glass fibers in the telephone network instead of electric currents and wires. But it was not started at that moment. The first serious proposal to employ the optical fibers as a telecommunications transmission meduim was presented in 1966 by K.C. Kao and G.A. Hockham, a Chinese engineer and an English engineer, respectively, in STL (which is in England).

At the time the problem seemed a formidable one; that is the attenuation of existing fibers was about 1000 dB/km, the bandwidth was expected to be low and fiber bundles were fragile. (see Electronic Inventions 1745-1976, pp. 137-138, 1977 edition)

However, it was not until 1970 that a low-loss fiber of 20 dB /km was achieved by Corning Glass Works in the United States. From then on, progress in the field of optical fibers transmission has been both rapid and abundant. The reduction of fiber loss to 2 dB /km at wavelenghth = o.82 λ m and 0.5 dB /km at =1.2 μ m has been succeeded in field tests. Futhermore, the reliability of the AlGaAs injection laser diode (LD), operating continuously at room temperature, has been improved dramatically to a mean life in excess of 10^6 hours.

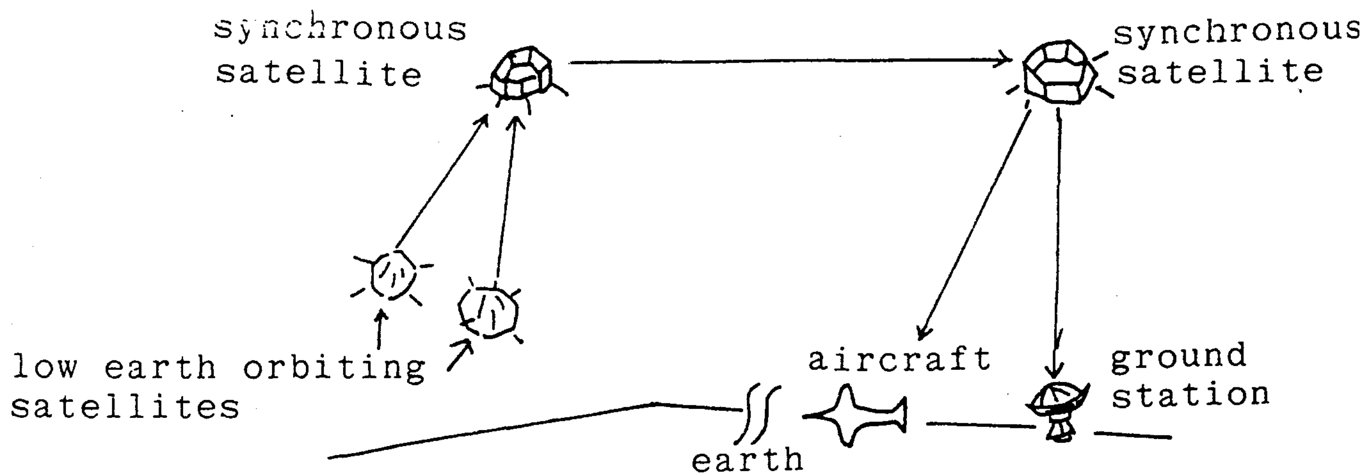
In general, the transmission media with large information-carrying capacity has long been a strong motivating force in telecommunications research. Even if laser and optical fibers communications have been applied and tested very well in research, in the near future, "commercial applications are likely to be limited by the ability of potential users and suppliers to understand and apply the technology and to establish standards". (see IEEE SPECTRUM, "Optical Systems: A Review," Oct. 1979, p.70)

II. LASER AND FIBER OPTICAL COMMUNICATION SYSTEMS

A beam of light can transmit thousands, even millions, of times more information per second than a conventional wire or cable. Based on this idea, there are two approaches to study the laser and optical fiber communication systems; atmospheric system and waveguide system. The atmospheric system does not rely on wires or cables; this means there is nothing between a receiver and a sender except the air information is transmitted through atmosphere by light, i.e.,laser beam. But the reliability and the usefulness of this system are limited by adverse weather conditions such as fog, rain,dust, snow, etc.

To define briefly the optical communications, we can say, "Optical communications means modulating a beam of light with information at one point and transmitting it to another where it is detected." (see MOSAIC, "Communicating with Light," Vol:4, No.3, 1973, p.4)

The basic theory of optical communications can be shown as follows:



(1) Low earth orbiting satellities are generating data from various locations, transmit the data to a synchronous satellite.

(2) Synchronous satellites relay the data to other synchronous satellite or receivers located in the continental United States.

In comparison with the atmospheric system, the waveguide system which uses optical fibers as the transmission has some important features stimulating research and development in laser and fiber optic communications. These features are:

- low transmission loss (greater distance between repeaters),
- wide transmission bandwidth,

- potential low cost,
- insensitivity to electromagnetic and radio-frequency interference,
- improved security compared with electronic cabling (no cross-talk among parallel cables),
- relatively small size, light weight, high strength, and flexibility,
- elimination of combustion or sparks caused by short circuits,
- flexibility in upgrading system capacity without need to install new cables,
- immunity to ground-loop problems,
- suitability for digital communications and pulsemodulation methods (fiber-optic cable losses are independent of transmission frequency),
- fewer government regulatory difficulties (because of the elimination of frequency allocation), and
- suitability for relatively high temperature.

(see IEEE SPECTRUM, Oct. 1979, p.70)

(also see IEEE SPECTRUM, Feb. 1977,p.33; MOSAIC Vol:4, No.3, 1973, pp. 3-5; IEEE

SPECTRUM, Jan. 1978, p.31.)

Owing to the advantages of optical fibers are feasible today, scientists think that lightwave communications using fiber optic transmission will have a major role in the future of modern communications.

III. THE DEVELOPMENTS AND APPLICATIONS IN THE WORLD

The following tables show the developments and applications of optical fiber communication systems in the world, including the United States and Canada, European countries, and Japan.

OPERATIONAL OPTICAL-WAVEGUIDE SYSTEMS

User-Location	Date	Bit Rate Mb/sec	Type of Cable	Route Length, Km	Repeater Spacing	Light Source λnm	Detector	Splices	Comments
1. Walt Disney World Orlando, Fla.	7/78	44.7	NEC-6 graded-index, 4-step index	8.7	5.1km	Injection Laser Diode (ILD) 830	Avalanche Photo Diode (APD)	Fusion	1. Excellent reliability 2. Interoffice trunk 3. Subscriber loop planned (1980) 4. Severe season experience: ok 5. Voice, data, music
2. Bell Canada-Nontreal	10/77	6.3	Bell Northern Research - 6 fibers, 5.2 dB/km, 1.2ns/km	1.5 (6 km tested)	-	LED 830 (light Emitting Diode)	PIN	Epoxy	1. Excellent Reliability 2. Assess practicality, economics, technology, maintenance 3. Underground conduit
3. AT&T - Chicago	5/77	44.7	Western Electric - 24 fibers (2 ribbons), 5.1 dB/km, 550 MHz.km	2.6	-	ILD LED 820	APD	Epoxy	1. Excellent reliability 2. Logical follow-up to Atlanta 3. Video, data, telephone service 4. Evaluate fibers for wide range of services
4. General Telephone of California - Long Beach, Calif.	4/77	1.544	General Cable 6-fiber ribbon, 6.2 dB/km	9	3.7km	LED 820	APD	Epoxy	1. Excellent reliability 2. Live telephone traffic
5. Central Telephone-Las Vegas, Nev.	12/77	1.544	Valtec-6 fibers, 5.1 dB/km, 150 MHz.km	4.5	-	ILD820	APD	Epoxy Lensed	1. Excellent reliability
6. Commonwealth of Kentucky - Lexinfton, KY.	12/78	Video	Times Fiber - 6 fibers, 8 dB/km, 400 MHz.km	2	-	ILD850	PIN	Lensed	1. Emergency warnings 2. Educational TV 3. Public information
7. Teleprompter - Lompoc, Calif.	12/78	12TV	Times Fiber - 3 fibers 6 dB/kn 400 MHz.km	8.2	2	ILD850	APD	Lensed	1. Replaces microwave link 2. 90 percent arerial; 10 percent duct 3. serves 6000 subscribers
8. British Columbia Telephone - Canada	3/79	44.7	Corning-Phillips - 2 fibers, 4db/km, 2 ns/km	7.2	-	ILD850	APD	Epoxy	1. Field trial; live traffic 2. Cable geometry test 3. 1-year test and evaluation
9. Australian Defense Department Australia	6/77	6	Amalgamated Wireless Australasia - 3 fibers, 6.5 dB/km, 4.8 nsec/km	2.3	-	LED	PIN	Epoxy	1. Essentially error-free 2. Aerial, plowed, duct 3. First effort in Australia
10. Mountain Bell - Phoenix, Ariz.	6/79	44.7	Siecor - 6 fibers, graded index, 10 dB/km, 200 MHz.km	2.8	-	ILD850	APD	Fusion epoxy	1. - 30° to 65°C; 90 percent relative humidity

OPERATIONAL OPTICAL-WAVEGUIDE SYSTEMS

User-Location	Date	Bit Rate Mb/sec	Type of Cable	Route Length, Km	Repeater Spacing	Light Source λnm	Detector	Splices	Comments
11. Western Telecommunications -- Colorado Springs, Colorado	12/78	1.544	Siecor - 8 fibers, 10 dB/km, 400 MHz.km	1	-	LED850	PIN		1. NORAD central office to 2-GHz radio site
12. BCN Fiber Optics -- London, Ontario	12/78	15 TV 12 FM stereo 322.2 Mb/s per fiber	Canstar-Corning - 8 fibers, 8 dB/km, 600 MHz.km	8.5	2.5km	ILD850	APD	Fusion epoxy	1. Aerial and burried cable 2. CATV supertrunk 3. To - 40°C 4. 1 - year test and evaluation
13. United Telephone of Pennsylvania -- Carlisle, Pa.	3/79	44.7	Siecor - 6 fibers 4.4dB/km, 620 MHz.km	12.3	6km	ILD830	APD	Fusion epoxy	1. Carlisle to Holly Springs 2. Buried, ductd, and aerial sections 3. Test of practicality
14. General Telephone of Indiana, Ft. Wayne	3/79	44.7	Siecor - 10 fiber, 6 fibers, 4.4 dB/km, 640 MHz.km	4.3	-	ILD850	APD	Fusion epoxy	1. Cost savings of 36 percent 2. Central office to central office 3. Permanent installation 4. Activation of fibers as needed
15. Bell Canada -- Yorkville, Toronto	12/78	Video Telephone	Northern Telecommunications -- 12 fibers, 4 dB/km, 200 MHz.km	1.4	-	LED840	PIN	Fusion	1. In-service test 2. Subscriber 100p: 108 fibers 3. 4 bidirectional single fibers 4. Simulated CATV to test site
16. Alberta, Government Telephone -- Calgary, Canada	11/79	274	Corning-Canstar -- 12 fibers, 8 dB/km, 600 MHz.km	52	3.5km	ILD850	APD	Fusion epoxy	1. - 40°C to 50°C 2. Microprocessor-based controller 3. Harsh environment 4. 37 km plowed, some aerial
17. Commonwealth Telephone -- Mansfield -- Wellsboro, Pa.	4/79	44.7	ITT - 5 fibers, 6 dB/km, [illegible] MHz.km	22	4km	ILD850	APD	Fusion	1. Plowed, aerial, duct 2. Central office to central office 3. Lack of fiber standards a hindrance
18. RKO/Cablecom -- Joplin, Mo.	2/79	5 MHz video per fiber	Siecor - 4 fibers, 4 dB/km, 540 MHz.km	6	3km	LED850	APD	Fusion	1. 3-km lengths of cable 2. Siemens hardware 3. Aerial installation
19. Viacom -- Islip, N.Y.	12/78	11 MHz video audio	Valtec -- [illegible] fibers 4 dB/km, [illegible]0 MHz.km	2.7	-	ILD800	PIN	Epoxy	1. Studio-quality video plus voice 2. Permanent aerial installation 3. One channel on one fiber

PIN = An intrinstic layer between P - Njunction

(Copied from IEEE SPCTRUM, Oct., 1979, pp.72-73)

JAPANESE OPTICAL-COMMUNICATION SYSTEMS

Organization	Objective	Date of First Transmission	Cable Length (km)	Signal	Comments
Yokosuka Electrical Communication Laboratory (ECL)	LT	10/76	8 T.C.A.	32Mb/s	Four cables are installed in single conduit
Nippon Telegraph and Telephone (NTT)	LT	1/78	4	100Mb/s 400Mb/s	
	LT	10/78	2 1 2	32Mb/s 100Mb/s 400Mb/s 800Mb/s	Repeaterless-span is 52.6 km at 100 Mb/s. λ= 1.3 μm
	LT	4/79	2	800Mb/s	λ= 1.3 μm; single mode fiber
	FT	9/78	18.7 T,C 2.1 T	32Mb/s 100Mb/s 43±25MHz	
		9/78	0.3X2	6.3Mb/s 32Mb/s	Intraoffice
Tokyo Electric Power Co.	IS	3/78	6.3 A	1.5Mb/s	EMI protection
Kyushu Electric Power Co.	CT	3/78	6	32Mb/s	EMI protection
Chubu Electric Power Co.	FT	9/77	0.3	10MHz ± 150 KHz	Lightning surge protection
NHK	CT	3/78	0.15	16.5 - 22.5 MHz	WDM λ = 0.8, 0.875 μm; Lightning surge protection
ECL, NTT	IT	4/78	4	10 Hz - 6 MHz	Interactive TV; WDM λ=0.7, 0.82, 0.9, 1.2μm
	FT	12/78	0.12	10 Hz - 6 MHz	TV Conference System; WDM λ = 0.83, 1.2 μm
Visual Information Systems Development Assoc.	FT	7/78	14 6 30 A	-7 MHz	Hi-Ovis CATV (Interactive TV)
Hokuriku Electric Power Co.	FT	11/78	0.2 0.3	-	Weather survey telemetry

Note: LT = Laboratory test　IS = In service
FT = Field trials　T = Tunnel cable
CT = Commercial test　C = Conduit

A = Aerial
WDM = Wavelength division multiplexing
Hi - Ovis = Higashi-Ikoma Optical Visual Information System

(copied from IEEE SPECTRUM, Oct. 1979, p.75)

BRITISH POINT-TO-POINT OPTICAL TRANSMISSION SYSTEMS

Repeater Spacing, km	Route Length, km	Line Rate MBd	Cable/ Fiber	Source	Establishment	Status/ Location	Repeater Location
8Mb/s - 120 Channel Systems							
13	13	10-14	BICC/Corning	Post office Laser	Post Office	Operational/ Martlesham-Ipswich	Building
7	13	10-14	BICC/Corning	BNR LED	Post Office	Operational/ Martlesham - Kesgrave-Ipswich	Building
6	12	11-26	BICC/Corning	Plessey LED	Plessey/ BICC	Being installed/ slough-Burnham - Maidenhead	Buried and building
9	9	-	STC	STL Laser	STC Co.	Stevenage - Hitchin	Building
140Mb/s - 1920 Channel Systems							
8	6	159-16	BICC/Corning	STL Laser	Post Office	Operational/ Martlesham - Kesgrave	Building
3	9	147-46	STC	STL Laser	STC Co.	Operational/ Stevenage - Hitchin	Buried and Building

(Copied from IEEE SPETRUM Oct., 1979, p.77)

Four phases of development are apparent in the evolution of optical fiber communication systems. (see IEEE SPECTRUM, Oct 1979, p.71).

Phase 1: low data rates, usually less than 100 Mb/s, are common. The applications are mostly for interoffice and special purpose links, such as aircraft and shipboard use.

Phase 2: where the technology appears to be at present, cost drop rather quickly, and users are less inclined to be scared off by the risks of fiber communications. Community antennatelevision operators begin to see economic benefits in the applicaiton of fibers.

Phase 3: which seems imminent, is marked by operators at more than 100 Mb/s. The use of fibers in trunk lines will be the hallmark of this phase. In addition certain innovative applications will emerge. New sophistication in terminal devices will lead to the penetration of fibers in subscriber loop networks. People in computer science and telephone industry have been studying this for a couple of years.

Phase 4: will almost surely see the use of devices suitable for longer wavelengths ($\lambda > 1000$ nm), monomode fibers, and integrated optical repeaters,. Maybe submarine-cable applications and other long-haul systems will be designed with optical communication links.

Under the consideration of technology, these four phases are feasibel in the future and at present. Thinking about the social and ecomonic barriers, the optical communication systtems will take time to be applied pervasively among our society.

In the United States and in Canada, telephone operating companies that have been polled report that the allure of the new technology entered into their decision to use fibers rather than metallic waveguides. General speaking, after using fiber optics into their operating systems, the General Telephone Company in Indiana predicts that the fiber system represents a 35 percent saving. The other example in North America is two Canadian installations which are used in two-way subscriber loops to telephone customers (see details in the front pages of tables). One of the installations is a joint ventures by Bell Northern Research, Northern Telecom, and Bell Canada. "The system consists of a subscriber loop connected to 45 customers. It provides. telephone service and has the potential for adding community antenna television. Interactive CATV is provided to a test site that is part of the link. The fiber drop cable goes directly to the customer's premises, where transition is made to the conventional telephone connection. Four of the customers have a full duplex connection to a bidirectional single-fiber transmission line. A clever fusion divider is used to split the bidirectional signal". (see IEEE SPECTRUM, "Optical Systems: A Review," Oct. 1979, p.73)

In Japan, low-loss optical fiber technology, including both device fabrication and transmission equipment, has been made very advanced progress in public communications, video transmission, data links and electric power control. And, except for the technology of wavelength division multiplexing, Nippon Telegraph and Telephone Corp. is also enthusiastic about the development of high-bit-rate technology.

In Europe, operation of optical communicaiton links at 8 Mb/s and 34 Mb/s and 140 Mb/s appears practical. The long repeater separations, and reliable operation have been achieved. When high-volume production is established, optical fiber systems can offer the possibility of very low-cost transmission. But with multiple manufactures and low overall growth rates, this will be hard to achieve until there is a need for many new transmission systems. Even if there is an interest in the use of fiber links for wideband services to customers, which services include business teleconference links and interactive community service (CATV) trials, there are very wide variations in this service from country to country in Europe.

Briefly speaking, there are some achievements done in West Germany, France, Sweden, Belgium, Netherlands, Italy, and England.

It is beyond dispute that "optical fibers are appearing everywhere, according to Allen A. Boraiko's reporting (see National Geographic, "Harnessing Light by a Thread," Oct. 1979, p.516 & 518). However, the more sophisticated and pervasive applications still depend on the more advanced research in the future, not only in technology but in social and economic aspects also.

IV. THE FUTURE OF LASER AND FIBER OPTIC COMMUNICATIONS

The idea of laser and fiber optic communication has been introduced for almost 25 years since 1966. Dr. Lee L. Davenport, chief scientist and a vice-president of General Telephone Electronics Corportion, says that laser and optical fibers "may bring greater change in our lives than anything since the computer and transistor. It ushers in the fiberoptics revolution". (see National Geographic, "Harnessing Light by a Thread," Oct. 1979, p.518). No matter whether Dr. Davenport's prediction will become true or not in the future, at present, fiber-optics has been used into communication systems and is studied by some private industrial companies and governmental organizations. Bucause of the development of tiny light sources and the perfection fo high-purity glass and the important features and advantages of fiber-opics, it is beyond dispute that the optical and laser communication system will play a very important role in the future telecommunication systems.

From the standpoints of scientists, optical systems promise a new dimension of information exchange. Because one optical conductor can transmit, over long distances, several thousand voice circuits or an integration of voice, video, and data services, the technology of fibre-optics may offer a solution to the integration of services in the coming information age.

In general, the largest near-term market for fiber optics is telephony -- inter-office trunk and microwave-radio and power utility entrance links. The dielectric characteristic of optical fiber technology supports data transmission without concern for group loops, potential gradients, and pickup in the cable. And some developers of inexpensive integrated data transceivers offer fiber optic links as features within existing product lines. Except for the market of telephony, "other established, but specialized, market for fiber-optic hardware are in the government military and video industries; radar entrance and electromagnetic-pulse-resistant links have been built for government agencies; and short urban television trunk, satellite earth-station entrance and security system links are typical video applications". (see detail in Microwave Journal ,"Fiber Optic Communications: Another Electromagnetic Wave Technology", Vol: 22, No.7, July 1979, p.16 and p.18.)

As G.Harlan Carothers, Jr., the vice president and general manager of Harris Government Inforamtion Systems Division, says "there is promise that fiber optic systems will be principal in meeting the information growth demads of the 1980s". And, it is the new era of telecommunications, in which the telephone, computer and data, and video industries merge, that will make fiber optic systems a major imdustry. A predication which is made by a market forecasting company shows that within the next decade worldwide sales of optical fiber asemblies of communictation system will increase annually at an average 50 percent from 1978-1985, and at 20 percent from 1985-1990. The assemblies include the cable, source, detector, connectori and splices.

The follwing table shows the projections in millions of dollars.

	1978	1985	1990
United States	21	350	889
Canada	6	40	85
Japan	2	91	333
Europe	10	178	462
Total	39	659	1770

(copied from IEEE SPECTRUM, Oct. 1979, p.70)

Since the feasibility of optical fibers system is inevitable, it is possible that the optical fibers system will replace a part of the conventional communication systems in the near future, The efficiency and economy of technology will be more available for people in the future than now.

V. TECHNICAL FEASIBILITY

The optical fibers system will not replace the conventional system totally. Even if the optical fiber system of technology is to reduce cost, power consumption, and the size of telephone equipment, while increasing reliability and service features, there are still some limiting factors in applying this new technology in telecommunications. Because of not only the relatively long time it takes to design and deploy equipment, but also reluctance to use it while older equipment is still performing well, the optical fibers system will not replace the conventional communication system totally and quickly. It is true that the optical fiber has been used in telecommunications, but the wires and cables which are wired with copper will not be replaced with threads of glass for decades, and not even then unless some problems in optical communications are solved. The problems are such as: the fibers cannot be made infinitely long, they cannot be soldered because the fibers cannot run together end to end, the lasers are not reliable, the semiconductor lasers are limited by their need for cooling, their wavelengths, and their poorer coherence. Perhaps integrated optics will overcome these problems when the integrated electronics develops very well in industry.

In fact, the conversion to all opticsystems is the high cost of replacing existing usable facilities at present. Therefore, fiber optics systems are seldom chosen unless present facilities are either exhausted or must be replaced. (see detail in Optical Spectra, "Communications Spectra", Oct. 1979, p.54.)

In genreal, there are not serious problems for the technical feasibility of optical fibers communication system. The technology is there now. And it is thriving in telecommunications. It will be like the telephone, radio, television and cable television accepted gradually by people.

VI. SOCIAL IMPACT

Dr. C. K. Kao, the first engineer who introduced the idea of optical fibers for communication, says "I think people will need what fiber optics has to offer and in getting it, it, we'll see fiber optics produce major changes in the way we live and work, perhaps by the year 2000". (see National Geographic, "Harnessing Light by a Thread", Oct. 1979, p.534.)

According to the technological history of the telephone, radio, television, computer, and electronics, we do find out that those technologies have changed people's life and work. For instance, telephones give people a convenient access to communicate to each other; televisions change people's home life and habit; computers and calculators take over lots of labor work.

Since the laser and fiber optics is a kind of combined technoloyg with lasers, telephones, computers, integrated circuits, and so on it is true that the optical communications will have much influence on our society when optical fibers system becomes available for everyone.

"The messages of modern society -- a computer-oriented society -- far exceed the capabilities of signal fires and crystal sets, and eventually they (i.e., optical communications) will transcend the capacities of microwaves and millimeter waves". (MOSAIC, "Communicating with Light", Vol:4, No.3, Summer 1973, p.7) Because the need for information and knowledge is increasing in modern society, optical fibers may become as indispensable to urban lives as electric power lines and water mains. In the future, optical fibers system will reach to every home. And, it will fill the role that promises a new dimension of information change. At that time, as Marshall McLuhan says that the global village will come true. Since the optical communication system can supply all the information such as telephone, radio, television, facsimile, etc., through a thread of fiber optics, people can exchange information easily and quickly. The more information exchange, the larger channel capacity the optical fibers can supply. In other words, when optical communications come true and reach to each home, people can use picture-phone, telex, facsimile, and mini-computer at a low price whenever they want to use. Gradually, the information data bank, education data base, and electronic library will become available to everyone. Above all, because of the advanced development of computer and electronics, optical fibers technology has been made much progress for applications and developments.

In short, the optical fibers communication system will cause another revolution -- the information processing revolution -- and will drastically increase the social mobility in the future. Since the convenience and economy of communication channel is there, the amount of information change among people and the activity of human communication may be increased and extended.

VII. PROBLEMS IN THE FUTURE

Waldemar Kaempffert says, "...technology has so far been applied chiefly in winning wars and making profits, changing the environment and improving man's material condition". (see detail in Technology and Social Change. The Past Century -- and the Next -- in Science"., 1972, p.121.) According to the preceding statement, in the future there will not be serious technical problems in optical fibers communication system. However, the serious problems will be like the ownership, the management, the operation, and so on.

1. Ownership

In telecommunicatios, debate has continued within the FCC over the distinction between data processing (e.g. computer) and data communications (e.g. telephone) for years. Commercially, this means and increased emphasis on marketing-based approaches to data networks, as opposed to the traditional technology-based strategies for developing new products. At the heart of the controversy is the Bell Data Network which belongs to AT & T.

According to some observers, the Bell Data Network, labeled a communications network could be used as the basis for a telephone-based shopping and bill-paying system. This system is similar to the data-processing applications served by computer firms like IBM. "Under the terms of the 1956 consent decree, AT&T is limited to being a common communications carrier, which effectively bars it from anything to do with the actual processing of information". (IEEE SPECTRUM, January 1978, p.33)

FCC decisions continue to favor competition for equipment manufactures , as well as to reflect an awareness of interconnection by business and residential customers. Anyway, as a result, the telephone companies may supplement their lease-only practices with direct sales of main station telephones, key systems and private branch exchanges.

The other case is that Satellite Business Systems (SBS) -- a combined venture of IBM, Comsat, and Aetna Life & Casualty -- has proposed a network of on-premise earth terminals for use by some corporate customers such as CATV operators, broadcasters, and newspaper services. This is supposed to be a part of data communications which belongs to AT&T's (or IT&T's) business.

At present the distinction between data processing and data communications is still a controversial issue. As the advent of optical communications, this issue will become more complicated than now. And, at that time, it will be the debate not only between AT&T and IBM but also among all the business involved in telecommunications because the optical communications can convey all the information for customers through fiber optics, presumably and technically.

2. Monoply or Competition

This problem is related to "ownership", too. In many European countries, to some extent, the optical fibers system is developing limitedly because it has to be supported by the government or meet the satisfactory standards given bv the government. At present there are both practical and economic limits to the amount of information that can be transmitted by way of fiber optics. No one, except the government or the giant companies, can afford the experimental work of optical communications. In the United States, the optical fibers system is developing in the "monoply-capitalist period of communications institutions". (This term is copied from Raymond Williams' book -- Television: Technology & Cultural Form, 1975.)

It will become monoplly if the optical fibres system is developing under the control of government or the support of those giant companies. Whether monoply or competition is a contest which involves regulatory agencies, the courts, private industry, and the nation's largest legal monopoly (e. g. AT&T) in the States. Owning to the well-developed telecommunications and the good service offered by AT&T company, most people assume that the monopoly is inevitable and not painful. So they see the position of AT&T (or other giant companies) as a "natural monopoly".

The pros and cons of monopoly versus competition in the communications industry are very complex. Don Mennie has explained very clearly, "Certainly involved are several reasoned, contrasting philosophies about who can make best use of capital and labor in meeting expanding communications needs; arguments that monopoly business practices are not well suited to the swift introduction of new or specialized communications services; and the chained detrimental effect extensive competition would have on the cost and quality of residential phone service..." (see detail in IEEE SPECTRUM, January 1977, p. 46.) In IEEE SPECTRUM (1977 Jan.), Don Mennie rediscussed the issue of monopoly and competition in communications industry. There is still no solution, up to now.

In retrospect, there is not definite answer for whether monopoly or competition is good for people. When the optical communications become available to everyone, the issue of whether monopoly or competition will be complex for the policy-makers for sure.

3. Regulatory

Because of the difficulty to understand technologies, policy-makers will have problems to make decisions if they do not consult with experts about expertise. But, today's scientists or engineers have been involved, more or less, in the complicated situation. Such as people in the Bell System are the most qualified persons to evaluate the telephone system. And, most of them are likely to be chosen as the consultants for a regulatory board to regulate the telephone system, because outside of the Bell System there may not have experts know much about telephones.

VIII, CONCLUSION

After reviewing the literature of optical fibers communications, I doubt whether fiber-optics are appropriate to every country or not. The idea of communicating with light come out of laboratory and the developments and applications of optical fibers are thriving in those well-developed countries. Because of the explosion of information, the pervasive applications of computer, and the frequent usage of telephone in those countries, the advent of optical communications becomes fast and urgent. No one can precisely predict its influence on human society. It will become a part of human life like today's TV and telephone for American people, but it may not go into some people's living for ever like people live in some isolated islands.

Technology is a part of human culture. However, for different people, the need for technology may be very different. Therefore, what is appropriate technology will be more important than how to develop and apply new technology for every and for different people.