A Construction Support System for Optical Fiber Networks

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ABSTRACT The expansion of optical fiber networks has created an increasing demand for greater efficiency and higher quality in cable laying and repair work. This paper reports on the development of a compact, simple system for the support of optical fiber testing and measuring work in the course of construction. In this system a small, lightweight portable terminal is used to operate an Optical Time Domain Reflectometer and Optical Fiber Selector that are installed at a considerable distance from the work-site, allowing the results of measurement to be referred to as work proceeds.

1. INTRODUCTION

As with wide use of the terminology "Multimedia", recent development of the telecommunication industry has resulted to produce higher levels of various services, by means of construction of wide area optical communication networks with high quality, large capacity data communication through the employment of optical fibers.

Optical fibers, for mass information transfer media, have higher reliability than conventional metal cables. However, work failure due to improper installation or road repair work (causing damage on buried cables) seriously affects the reliability of optical networks.

Supporting systems performing inspection of cable network installation, track maintenance for information transfer quality, and urgent recovery from troubles are essential to the optical fiber networks; the development of a network maintenance then becomes necessary for assuring effectiveness of the networks.

To comply with the requirement, we have developed a recovery support system for optical fiber installation troubles or accidents that may happen in the network laying-out and maintenance work. Our recovery support system has a feature of smaller size/space saving, and simple

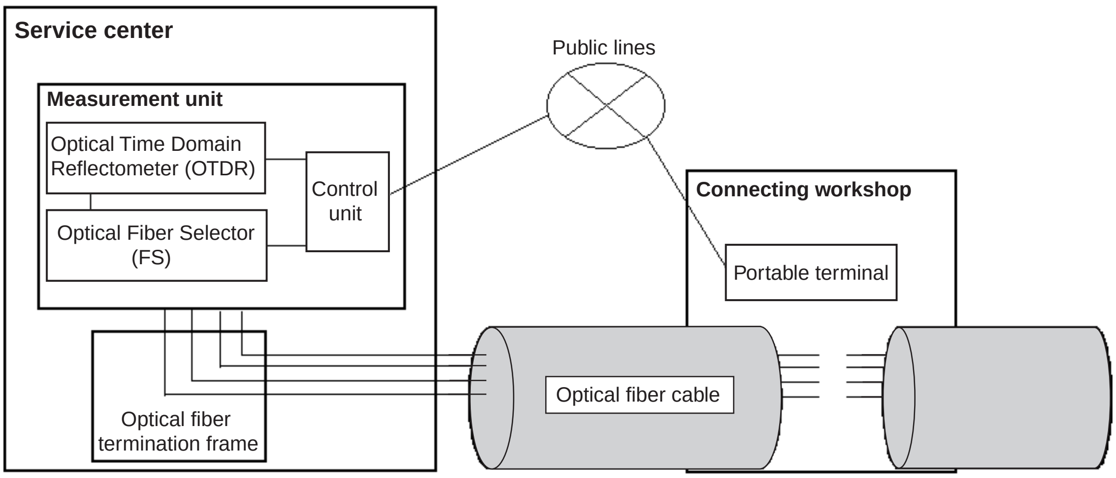

Figure 1 System configuration

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operation through portable terminals to correspond various optical networks operated by different carriers.

2. SYSTEM CONFIGURATION

2.1 System Outline

Figure 1 shows the outline of our optical cable installation support system. The system consists of such measuring equipment to be installed near the optical fiber termination frame in the service center as an Optical Time Domain Reflectometer (OTDR), an Optical Fiber Selector (FS), measuring equipment having a control unit, and a portable input / output terminal carried by cable installation operators. The control unit of the measuring equipment is connected to the portable terminal through the public lines; therefore, the operators are able to run various meters and watch data from a remote work-site. The testing light generated from the OTDR passes through FS and is connected to an optical fiber cable in the optical fiber termination frame. The FS automatically switches the test light into a designated optical fiber in optical cables. The purpose of our system developed is to support the work of connecting or transferring optical fiber cables, and to search for trouble points in optical cables, therefore, one operator can perform his/her entire inspection work from a distant service-center room achieving the above connection and trouble seeking procedures.

2.2 Measuring Equipment

The measuring equipment consists of an Optical Time Domain Reflectometer (OTDR), an Optical Fiber Selector (FS) and a control unit.

2.2.1 OTDR

This system uses a Hewlett-Packard made mini-OTDR. Table 1 shows the specifications of OTDR. The mini-OTDR is small-sized and lightweight, exhibiting the same performance as the conventional types of OTDR. In addition, the mini-OTDR acts as a light source for fiber identification and loss measurement. Other maker's OTDRs are also available by changing the control commands between the control unit and the OTDR.

2.2.2 Optical Fiber Selector

Figure 2 shows the structure of the Fiber Selector (FS). In the FS, an optical fiber on the measuring equipment side (Master) and an optical fiber for connecting (Slave) are jointed through the V grooves. FS is filled with matching oil to reduce the connection loss and the reflection on the jointed portion. Table 2 shows the characteristics of the FS.

2.2.3 Control Unit

The control unit is accommodated with the FS, and Photo 1 shows its appearance. It can connect a maximum of 144 connectors of optical fibers; SC connectors are aligned in front of the unit. SC connectors for connecting OTDR optical cords, connectors (D-sub 9 pin) for OTDR control cables, and control terminal connectors (D-sub 9 pin and modular jack) are provided on the front right side. Table 3 shows the specifications of the control unit (FS included).

Table 1 Specifications of OTDR

	Items	Specification
Horizontal axis	Span (full width of transverse axis)	1km~200km
	Reading resolution	0.1m (10cm)
	Precision of distance reading	±0.1m ±Sampling interval×0.5 ±Measured distance×10^{-4}
Vertical axis	Vertical axis scale	0.1~10.0dB/div
	Reading resolution	0.001dB
	Linearity	0.05dB/dB
	Reflection measurement range	20dB~>60dB
Light source output	CW mode output power	-3dBm
	CW mode stability	±0.1dB/15 minutes, After 10 minutes warming-up at constant temperature
	Modulation	270Hz, 1kHz, 2kHz, Square wave
	Modulation mode output power	-6dBm
Pulse light source	Wavelength	1310/1550nm
	Test fiber	Single mode
	Dynamic range	10ns 24/22 100ns 29/27 1µs 35/34 10µs 40/39
	Dead zone	5m
Function	Auto-analysis	Built-in
	Type of event	Reflective, Non-reflective event
	Maximum event No.	100
	Non-reflective event detection value	0.0~5.0dB Setting in 0.01dB step
	Reflective event detection value	-14.0~65.0dB Setting in 0.1dB step
	Detection value of broken point analysis	0.1~10dB Setting in 0.01dB step

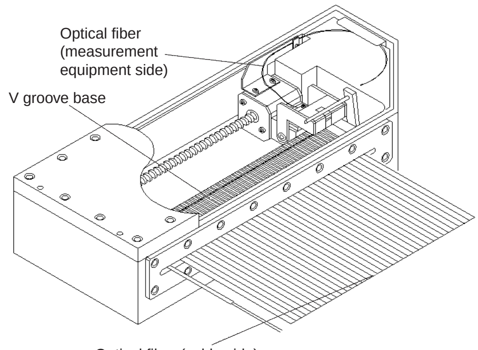

Figure 2 Structure of fiber selector

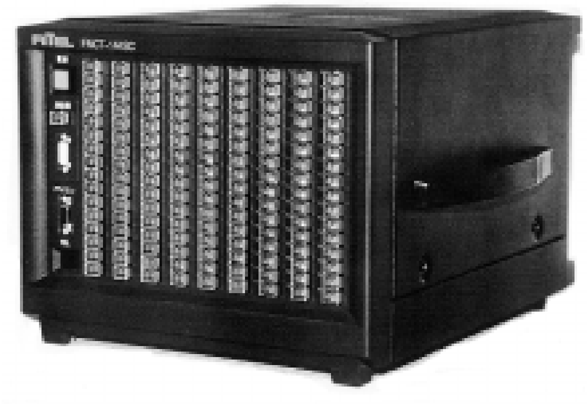

Photo 1 Control unit

Table 2 Performance of Fiber Selector

Items	Specification
Optical properties	
Insertion loss	Less than 0.5dB
Reflection attenuation quantity	More than 40dB
Function	
Transfer port No.	Less than 400 cores
Transfer work time (second)	Less than 10 seconds
Durability	More than 1 million cycles
Connecting loss reproducibility	Less than 0.1dB

Table 3 Specifications of control unit

Items	Specifications
Size	W300×H250×D380 mm
Weight	12kg
Interface	D-sub 9pin×2 Modular jack×1
Port No.	144 ports
Power source	AC100V

Table 4 Specifications of Zaurus

Items	Specifications
Size	W161×H90×D23 mm
Weight	320g
Display	320×240 dots 65536 color
Power source	Lithium ion battery AC adopter with charging function

2.3 Portable Terminals

SHARP's PDA, named as "ZAURUS" is used for the portable terminal. Table 4 shows the specifications of ZAURUS. The portable terminal can transmit and receive data by using a control unit and a portable phone. Also, through an RS232-C, it can transmit and receive data; and controlling of communication devices having RS232C interface such as optical talk sets can be made, in addition to direct connection.

3. FUNCTIONS

3.1 Support for Connecting Work

In the connecting work support mode, the connection loss at the joints is measured in order to confirm whether the connection is correctly made in optical fiber extension jointing work. Figure 3 shows a flow chart of the support for connecting work.

In order to measure the characteristics of jointed section, several data, such as types of connections (fusion, MT, single connector), connection loss threshold, reflection threshold, connected positions, and position errors are to be input (refer to Figure 4). Based on the input data, cable conditions before connection are measured by the OTDR and the connecting point is confirmed by measuring the position of the cable termination. Figure 5 shows an example of measurement trace data.

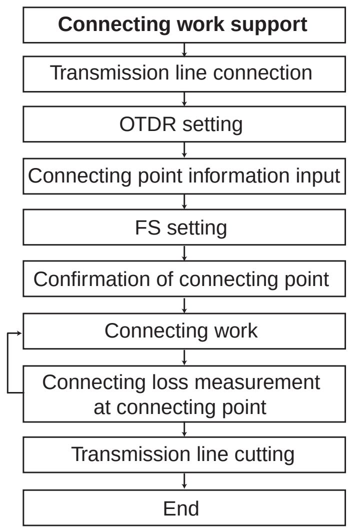

Figure 3 Flow chart for connecting work

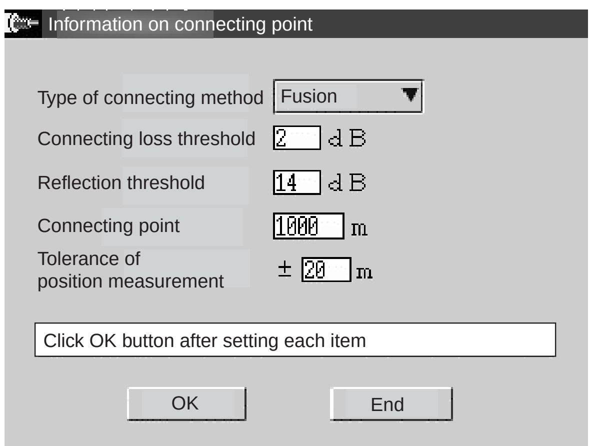

Figure 4 Information page of connecting point

After the connection work, the optical loss of the optical fiber at the confirmed point is measured (refer to Figure 6 Measurement trace data), then judgement for right connection is done by comparing the measured data with the pre-input connection loss threshold. Another judgement is also required if connectors are used. Figure 7 shows a page for the optical cable connecting work.

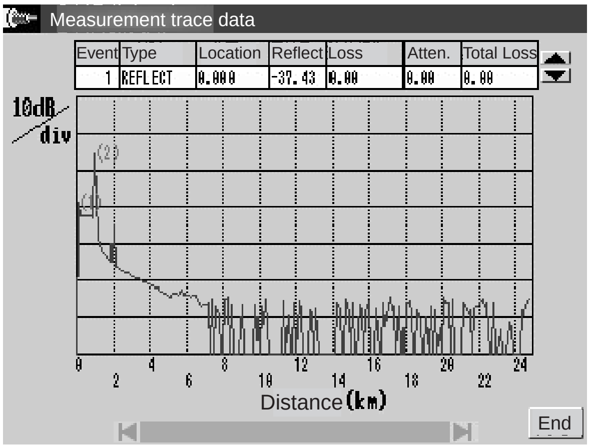

Figure 5 Measurement trace data (before connecting)

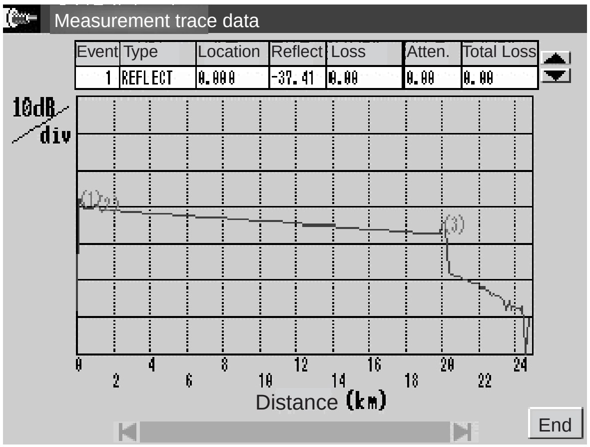

Figure 6 Measurement trace data

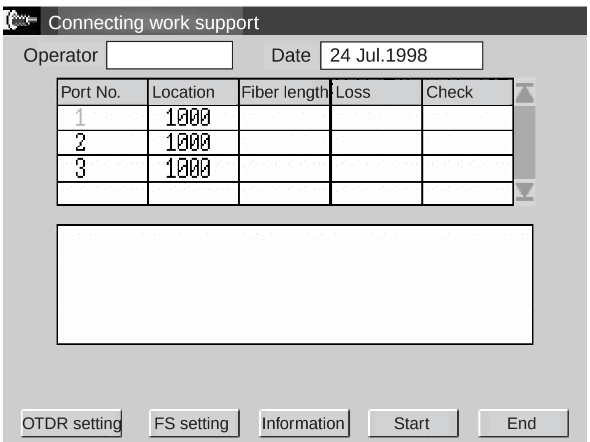

Figure 7 Page of optical cable connecting work

3.2 Support for Cable Transfer Work

In this work, in order to confirm completion of proper cable transfer work made with another optical cable at a certain service field, the optical loss of the optical fiber in the transferred section is to be measured. Figure 8 shows a flow chart of the support for cable transfer work.

In order to measure the optical loss in the transferred section, transferring information, such as: the type of transferring point, the optical loss threshold after transferring, positions of two replacement end points must be input (Figure 9). Firstly, to identify the transferring optical fiber, by applying a light source emitting menu (Figure 10), an OTDR is used as the identification test light source (270 Hz modulation light).The operator confirms the optical fiber in which the identification testing light is in by means of the optical fiber identifier.

After the completion of the optical cable transfer work, the optical loss of the transfer section (designated on the information input page) are to be measured to confirm the optical loss whether the data measured is within the range

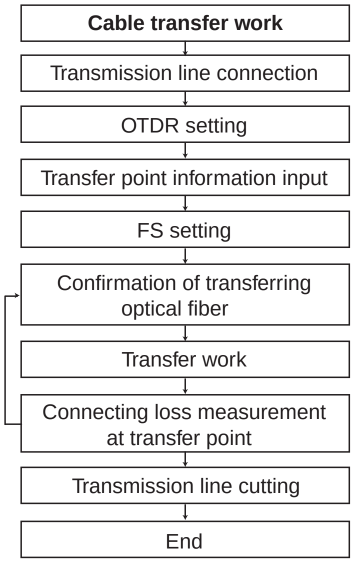

Figure 8 Flow chart for cable transfer work

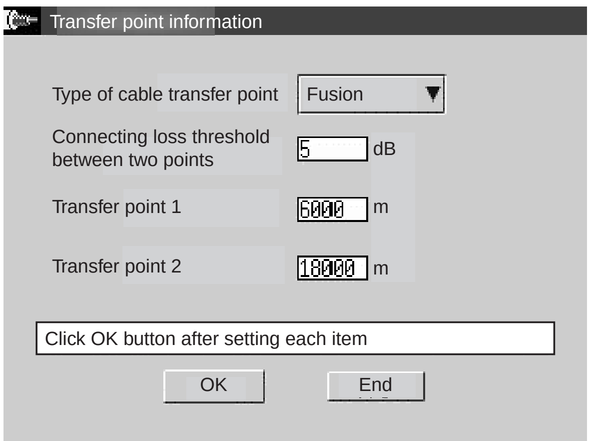

Figure 9 Information page of cable transfer point

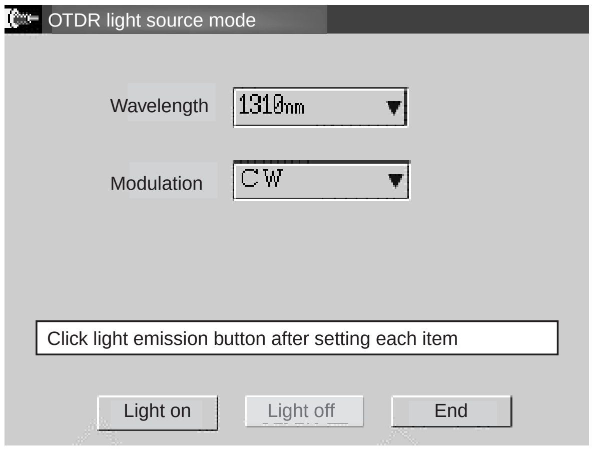

Figure 10 Page of light source mode

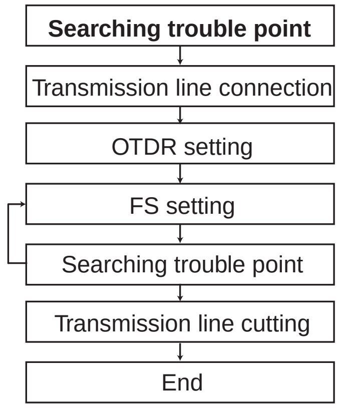

Figure 12 Flow chart for searching trouble point

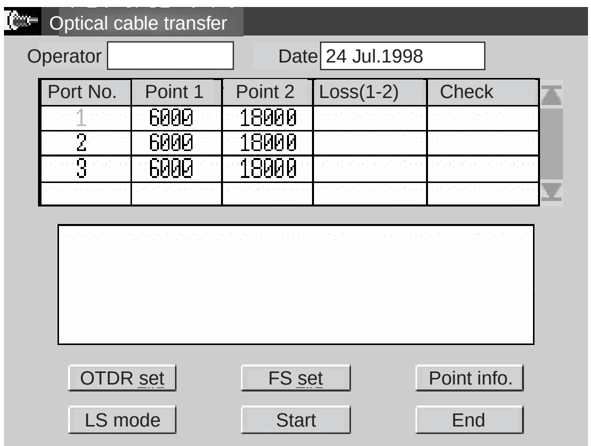

Figure 11 Page of optical cable transfer

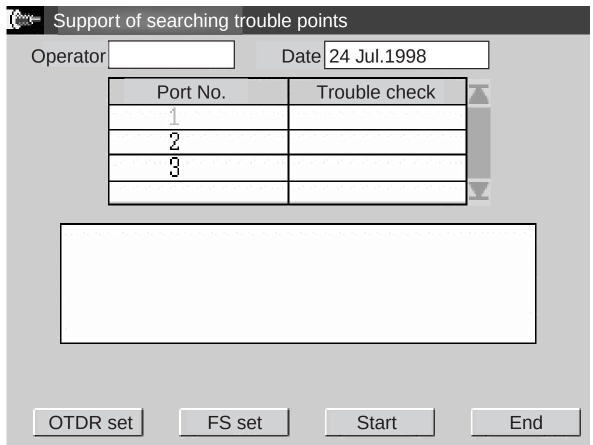

Figure 13 Page of searching trouble point in optical cable

of pre-input threshold value. Figure 11 shows a page for the work of optical cable transfer.

3.3 Locating Trouble Points in Optical Cables

Locating troubled points is carried out by measuring the optical fiber with the OTDR. Figure 12 shows a flow chart for searching trouble points.

Location of troubled points is searched through the automatic function of the OTDR by analyzing mismatching points against the event judgement value pre-determined as OTDR measuring conditions. The operator can designate a fiber cable to be checked, as required, and uses the automatic analyzing function of the OTDR for the evaluation. Figure 13 shows a page for locating work of troubled points in optical cables.

4. In Conclusion

We have made a success in the development of the support system for the installation of optical fiber cables with high efficiency and quality. We are going to continuously pay the efforts to develop much smaller-sized and lightweight, portable terminals with improved functions matched to the user's needs.

Manuscript received on November 3, 1998.