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STUDY REPORT
ON
KUANTAN - KOTA KINABALU
SUBMARINE CABLE PROJECT
IN
MALAYSIA

(VOLUME 3)

BASIC DESIGN

JANUARY 1987

JAPAN INTERNATIONAL COOPERATION AGENCY

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1. SUMMARY

IV. BASIC DESIGN FOR KUANTAN - KOTA KINABALU SUBMARINE CABLE SYSTEM

1. Summary

The basic design of submarine cable system connecting Kuantan and Kota Kinabalu has been carried out based on the survey results of the cable landing sites, the sea portion and the traffic forecast and estimation of trunk circuits, which were described in Parts II and III of this report.

The number of channels required for the system between kuantan and Kota Kinabalu in the year 2015 is estimated as 5,641 telephone channels and two TV channels. In view of economical use of the system, it is preferable that the system should have a capacity of at least 3,200 telephone and two TV channels, i.e. the system may be fully occupied in the middle of the system life.

At present, there are no submarine cable system which has such a large number of channel capacity except an optical-fiber submarine cable system. Consequently, the Study Team carried out the system design works to apply the optical-fiber submarine cable system for the submarine cable system connecting Kuantan and Kota Kinabalu.

The optical-fiber submarine cable system is now being developed in the major countries and its first long-haul system will be constructed in the year 1988. On this situation, the Study Team made brief description on the development progress of the optical-fiber submarine cable system at each country.

The design requirements for this system is based on the present worldwide techniques of the optical-fiber submarine cable system. For regenerating the optical signal which is transmitted through the thin optical-fiber, repeaters should be inserted at certain intervals along the cable. As the result of the study for the basic design of this system, the average cable slack in this submarine cable section and total required cable length which includes land portion cable are estimated at about 2.7% and 1,489.84 km (804.45 nm), respectively.

The Study Team made a description of OS-280 Mbps Optical-Fiber Submarine Cable System (OS-280M System) developed in Japan and designed the Straight Line Diagram of the Kuantan - Kota Kinabalu submarine cable system inserting 32 repeaters by applying the OS-280M System as an example.

2. SELECTION OF SUBMARINE CABLE SYSTEM

2. Selection of Submarine Cable System

2.1 System Channel Capacity

According to the results of the study on traffic forecast and estimation of trunk circuits for this system up to the year 2015, the number of telephone channels required are 5,641 which is based on an annual GDP growth rate of 4%. However, it is more economical to provide a system which will be fully utilized after 10 to 15 years of system completion.

The existing Kuantan - Kuching submarine cable system will reach its end of life in the year 2005, therefore, it is necessary to take into consideration the capacity of existing system in estimating the channel capacity for this system.

In addition, JTM also has a plan to transmit two TV channels through this system.

By taking the above matters into consideration, the required channel capacity of this system will be as follows:

Telephone Channels:	3,200 channels (in the year 2003)
Two TV Channels:	1,920 telephone channels (equivalent)
Total:	5,120 channels

2.2 Recommendation of an Optical-Fiber Submarine Cable System

The optical-fiber submarine cable system presently being developed will be used commercially in the very near future. The optical-fiber submarine cable system can transmit about 4,000 telephone channels by high-speed digital signal through 1.3 μm fiber pair with a bit rate of 280 Mbps.

The key features of the optical-fiber submarine cable system are as follows:

(1) The optical-fiber has considerable low transmission loss.

(2) It is possible to transmit high speed digital signals with long distance.

(3) It gives practical effect to the submarine cable system to increase its channel capacity.

(4) The construction cost of the optical-fiber submarine cable system is higher than the conventional coaxial system. However, the channel capacity of optical-fiber system is considerably larger than that of conventional coaxial system, therefore the construction cost per channel of optical-fiber system is much lower than for the conventional coaxial system.

(5) The signal transmission method of the optical-fiber system utilises the digital techniques which is now widely used in the world networks.

(6) It is possible to significantly increase the channel capacity of the optical-fiber system by applying the digital multiplication technique.

The new digital signal transmission system of the Malaysian domestic telecommunication network is gradually being installed to increase the capacity of the existing system and to replace old systems. From this, it is clear that the digital signal transmission will be used in both major and local networks in the near future. Therefore, it will be easy to connect a land digital line with the optical-fiber submarine cable system.

Taking the above points into consideration, the optical-fiber submarine cable system is recommended for this system.

2.3 Present Status of Development of Optical-Fiber Submarine Cable Systems

As described in Subsection 2.2, the optical-fiber submarine cable system is now under development in Japan, U.S.A., U.K. and France. The present status of each country is as follows:

(1) Japan

The development activity of the optical-fiber submarine cable system is carried out by NTT (Nippon Telegraph & Telephone Co., Ltd.) for domestic short-haul system and KDD (Kokusai Denshin Denwa Co., Ltd.) for international long-haul system.
NTT started to develop the 400 Mbps system using 1.3 μm single mode fiber in 1978 and field tests on the system were carried out in November 1980 and January 1981, respectively. The first commercial system was completed in August 1986 between Honshu (Japan Mainland) and Hokkaido.
KDD started to develop the 280 Mbps system using 1.3 μm single mode fiber in 1976. In April 1980, deep sea trial for the optical-fiber submarine cable was carried out by C.S. KDD Maru to check the mechanical characteristics of the optical-fiber cable. In November 1981, the field test of the system which include one repeater, was carried out at Sagami Bay where the sea depth was 500 m, to confirm the transmission characteristics of the cable and repeater. The final commercial test using 350 km cables and 7 repeaters is scheduled in 1986 at the Japan Trench where the sea depth is about 8,000 m.

This system is named OS-280M Optical-Fiber Submarine Cable System (OS-280M System) and will be applied to the TPC-3 cable which is planned for installation in 1988.

(2) U.S.A.

The development of optical-fiber submarine cable in U.S.A. has been carried out by BTL (Bell Telephone Laboratories) with the sponsorship of AT & T (American Telephone & Telegraph Co.). The system under development is named SL System which has a transmission speed of 280 Mbps using 1.3 μm fiber. The commercial test of SL System was carried out in November 1985 at Canary Islands. This test system consists of 120 km optical-fiber cable with 3 repeaters.
This SL System will be applied to the TPC-3/HAWAII-4 cables and TAT-8 cable which are planned for installation in 1988.

(3) U.K.

The development of optical-fiber submarine cable in U.K. has been carried out by British Telecom. since 1976. In February 1980, 10 km field test system was laid at Loch Fyne (west part of Scotland). And one repeater was inserted to this test system in May 1980 for carrying out the transmission test of 140 Mbps system. The system under development is named NL-2 System and will be applied to the TAT-8 cable which is planned for installation in 1988.

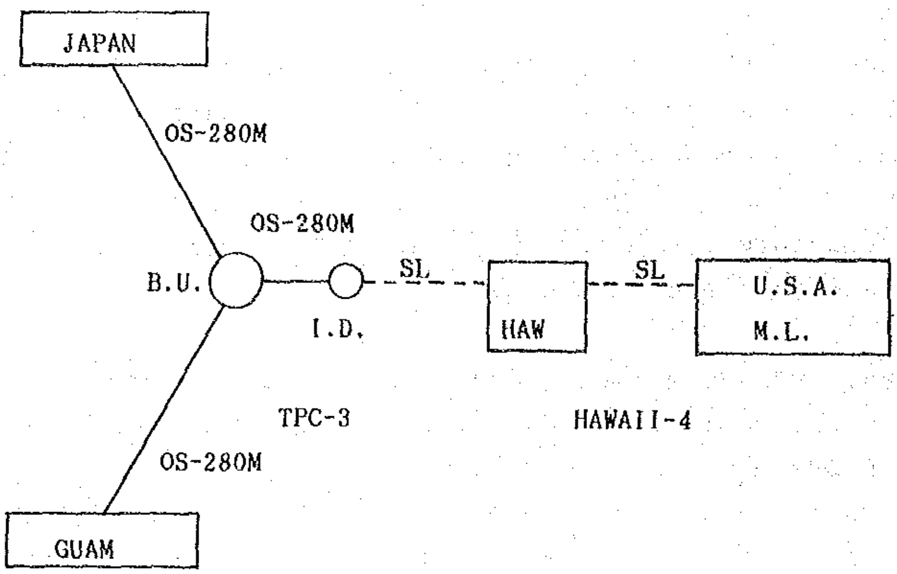
(4) France

The development of optical-fiber submarine cable system in France has been carried out by CNET (Centre National d'Etudes des Telecommunications) since 1979. The field test of the system was carried out in 1981. The system being developed is named S-280 System and will be applied to the TAT-8 cable which is planned for installation in 1988.

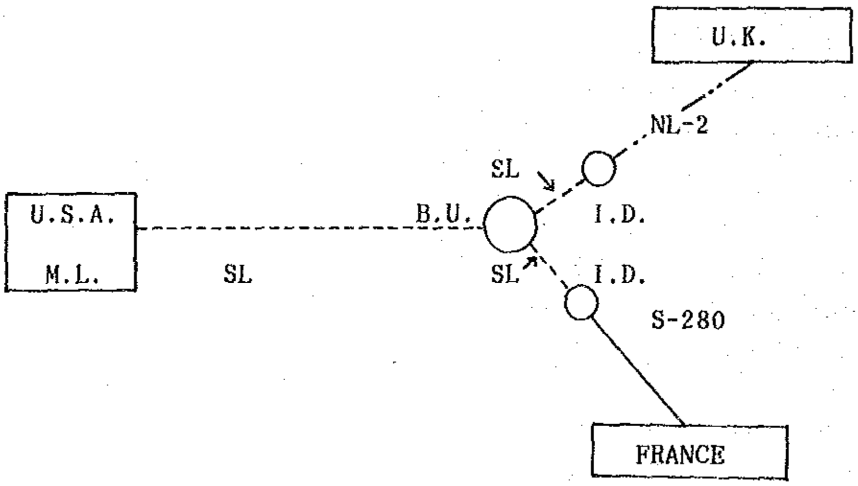
As shown in Table IV-1, the principal parameters of OS-280M, SL, NL-2 and S-280 Systems are almost the same because each system has been designed to conform to the CCITT recommendations for the 140 Mbps digital signal stream. Therefore, it is possible to connect one system to another through an interface device on the ocean bottom.

In 1988, trans-oceanic optical-fiber submarine cables will be laid in the Pacific and Atlantic oceans. At this time OS-280M System developed in Japan and SL System developed in U.S.A. will be used in the Pacific, and SL System, NL-2 System and S-280 System also will be used in the Atlantic as shown in the following figures.

TPC-3/HAWAII-4



TAT-8



B.U.: Branching Unit

I.D.: Integration Device

Table IV-1 Principal Parameters of Optical-Fiber Submarine Cable Systems Being Developed

Item \ Country	Japan KDD (OS-280M)	Japan NTT	U.S.A. BTL (SL)	U.K. BT (NL02)	France CNET (S-280)
Transmission Speed	280 Mbps	400 Mbps	280 Mbps	(140), 280 Mbps	(140), 280 Mbps
Number of Fiber Pair	1 - 3	1 - 3	1 - 3	1 - 3	1 - 3
Max. System Length	8,000 km	1,000 km	8,000 km	7,500 km	7,500 km
Max. Sea Depth	8,000 m	8,000 m	7,500 m	7,500 m	6,500 m
Repeater Span	30-53 km	32-42 km	30-50 km	40-50 km	50 km
Wavelength	1.3 μm	1.3 μm	1.3 μm	1.3 μm	1.3 μm
Fiber	SMF	SMF	SMF	SMF	SMF
Power Supply	±1.6 A	±1.8 A	±1.6 A	±1.6 A	±1.6A
System Life	25 years	20 years	25 years	25 years	25 years
Reliability	MTBF 10 years	MTBF 10 years	MTBF 8 years	MTBF 10 years	Unknown

(1986.2.)

3. DESIGN REQUIREMENT FOR THIS SYSTEM

3. Design Requirement for This System

3.1 System Traffic Capacity

All types of long-haul optical-fiber submarine cable system in the world are designed to conform to the CCITT recommendation for the 140 Mbps digital input/output ports. One 140 Mbps digital stream can carry 1,920 telephone channels of 64 kbps or two color TV channels of broadcasting quality.

According to the circuits requirement described in Subsection 2.1, three 140 Mbps digital streams will be necessary for the Kuantan - Kota Kinabalu system. At the present stage of development of the optical-fiber submarine cable system, 3 x 140 Mbps (with 3 fiber pairs) or 280 Mbps + 140 Mbps (with 2 fiber pairs) are not likely to be of reasonably low cost compared with the system of 2 x 280 Mbps (with 2 fiber pairs). Therefore, the system of 2 x 280 Mbps is proposed for the transmission between Kuantan and Kota Kinabalu.

The residual 1 x 140 Mbps could be kept for new telecommunication services or increased demand due to extension of the submarine cable system in the future.

3.2 System Design Life and Reliability

All long-haul systems which have maximum length of 8,000 km are designed to have a life of 25 years and overall reliability of main transmission path through the submersible plant is such that the objective number of ship repair due to system component failure is less than three during the life of system.

The system length of the optical-fiber submarine cable connecting Kuantan and Kota Kinabalu is about 1,500 km. Therefore, by applying the same quality of submersible plant designed for the long distance system, the system life and reliability for this system will be as follows:

(1)	System life	25 years
(2)	Reliability	The objective number of ship repair due to system component failure is less than one during the system life.

3.3 System Interface

Backhaul systems with 140 Mbps digital streams are planned at Kuantan and Kota Kinabalu. The primary interface of the submarine cable system shall be at the 139,264 kbps digital distribution frame. The 139,264 kbps input and output ports of the terminal equipment shall conform to CCITT Recommendation G703 (Red Book, Volume III, Fascicle III.3).

3.4 Transmission Performance

Transmission performance of each digital line shall conform to the characteristics that are defined in the CCITT Recommendation G921 (Red Book, Volume III, Fascicle III.3), and shall be designed to maintain these performance levels throughout its life, taking account of the seasonal temperature variation, normal cable terminal temperature variation and any allowances made for cable and system repair.

3.5 Loss Budget

To maintain the transmission performance described in Subsection 3.4 throughout the system life, the following loss budget for the system design of each repeater span will be taken into account.

Repeater Output Level - (Cable Loss + Fiber Splice Loss + System Margin + Repair Margin) = Repeater Input Level

The system margin includes the design penalty, laying effect, cable aging, input transmitter aging and output receiver aging.

3.6 Repair Allowance

The following repair allowances are required for the system for future maintenance.

(1) Deep water allowance (water depth is more than 1,000 m): In the deep water portion, when a cable fault occurs, one repeater section shall be added for repair. Therefore, no repair allowance is required.

(2) Shallow water allowance (water depth is less than 1,000 m): In the shallow water portion, the repeater spacing shall be shortened from nominal length of deep sea to compensate for the increase in transmission loss due to the repairing of cable fault. In case of the optical-fiber submarine cable system, the increase in transmission loss is calculated as 1 dB per repair, and this value is equivalent to 2.2 km of cable. The possibility of cable fault occuring in the shelf area

(water depth of up to 200 m) is higher than the shelf edge (water depth of 200 - 1,000 m).

Taking the above points into consideration, allowance for repair will be required in the following situations:

Shelf Area	4 cable joints (two repairs) per repeater section
Shelf Edge	2 cable joints (one repair) per repeater section

3.7 Design of Land Portion Cable Layout

The survey of communication land cable and land earth cable routes have been conducted at both Kuantan (Cherating) and Kota Kinabalu (Tg. Aru) sites. The results of the survey are described in Part II, Section 7. The basic design requirements on the land portion cable layout at both landing sites based on the survey results are as follows:

(1) Kuantan (Cherating) Site

At the Cherating site, the land and earth cables for the existing Kuantan - Kuching and M.S.T. cables are laid in a duct line, and three tubes of the existing duct can be used for the new land and earth cables from the beach manhole to the cable terminal station building.

(2) Kota Kinabalu (Tg. Aru) Site

At the Tg. Aru site, the new communication land and land earth cables may be installed along the abandoned SEACOM land cable and earth cable routes. In order to keep land cable free from man-made hazards, external force and influences of development of Tg. Aru area, it is recommended that an underground duct line with a depth of more than 1 m be laid between the beach and the cable terminal station building.

For the land cables of Kuantan - Kota Kinabalu submarine cable and future planned submarine cables, four tubes including one for spare in the new duct are required. Moreover, for splicing the seaward cable with land cable and laying the land cable, a beach manhole and two or three manholes are also required. A detailed survey shall be made before starting the actual construction work for the communication land cable to check for underground obstacles such as power cable, water supply pipe, etc. in the compound of the Kinabalu Yacht Club.

3.8 Design of Power Feeding Ground System

In case of the optical-fiber submarine cable system, a constant direct current of 1.6 A is required to energize the submersible repeaters. For feeding constant direct current to the repeater, it is necessary to install a stable ground system around the cable landing station where the power feeding equipment is installed. Generally, the earth resistance of less than 1 Ω is required for the power feeding system. An automatic change over device from the power feeding ground system to the station earth is also required in case of power feeding ground failure.

The Study Team carried out the earth resistivity measurement at the beach of both cable landing sites. The ground resistance data obtained is shown in Part II, Subsection 7.2.

After analyzing the data, the ground resistance along the measured line of both landing sites are shown in Fig. IV-1. Based on the analyzed data, the following power feeding ground system will be required.

(1) Electrode

In the case of the optical-fiber submarine cable system, power feeding current is 1.6 A. This value is very high when compared to the value of less than 0.5 A for the coaxial submarine cable system. Therefore, to save on consumption of electrodes, the use of silicon-iron electrodes instead of copper ones is recommended. The outline of a silicon-iron electrode is as follows:

Dimension:	670 mm (D) x 2,134 mm (L) x 10 mm (T)
Weight:	28.5 kg
Consumption:	16.0 kg/1.6 A (25 Years)

(2) Power Feeding Ground System at Kota Kinabalu

It is recommended that two electrodes be placed below 5 m from the ground level where the $\rho 5$ is 5.25 Ωm as shown in Fig. IV-2. Then the earth resistance is calculated as follows:

$$R = \frac{\rho}{2 \times \pi \times L} \times (\ln \frac{8 \times L}{D} - 1) = \frac{525\ \Omega cm}{2 \times \pi \times 600\ cm} \times (\ln \frac{8 \times 600\ cm}{20\ cm} - 1) = 0.62\ \Omega$$

R: Earth Resistance

ρ: Ground Resistance

L: Length of Electrode (including thickness of backfill)

D: Diameter of Electrode (including thickness of backfill)

(3) Power Feeding Ground System at Kuantan

It is recommeded that six electrodes be placed below 5 m from the ground level where the $\rho 4$ is 18.0 Ωm as shown in Fig. IV-2. Then the earth resistance is calculated as follows:

$$R = \frac{\rho}{2x\pi xLxN} x [In \frac{8xL}{D} - 1 + \frac{2xL}{S} x In (0.656 x N)]$$

$$= \frac{1800 \ \Omega cm}{2x\pi x600cmx3} x [In \frac{8x600 \ cm}{20 \ cm} - 1 + \frac{2x600 \ cm}{750 \ cm} x In (0.656 x 3)]$$

$$= 0.89 \ \Omega$$

S: Distance Between Electrode

N: Number of Electrode Hole

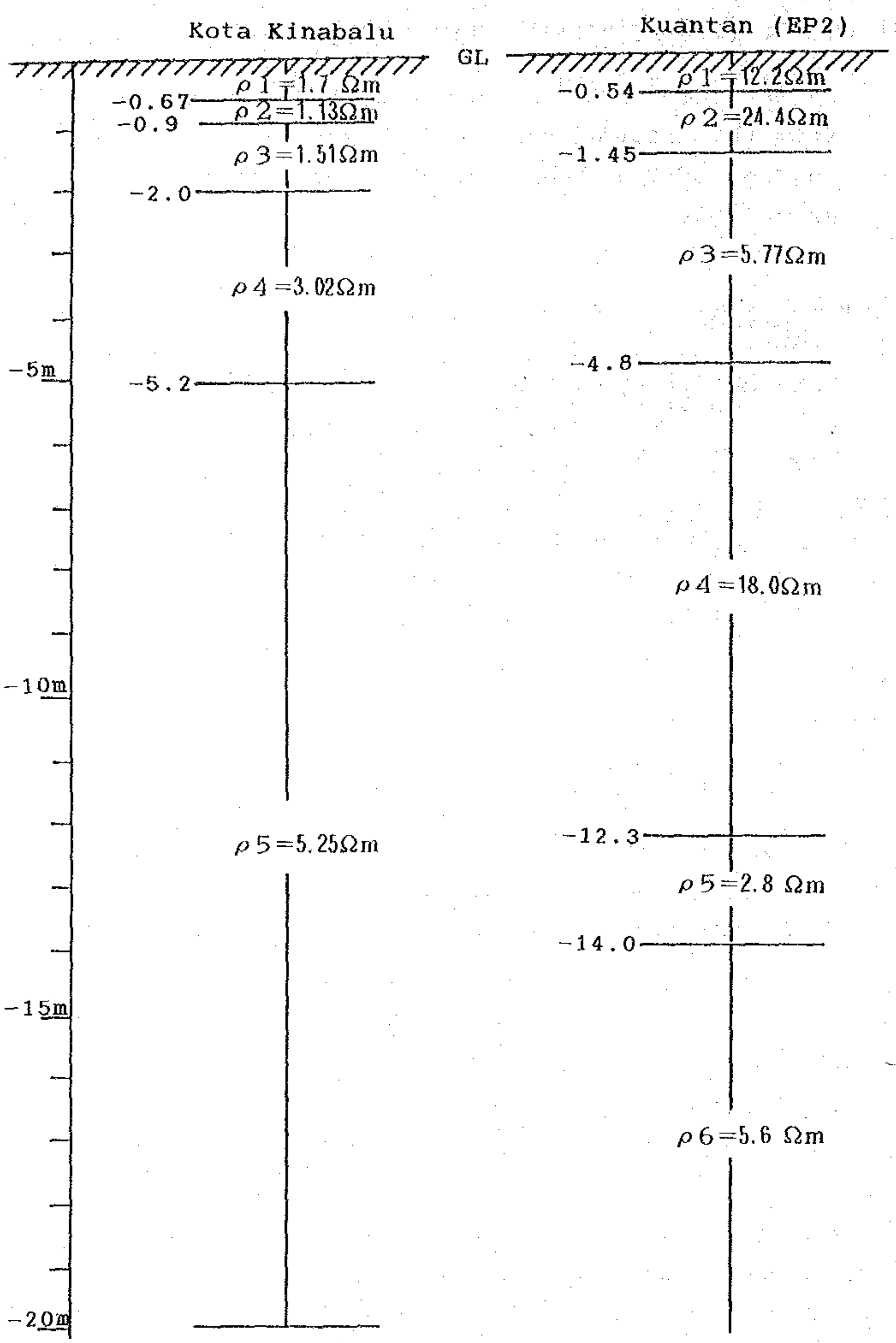
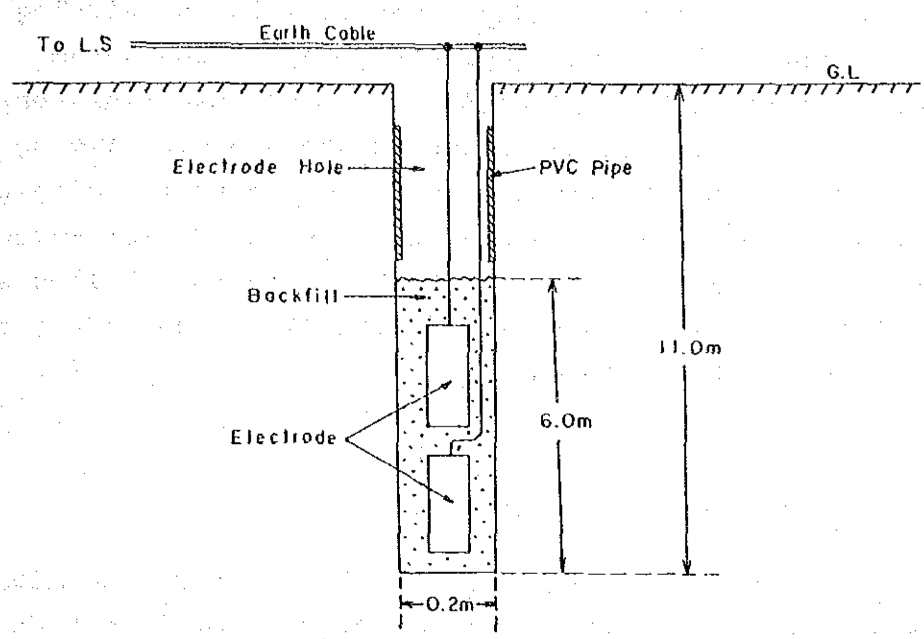


Fig. IV-1 Ground Resistance Analysis of Both Cable Landing Points

(1) Kota Kinabalu



(2) Kuantan

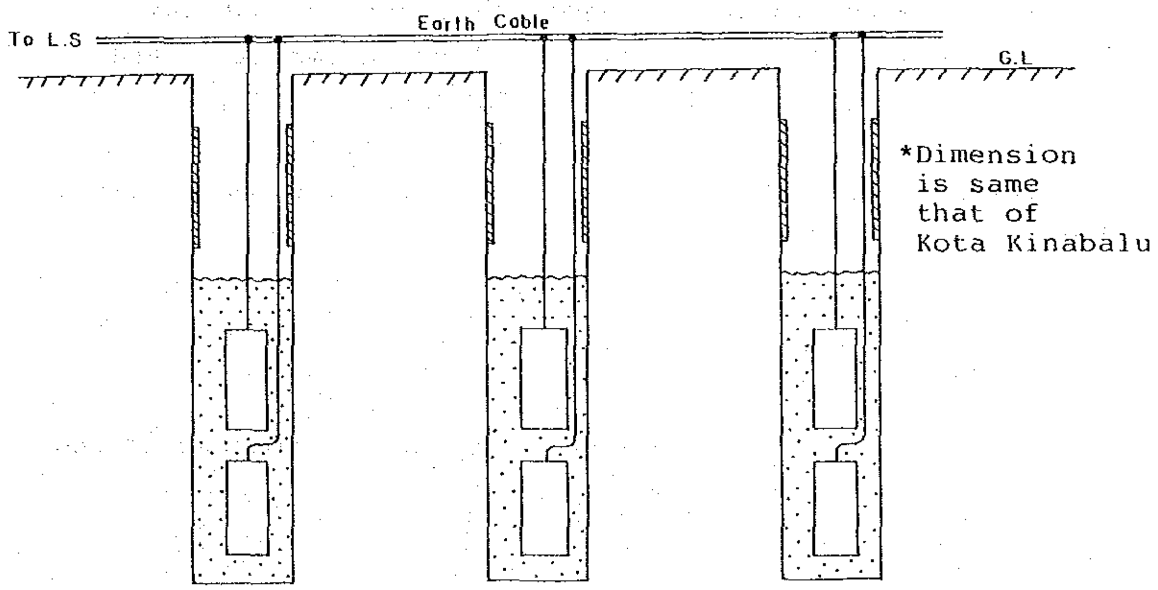


Fig. IV-2 Recommendable Power Feeding Ground System

3.9 Cable Protection in Shallow Water Area

During the ocean survey, many fishing boats and fishing gears were observed on the shallow water portion around the proposed cable route, and also the cable route runs near the shore-industry zone in the offing of both cable landing sites. Therefore, taking account of the penetration depth of less than 1 m by fishing gears and anchors of small-sized ships, it is recommended that the cable in the shallow water area be buried to a depth of more than 1 m under the seabed to avoid possible cable damages.

3.10 Maintenance and Supervision

To maintain and supervise this system, it is recommended that the system provides alarm information and consequent actions which conform to the related CCITT standards requirements. A computerized alarm/monitor information processing system will be necessary for efficient maintenance work.

In-service error monitoring and out-of-service optical loopback systems at each repeater allow an immediate and accurate location of intermittent and hard faults, respectively, by using computerized automatic Home Supervisory Units (HSU) located at a cable landing station. (Refer to Fig. IV-21.)

3.11 System Configuration

The optical-fiber submarine cable system is composed of the following plant and equipment.

(1) Submersible Plant

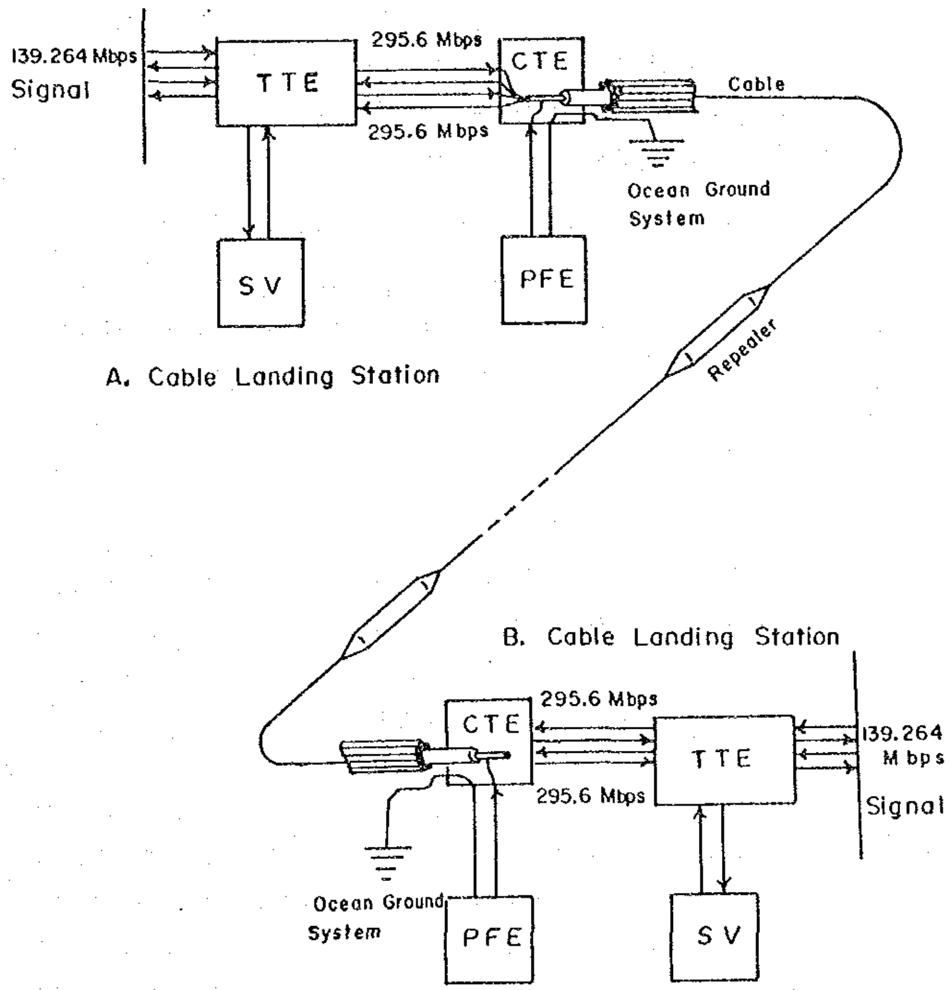
- o Optical-Fiber Submarine Cable
- o Repeater

(2) Terminal Equipment

- o Cable Termination Equipment (CTE)
- o Transmission Terminal Equipment (TTE)
- o Supervisory Equipment (SV)
- o Power Feed Equipment (PFE)

(3) Ocean Ground System

The typical composition of these plant and equipment are shown below. The functions of each plant and equipment are described in Subsection 3.12.



3.12 Functions of Each Plant and Equipment

(1) Optical-Fiber Submarine Cable

The optical-fiber submarine cable to be used in this system are composed of Single Armoured (SA) Cable, Double Armoured (DA) Cable and Unarmoured (UA) Cable. All cables shall be designed to meet the requirements of 25 years system life and shall be capable of being operated, deployed and recovered, stored and transported over the temperature range of -10°C to +40°C.

The optical-fiber submarine cable characteristics are as follows:

(a) Optical Characteristics

* Attenuation (1.30 to 1.32 μm)
  Less than 0.45 dB/km
* Chromatic Dispersion (1.30 to 1.32 μm)
  ±2.0 ps/nm km
* Variation of Attenuation Versus Temperature
  Less than 0.02 dB/km (0 to 30°C)

(b) Electrical Characteristics

* D.C. Resistance
  Less than 1.0 Ω/km
* Insulation Resistance
  More than 2 x 10^{11} Ω/km
* Maximum Voltage
  12 kV

(c) Mechanical Characteristics

* Cable Tensile Strength

DA:	42 tons
SA:	20 tons
UA:	10 tons

* Minimum Bending Radius

DA:	1.5 m
SA:	1.0 m
UA:	1.0 m

* Reverse Bending

  Cable shall withstand 30 reverse bends to a radius of 1.0 m without breaking the fiber.

* Water Pressure Resistance

  More than 500 kg/cm^2

* Water Ingress

  o Shallow Water Cable

    (Up to the depth of 1,000 m)

      Less than 250 m in each direction within two weeks.

  o Deep Water Cable

    (More than the depth of 1,000 m)

      Less than 1,000 m in each direction within two weeks.

(2) Repeater

The repeaters to be used in this system shall be designed to meet the requirement of 25 years lifetime and shall be capable of being operated, deployed and recovered, stored and transported over the temperature range of -10°C to +40°C.

The performance of individual regenerators shall be consistent with the transmission performance of the design requirements of this system. The failure of any one regenerator within a repeater shall not affect the performance of any other regenerator.

The repeaters shall withstand the surge voltage of more than 4,500 Volts and its housing shall withstand the pressure of more than 500 kg/cm².

The repeater characteristics are as follows:

(a) Input Condition

* Pulse Bit Rate
  295.6 Mbps ±3 ppm

* Wavelength
  1.30 to 1.32 μm

* Average Input Optical Power
  -32 dBm ±1 dBm

(b) Output Condition

* Optical Output Power
  More than -4 dBm

(c) D.C. Voltage Drop

Less than 70 Volts when power feeding current is 1.6 A ±2%.

(d) Dielectrical Strength

More than 4,500 Volts D.C. for 1 minute.

(e) Insulation Resistance

More than 2,000 MΩ at 1,000 Volts D.C.

(3) CTE

The CTE terminates an submarine cable and connects the submarine cable optical-fibers to the in-station fibers. And also, the power for energizing submersible repeaters is supplied through this equipment. CTE has the functions of monitoring the ground voltage, switching over the power line, protecting surge, etc.

(4) PFE

The function of the PFE is to provide a constant supply of D.C. current at ±1.6 A to the submersible plant for a period of 25 years lifetime. The maximum output voltage is ±7,000 Volts. Full duplication is adopted to achieve high reliability.

(5) TTE

TTE comprises of the transmit and receive apparatus and any ancillary monitoring, alarm, fault location, and speaker apparatus. The transmit apparatus assembles the digital line section interface signal into a form suitable for transmission to the line and the receive apparatus performs the complementary function.

(6) SV

The SV is a computer controlled device consisting of two subsystems:

(a) Out-of-Service Monitoring and Control Subsystem

(b) In-Service Monitoring and Control Subsystem

By using these two subsystems, the SV can monitor the system under both conditions.

(a) The redundancy switching to the standby laser is performed automatically at each regenerator to maintain normal traffic in the event of a faulty laser.

(b) The error performance monitoring which shows the digital transmission system quality can be done at any regenerator.

4. RECOMMENDABLE EXAMPLE OF SYSTEM CONFIGURATION

4. Recommendable Example of System Configuration

4.1 Preface

The Study Team studied the OS-280M Optical-Fiber Submarine Cable System developed by KDD and decided that the system configuration of Kuantan - Kota Kinabalu submarine cable be based on the system parameters of OS-280M System.

The key features of OS-280M System is described in Table IV-3, in Section 5.

4.2 Straight Line Diagram of This System

The System Straight Line Diagram of this system identifying the land portion cable, sea portion cable together with the nominal slack percentage and submersible repeaters insertion are shown in Fig. IV-3.

In designing the Straight Line Diagram, the following items were taken into consideration:

(1) Cable route is length is 1,451.47 km.

(2) The repeater spacing of deep sea portion is designed as 50 km by taking into consideration of systems being developed in the world. (Refer to Table IV-1.)

(3) Repeater span for shallow water portion is defined as 45 km in consideration of the increase in loss due to the possible repair works.

(4) To protect the shallow water portion cable, Single Armoured (SA) cable is required at the section, as described in Section 4 of Part II, where the cable cannot be buried.

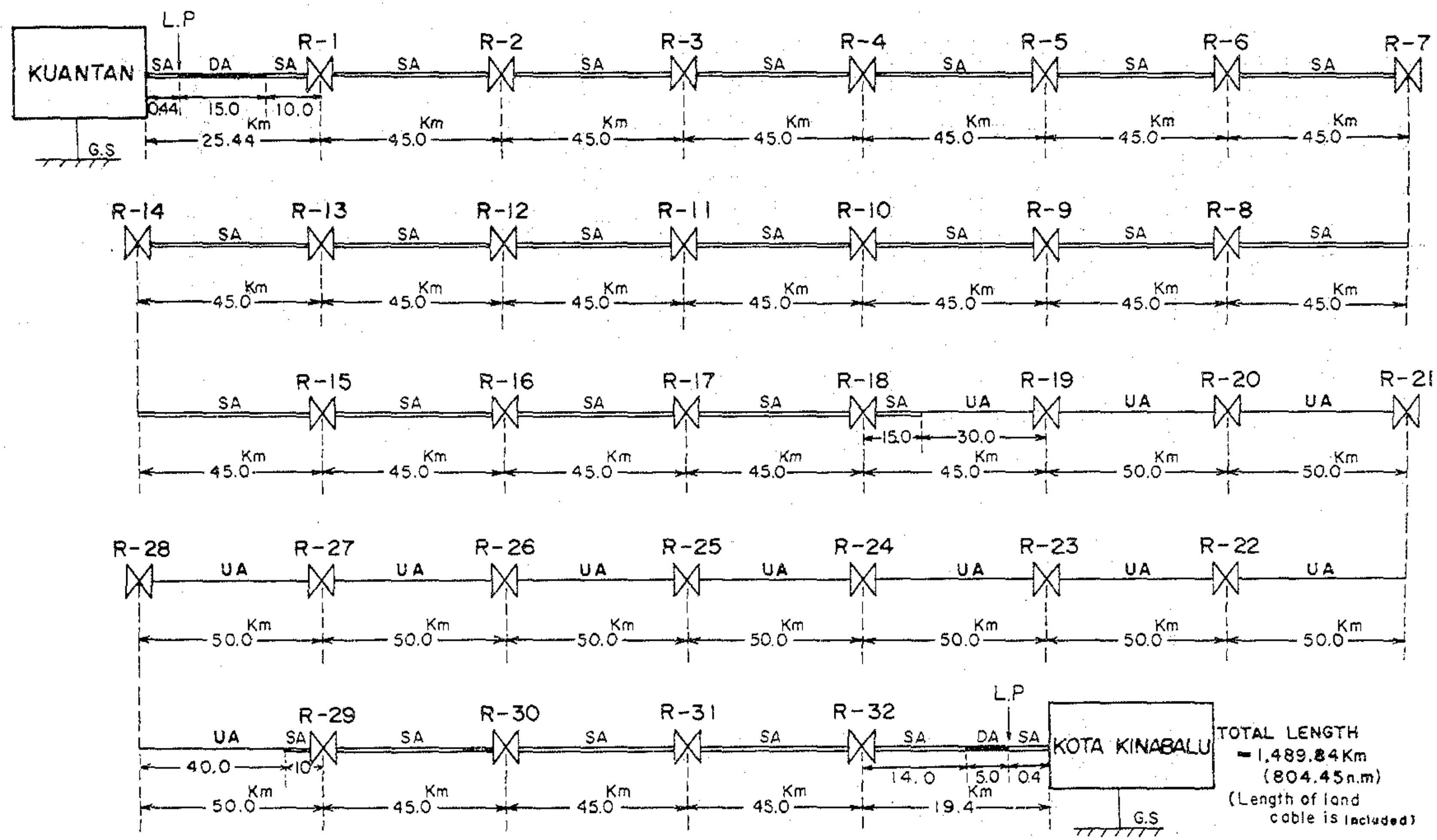
At the shallow water portion where the cable can be buried, it is recommended that Single Armoured (SA) cable be used, after considering the following reasons:

(a) Due to the thin insulator layer of Unarmoured (UA) cable, there is some possibility of cable damage by the cable burying equipment.

(b) To pick up the buried cable from the seabed on to the cable ship for repair of unexpected cable damage.

(5) The loss budget for each repeater span have been designed as in the following table.

Item	Deep Sea Portion	Shallow Water Portion
Repeater Output Level	-4.0 dBm	-4.0 dBm
Cable Loss	22.5 dB (0.45 dB/km)	20.3 dB (0.45 dB/km)
Fiber Splice Loss	0.5 dB	0.5 dB
Repeater Input Level	-36.2 dBm	-36.2 dBm
System Margin	9.2 dB (total)	11.4 dB (total)
Design Penalty	1.5 dB	1.5 dB
Laying Effect	0.7 dB	0.7 dB
Cable Aging	2.6 dB	2.6 dB
Opt. Trans. Aging	1.5 dB	1.5 dB
Ipt. Rec. Aging	1.7 dB	1.7 dB
Repair Allowance	0 dB	2.0 dB
Residual Margin	1.2 dB	1.4 dB



G.S: Ground System **DA**: Double Armoured Cable **SA**: Single Armoured Cable **UA**: Unarmoured Cable **R**: Repeater
L.P: Landing Point

Fig. IV-3 Straight Line Diagram

4.3 Necessary Types and Quantities of Submersible Plant

A summary of necessary types and quantities of submersible plant for this system are shown in Table IV-2.

Table IV-2 Necessary Types and Quantities of Submersible Plant

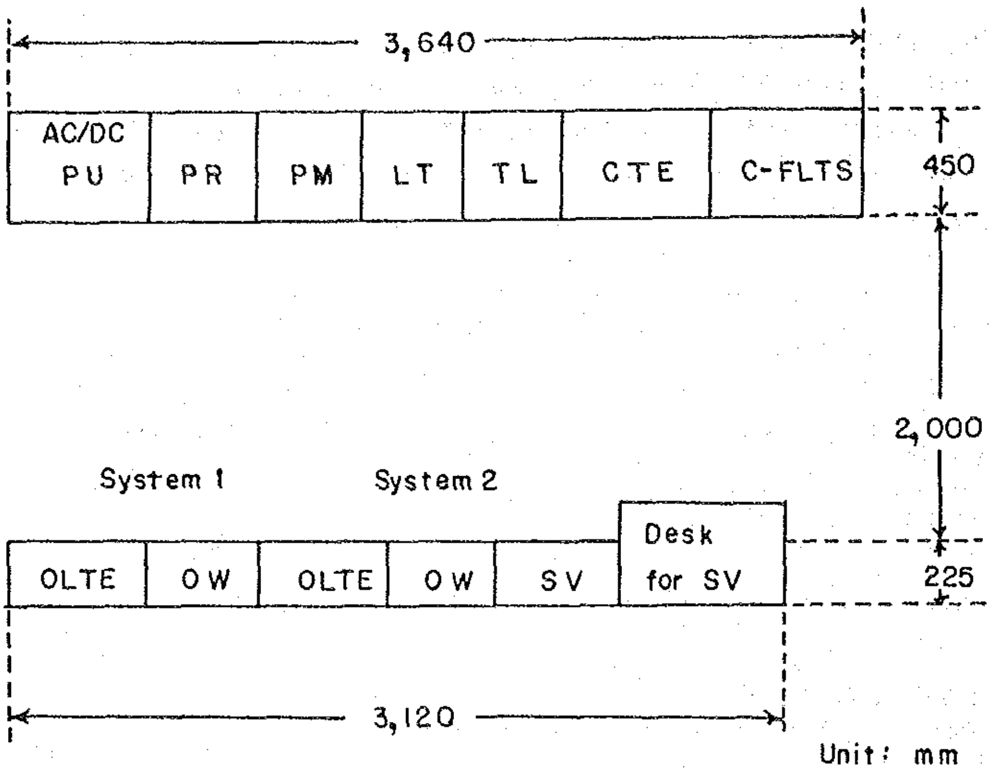
Type of Submersible Plant	Construction Use	Spare	Total
Double Armoured (DA) Cable	20.00 km	5.00 km	25.00 km
Single Armoured (SA) Cable	939.84 km	(Three Rep. Sections) 135.00 km	1,074.84 km
Unarmoured (UA) Cable	530.00 km	(Two Rep. Sections) 100.00 km	630.00 km
Repeater	32	3	35
Junction Box (For Repair)	0	10	10

4.4 Basic Terminal Configuration

The OS-280M System terminal equipment are composed of Cable Termination Equipment (CTE), Power Feed Equipment (PFE), Transmission Terminal Equipment (TTE), Supervisory Equipment (SV), etc. The necessary quantity of terminal equipment and size of bay for each cable landing station are as follows:

Name	No. of Bay	Size of Bay (mm)
		H W D
Optical Line Terminal Equipment	2	2750 x 520 x 225
Order-Wire Equipment	2	" " "
Power Regulator Bay	1	2750 x 520 x 450
Power Monitor Bay	1	" " "
Load Transfer Bay	1	" " "
Test Load Bay	1	" " "
AC/DC Power Unit Bay	1	" " "
Cable Termination Equipment	1	2350 x 520 x 450
Cable Fault Localization Test Set	1	2000 x 520 x 450
Supervisory Equipment	1 Desk 1	1700 x 520 x 450

The design of the floor layout of the terminal equipment will depend on the space of terminal equipment room of each cable landing station. However, a typical floor layout plan of terminal equipment is shown in Fig. IV-4.



Legend (Equipment to be installed)

1. C-FLTS: Cable Fault Localization Test Set
2. CTE: Cable Termination Equipment
3. TL(PFE): Power Feeding Equipment (Test Load Bay)
4. LT("): Ditto (Load Transfer Bay)
5. PM("): Ditto (Power Monitor Bay)
6. PR("): Ditto (Power Regulator Bay)
7. AC/DC PU: (") Ditto (AC/DC Power Unit Bay)
8. SV: Supervisory Equipment
9. OW: Order-Wire Equipment
10. OLTE: Optical Line Terminal Equipment

Fig. IV-4 Floor Layout plan

4.5 Arrangements of Terminal Equipment and Power Facilities for Both Cable Landing Stations

The provisional arrangements of terminal equipment and power facilities at both cable landing stations are shown in Figs. IV-5 and IV-6.

Power facilities to be provided in a cable landing station should be capable of supplying stable and highly reliable power to the repeaters as well as to the terminal equipment in the cable landing station.

The capacity of power to be derived from a commercial source depends upon the amount of power consumption of the terminal equipment and other facilities in the cable landing station.

The D.C. power unit for feeding power to the submersible plant is separated from the one for the terminal equipment to prevent electrical noise interference between them.

The power consumptions of this system by applying the OS-280M system and backhaul system at each cable landing station is estimated as follows:

<table>
<tr><th colspan="2">Category</th><th>Capacity</th><th colspan="2">Use</th></tr>
<tr><td rowspan="5">D.C.</td><td>-48 V</td><td>34.0 kVA</td><td colspan="2">Power Feed Equipment for Submersible Plant</td></tr>
<tr><td rowspan="4">-48 V</td><td>3.4 kVA</td><td colspan="2">OS Terminal Equipment for Submersible Portion</td></tr>
<tr><td>18.7 kVA</td><td colspan="2">OS Terminal Equipment for Land Portion</td></tr>
<tr><td>7.5 kVA</td><td colspan="2">Equipment for Backhaul System</td></tr>
<tr><td>1.5 kVA</td><td colspan="2">Order-Wire Equipment</td></tr>
<tr><td rowspan="6">A.C.</td><td rowspan="5">100 V/
115 V</td><td>0.1 kVA</td><td>Power Feed Equipment</td><td rowspan="6">o Transmission Line Supervising Equipment.
o Measuring Equipment.
o Clocks</td></tr>
<tr><td>4.4 kVA</td><td>OS Terminal Equipment for Submersible Portion</td></tr>
<tr><td>10.0 kVA</td><td>OS Terminal Equipment for Land Portion</td></tr>
<tr><td>0.8 kVA</td><td>Equipment for Backhaul System</td></tr>
<tr><td>3.0 kVA</td><td>Order-Wire Equipment</td></tr>
<tr><td>200 V/
220 V</td><td>1.0 kVA</td><td>Equipment for Backhaul Systems</td></tr>
<tr><td colspan="2">Total</td><td colspan="3">84.4 kVA</td></tr>
<tr><td colspan="2">Required Capacity for each Station</td><td colspan="3">84.4 kVA x 2.0 (Power Factor) = 168.8 kVA</td></tr>
</table>

If commercial power happens to fail, a diesel engine generator or gas turbine generator is considered suitable for this purpose a reliable machine.

The emergency power generator for this system, lighting and air conditioning equipment is required at each cable landing station and its capacity is estimated as follows:

Category \ Cable Landing Station	Kuantan	Kota Kinabalu
Consumption Power for Communication Systems	170 kVA	170 kVA
Lighting and Air Conditioning Equipment	-	200 kVA
Total	170 kVA	370 kVA

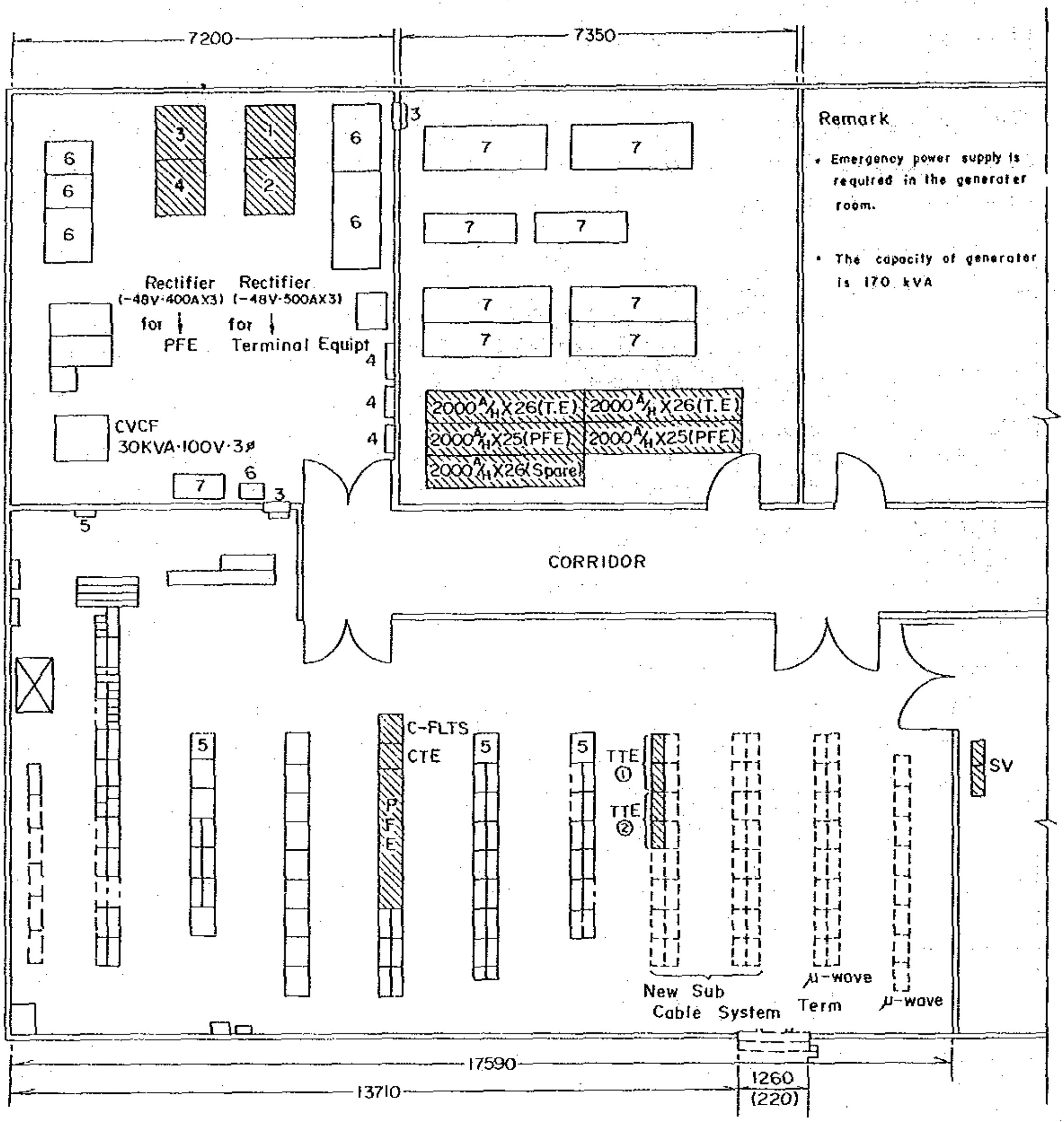


Fig. IV-5 Arrangement of Terminal Equipment and Power Facilities at Kuantan Landing Station

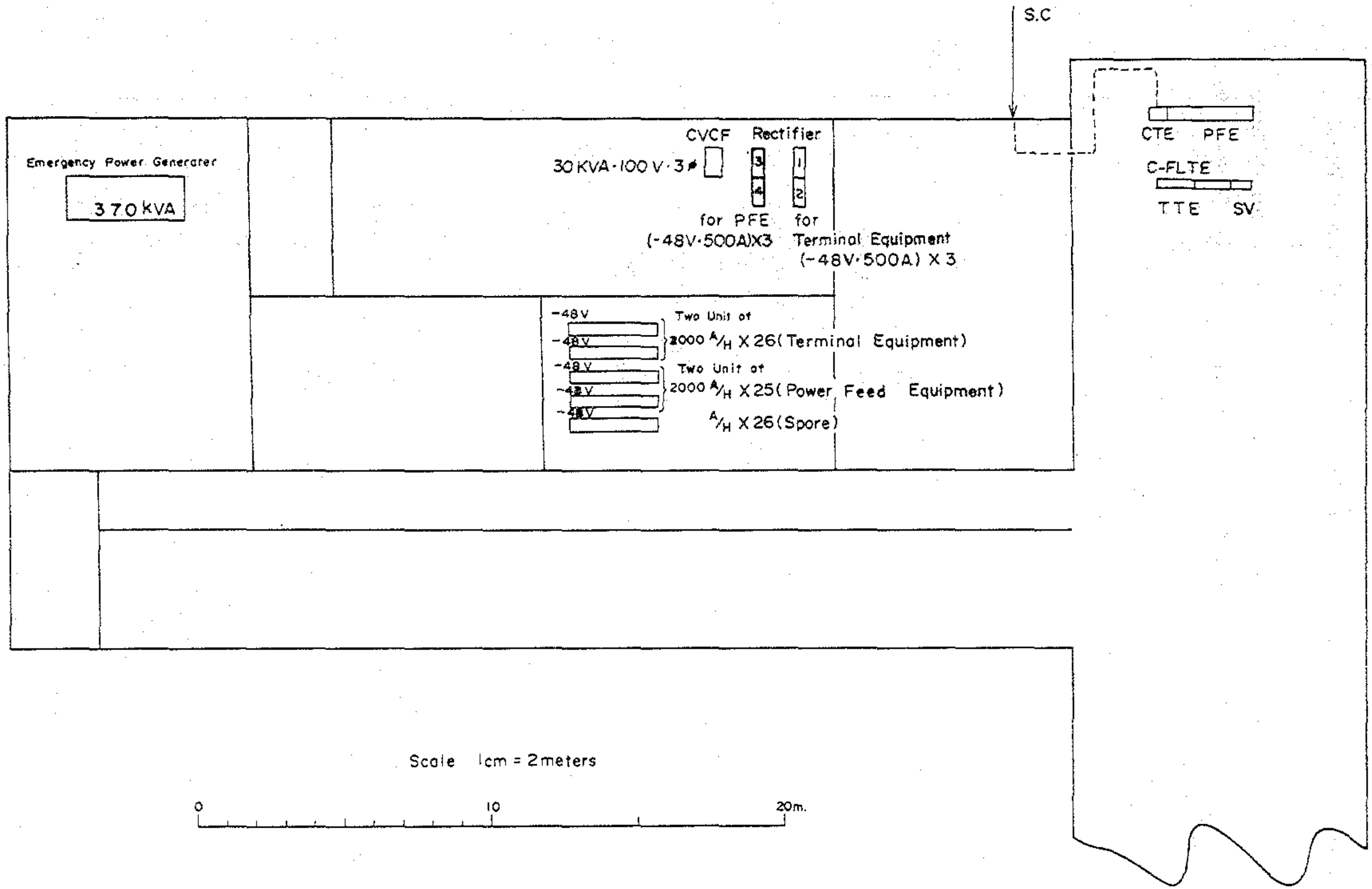


Fig. IV-6 Arrangement of Terminal Equipment and Power Facilities at Kota Kinabalu Landing Station

4.6 Design of Duct Route for Land Cable and Ocean Ground

The Study Team has designed the duct route and ocean ground facilities at both cable landing sites as shown in Figs. IV-7 (1/2) and (2/2).

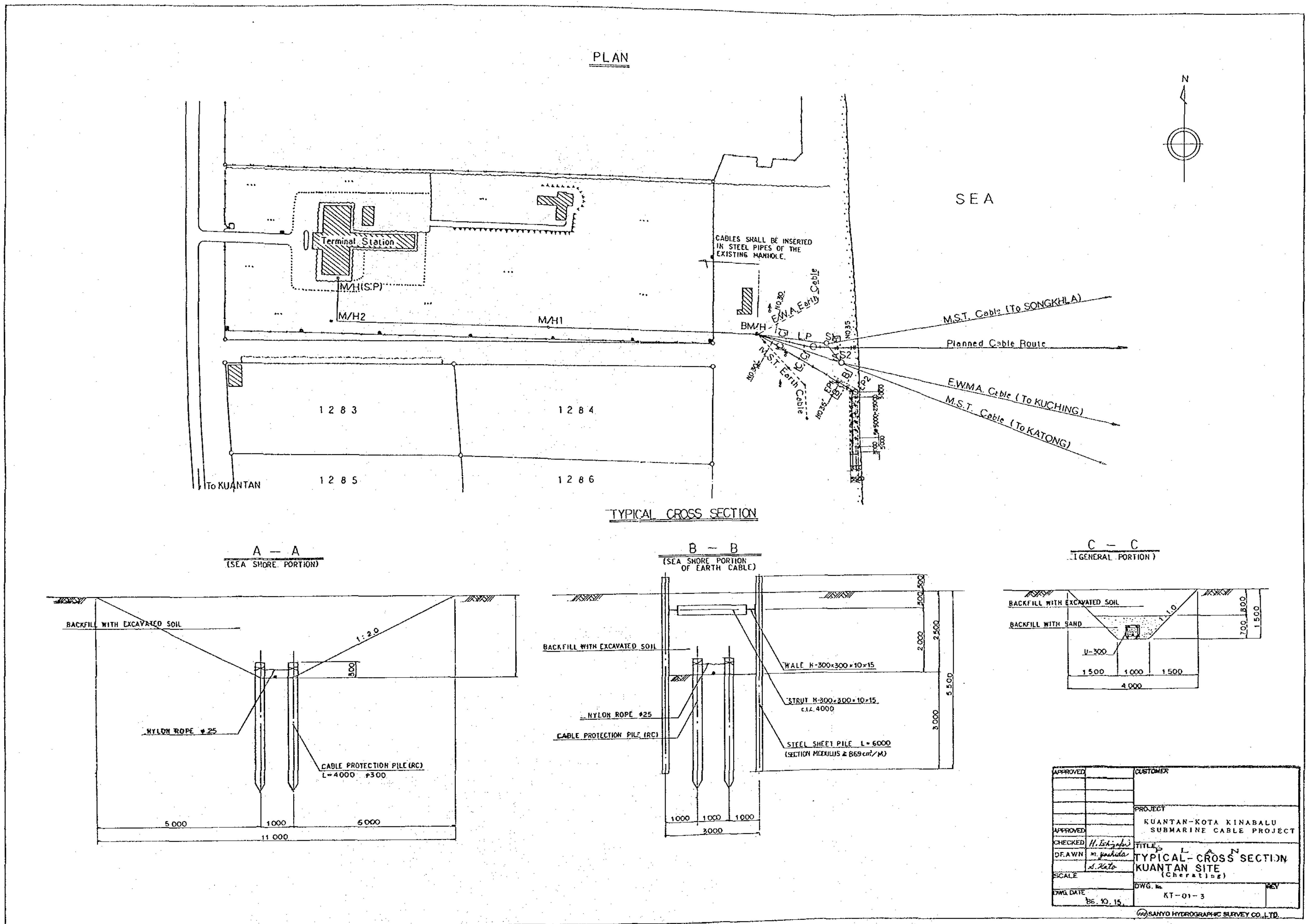


Fig. IV-7 (1/2) Design of Duct Route for Land Cable and Ocean Ground

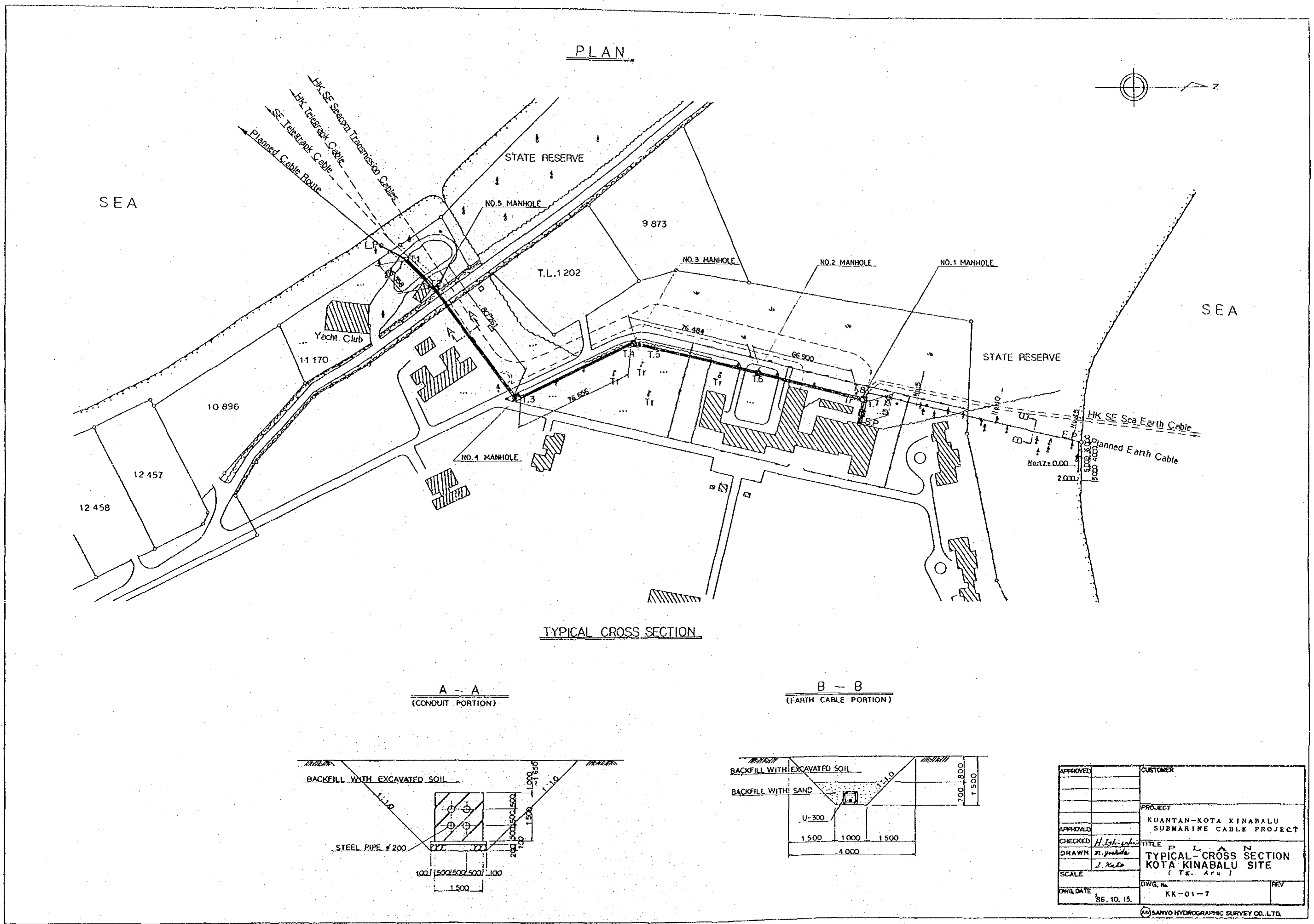


Fig. IV-7 (2/2) Design of Duct Route for Land Cable and Ocean Ground

5. KEY FEATURES OF OS-280M SYSTEM

5. Key Features of OS-280M System

5.1 Introduction

The OS-280M System is the first generation international long-haul optical-fiber submarine cable system in Japan. This system is designed to transmit 280 Mbps of digital information through the 1.3 μm optical-fiber and is developed by KDD.

5.2 Key Features of OS-280M System

The OS-280M System consists of cables with two operating fiber pairs, repeaters with four regenerators, and terminal equipment. Two CCITT 140 Mbps digital streams are multiplexed into a single, formatted 295.6 Mbps digital stream and converted into a 1.3 μm optical digital signal in the Transmission Terminal Equipment (TTE). Optical signals are transmitted through the optical-fibers and are regenerated at each repeater over an appropriate repeater span, while D.C. power for energizing the repeaters is fed through conductors in the cable. All the OS terminal equipment have been designed to meet the related CCITT standards.

The Table IV-3 summarizes the design parameters of the OS-280M System. The key features of the OS-280M System are as follows:

(1) Reliability

The overall system reliability is such that the anticipated number of ship repairs should not be more than three times during 25 years service life of the system. The OS-280M System is designed to ensure this objective with a reasonable margin, by the use of redundant circuitry and high-reliability components as well as closely-controlled manufacturing processes.

(2) Span Loss Budget

A normal repeater span is 53 km for deep sea portion. This figure, which includes no repair allowance, has been engineered to meet the error requirement with considerable margin for known and unanticipated effects. When applied in the shallow water portion, some repair allowances are taken into consideration.

(3) Maintenance and Supervision

The OS-280M System provides alarm information and consequent actions which conform to the related CCITT standards requirements. A computerized alarm/monitor information processing system is provided for efficient maintenance work.

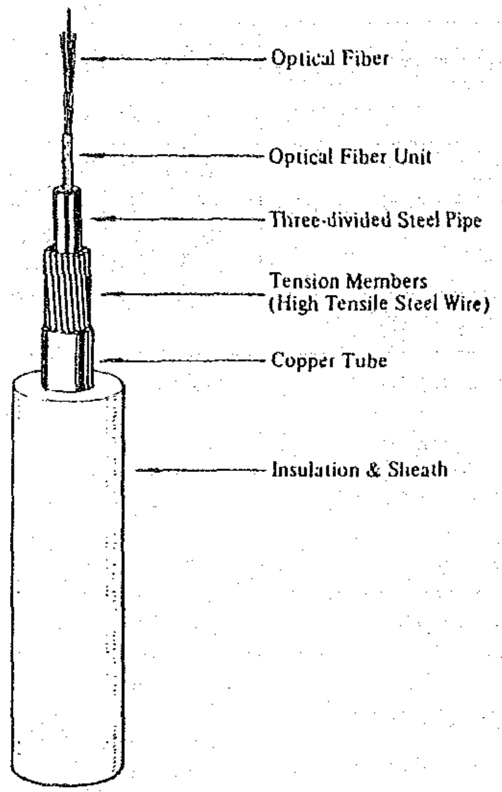
In-service error monitoring and out-of-service optical loopback systems at each repeater allow an immediate and accurate location of intermittent and hard faults, respectively, by using computerized automatic Home Supervisory Units (HSU) located at a cable landing station.

Table IV-3 OS-280M System Design Parameters

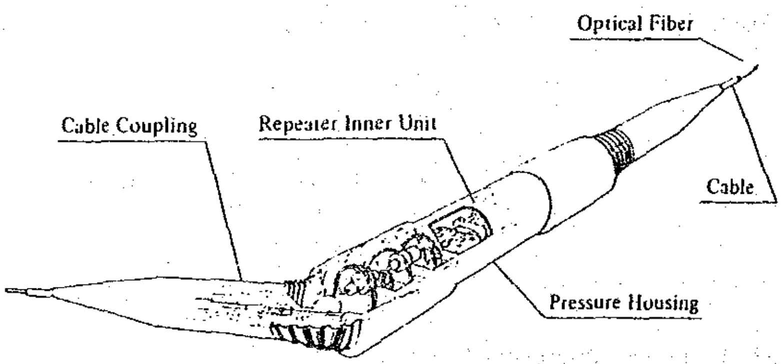
Item	Parameters
Line Bit Rate	295.6 Mbps
Transmission Capacity	7,560 ch (64 kbps) 2-subsystem
Line Code	24 B1P Scrambled binary NRZ
Bit Error Rate	Less than 4.4×10^{-8}/7,400 km
Jitter	Meet the CCITT Rec. G703 at 140 Mbps ports
Number of Subsystems	2
Maximum System Length	8,000 km
Maximum Sea Depth	8,000 m
Nominal Repeater Spacing	53 km
Optical Wavelength	1.31 μm
Optical-Fiber Type	Single-mode optical-fiber
System Design Life	25 years
Reliability	Not more than 3 ship repairs in 25 years
Repeater Supervision for Fault Location and Monitoring	In-service; o Bit error rate o Internal laser switching Out-of-service; o Optical loopback o Remote laser switching and operating laser detection o APD bias
Power:	
Constant Direct Current	±1.6 A
Maximum Voltage	±7,000 V

5.3 OS Submersible Plant and Terminal Equipment

Schematic views of OS submersible plant are shown in Fig. IV-8.



OS Cable (Unamoured Type)



OS Repeater

Fig. IV-8 OS Submersible Plant

(1) OS Cable

The technical features of the OS cable are as follows:

(a) Four high-strength, low-loss, single-mode optical-fibers together with two dummy fibers are contained in each cable.

(b) Optical-fibers are embedded in resin and the inside of the cable is filled with a soft compound. These two materials prevent the extension of water into the cable and provide for stable optical transmission characteristics.

(c) Steel pipe in three segments together with tension members protect optical-fibers from external mechanical forces.

(d) Welded copper tube surrounds the tension members and acts both as a barrier against the spread of moisture to the inner cable and as the power conductor.

(e) Polyethylene excluded for insulator of power feed line.

The cross-section of cable is shown in Fig. IV-9.

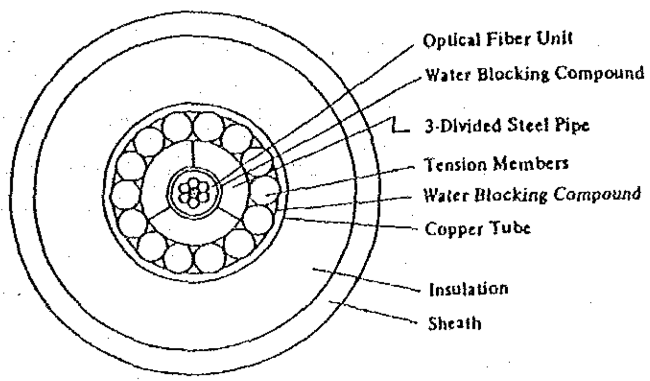


Fig. IV-9 Cable Cross-Section

(1)-1 Optical-Fiber Unit

Optical-fiber unit containing the optical-fibers shown in Fig. IV-10 are formed into three types of optical-fiber submarine cables, namely, Unarmoured (UA), Single Armoured (SA), and Double Armoured (DA) cables.

Optical-fiber physical parameters and transmission parameters after cabling are shown in Tables IV-4 and IV-5, respectively.

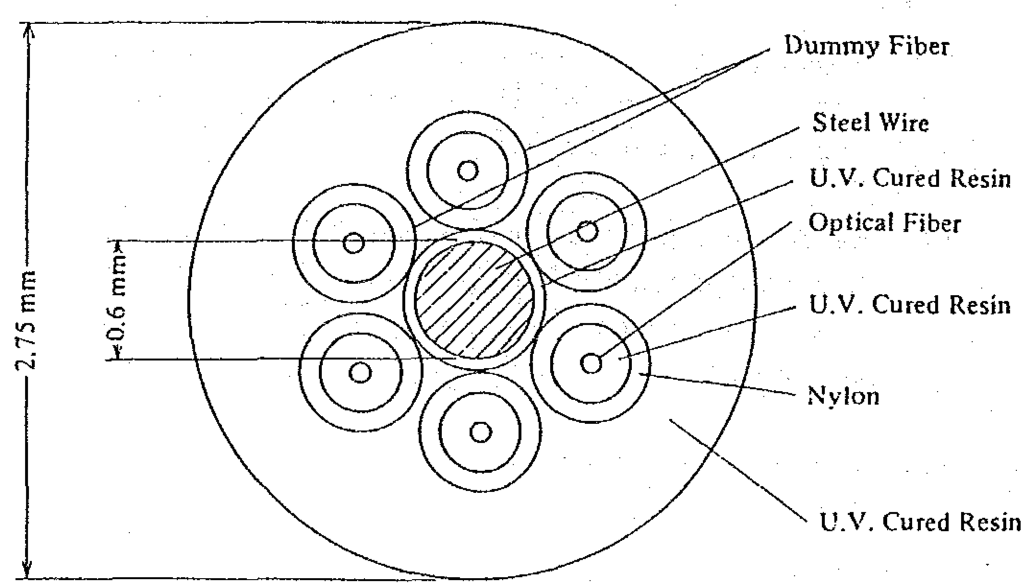


Fig. IV-10 Optical-Fiber Unit Cross-Section

Table IV-4 Optical-Fiber Physical Parameters

Item		Parameters
Optical-Fiber	Mode Field Diameter	10 μm
	Diameter	125 μm
Inner & Outer Coatings	Material	UV-cured Resion
	Diameter	Nominal 0.4 mm
Sheath	Material	Nylon
	Diameter	Nominal 0.6 mm
Elongation Proof Level for Normal Optical-Fibers		≧2%
Elongation Proof level for Splice Point		≧2.5%

Table IV-5 Optical-Fiber Transmission Parameters after Cabling

Item		Parameters
Optical Attenuation	1.30 μm to 1.32 μm	≦0.45 dB/km
Chromatic Dispersion	1.30 μm to 1.32 μm	±2.0 ps/nm km
Zero Dispersion Wavelength (typical value)		1.31 μm
Cut-off Wavelength		<1.30 μm

(1)-2 Unarmoured (UA) Cable

The structure of the unarmoured cable is shown in Fig. IV-11 and its characteristics are shown in Table IV-6.

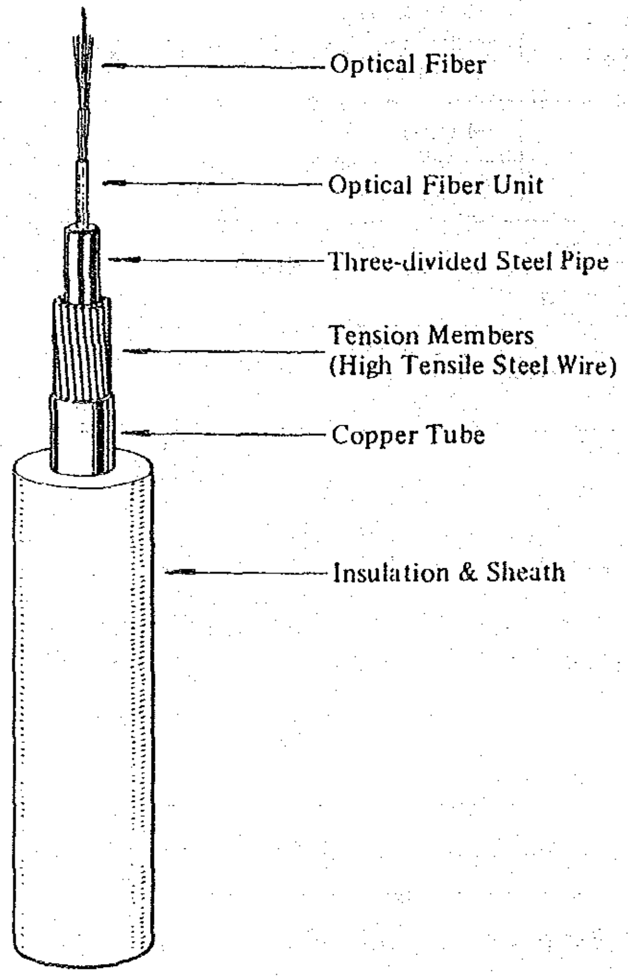


Fig. IV-11 Structure of Unarmoured (UA) Cable

Table IV-6 Unarmoured (UA) Cable Characteristics

Item		Parameters
Maximum Sea Depth		8,000 m
Diameter		22 mm
Weight	In Air	0.9 ton/km
	In Water	0.5 ton/km
Cable Tensile Strength		10 ton
Strength/Weight in Water		More than 20 km
Minimum Bending Radium		1 m
Water Ingress		Less than 2 km/2 weeks, at 7,500 m Less than 1 km/2 weeks, at 5,500 m Less than 0.25 km/2 weeks, at 1,000 m
Temperature Characteristics of Attenuation		0.006 dB/km (+50°C to -2°C)
D.C. Resistance		0.71 Ω/km
Insulation Resistance		2 x 10^6 MΩ/km
Maximum Voltage		12 kV
Number of Optical-Fibers		4 (Maximum 6)
Optical Attenuation		0.45 dB/km (3°C)

(1)-3 Single Armoured (SA) Cable

The structure of the single armoured cable and its mechanical characteristics are shown in Fig. IV-12 and Table IV-7, Respectively.

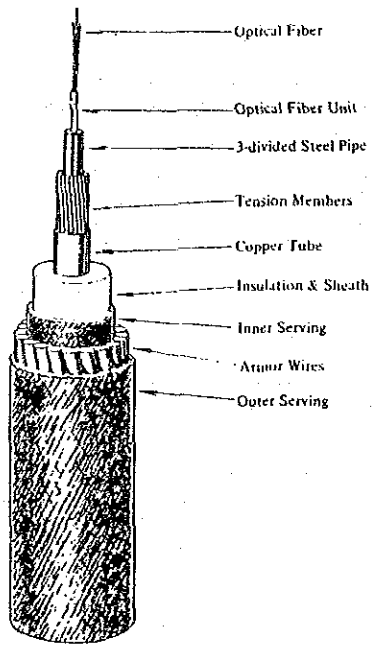


Fig. IV-12 Structure of Single Armoured (SA) Cable

Table IV-7 Single Armoured (SA) Cable Mechanical Characteristics

Item		Parameters
Diameter		41 mm
Diameter & Number of Armour Wires		5 mm x 18
Weight	In Air	4.1 ton/km
	In Water	2.8 ton/km
Cable Tensile Strength		More than 21 ton
Cable Torque		About 2 kg-m/ton
Minimum Bending Radius		1 m

(1)-4 Double Armoured (DA) Cable

The structure of the double armoured cable and its mechanical characteristics are shown in Fig. IV-13 and Table IV-8, Respectively.

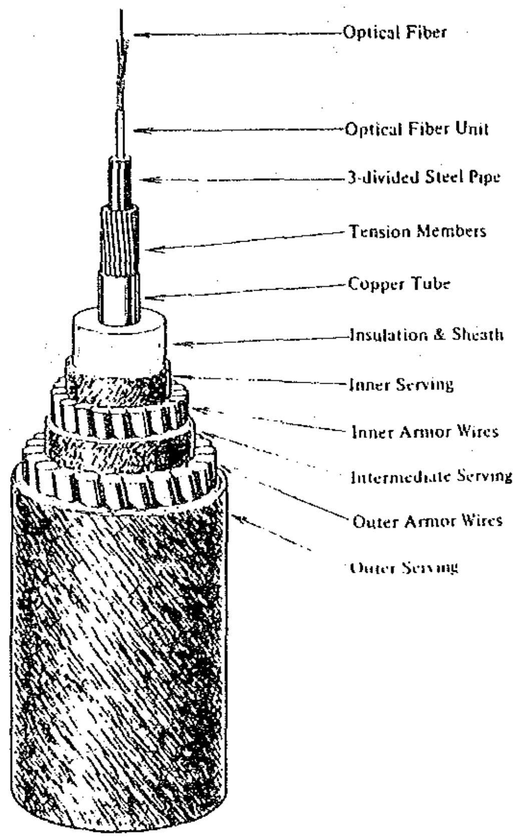


Fig. IV-13 Structure of Double Armoured (DA) Cable

Table IV-8 Double Armoured (DA) Cable Mechanical Characteristics

Item		Parameters
Diameter		58 mm
Diameters & Number of Armour Wires	Inner wire	5 mm x 18
	Outer Wire	7 mm x 20
Weight	In Air	10.7 ton/km
	In Water	8.1 ton/km
Cable Tensile Strength		More than 42 ton
Cable Torque		About 3 kg-m/ton
Minimum Bending Radius		1.5 m

(2) OS Repeater

The technical features of the OS repeater are as follows:

(a) Regeneration of optical signals transmitted through the optical cable.

(b) High-reliability design achieved by using sophisticated monolithic integrated circuits (ICs) and laser redundancy techniques.

(c) Monitoring functions for maintenance and repair:

In service
* Error-performance monitoring
* Internal laser switching

Out-of-service
* Optical loopback system
* Avalanche Photodiode (APD) bias monitoring
* Laser switching/operating laser detection

(d) Housing designed to protect the circuits from elevated water pressures and external mechanical forces.

Figs. IV-14 and IV-15 show the OS repeater configuration and block diagram of the regenerator, respectively. The Table IV-9 summarizes the design parameters of the OS repeater.

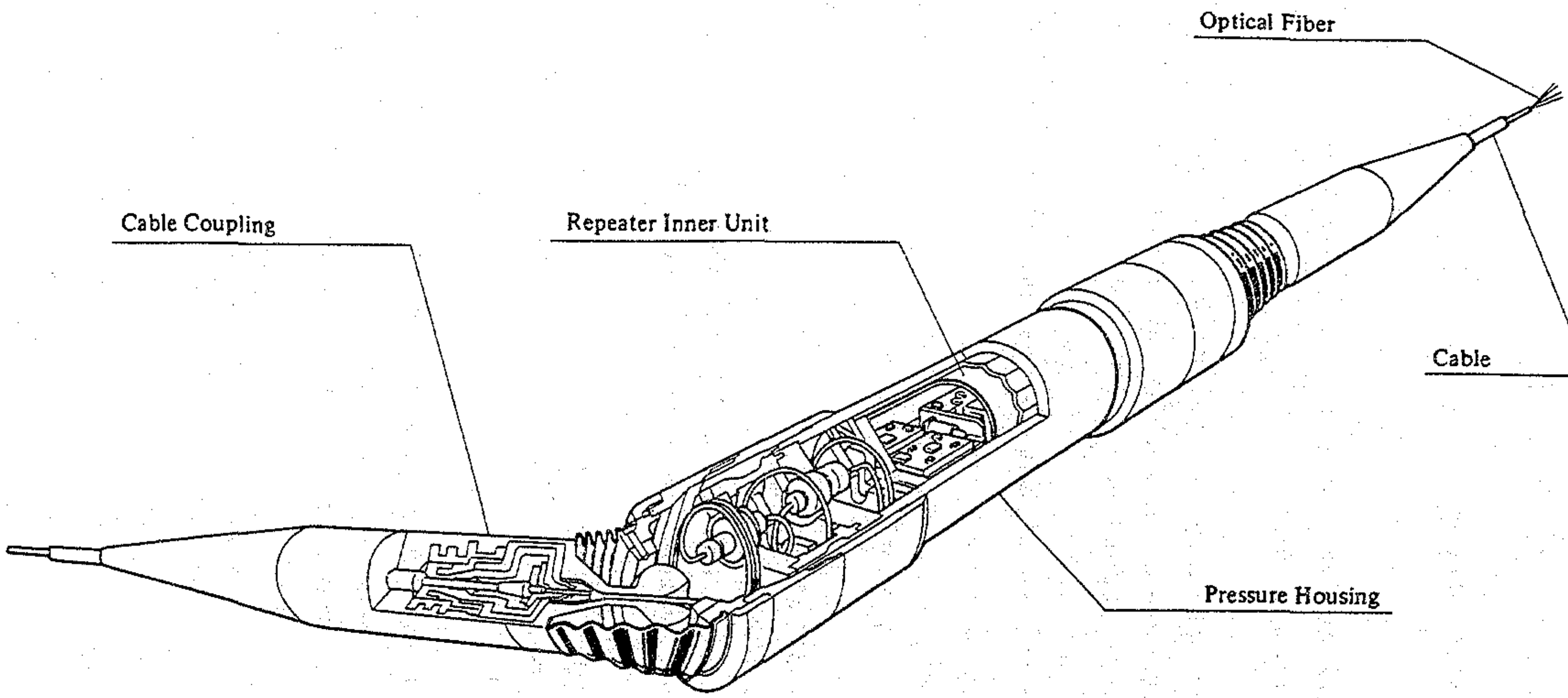


Fig. IV-14 OS Repeater Configuration

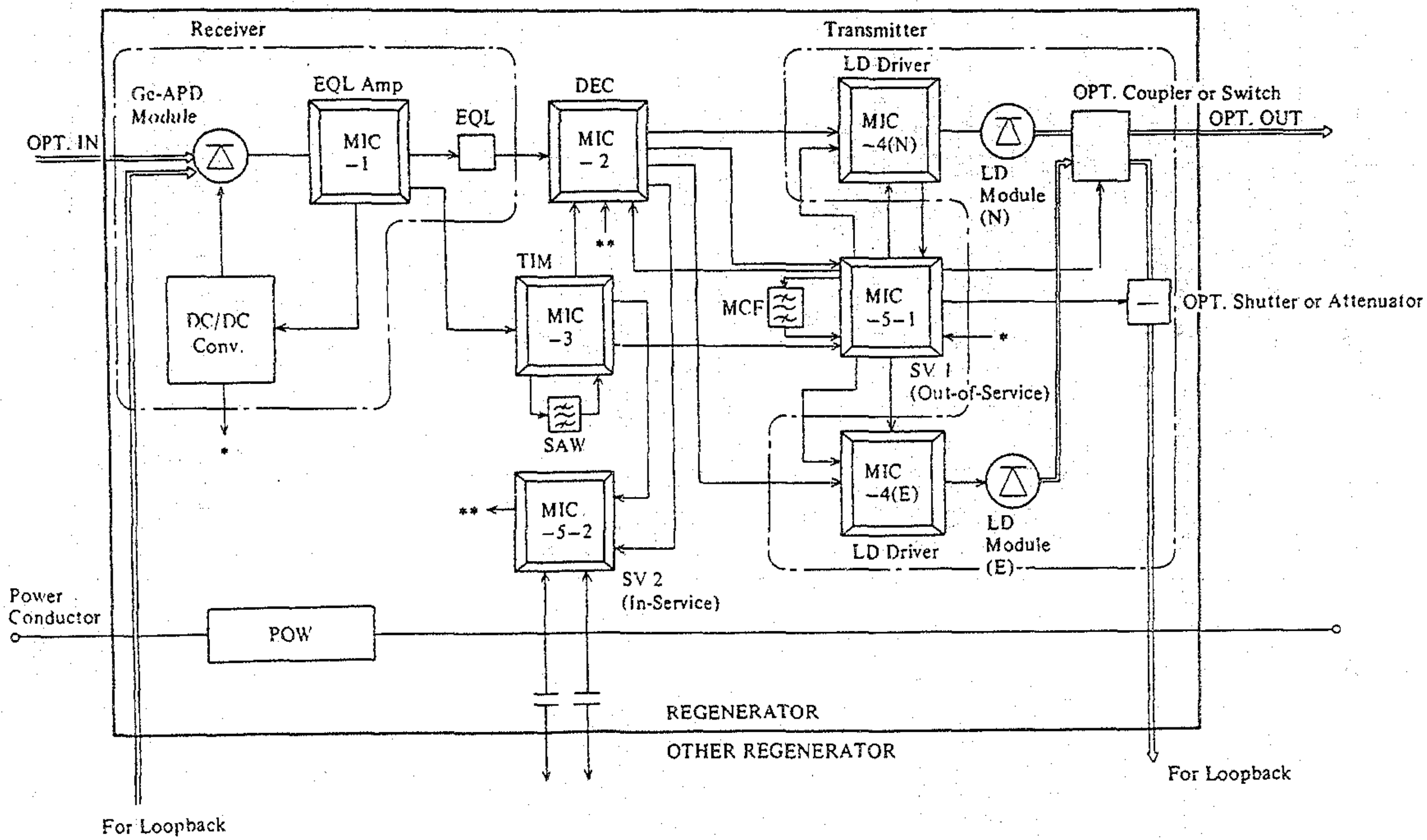


Fig. IV-15 Regenerator Block Diagram

Table IV-9 OS Repeater Design Parameters

Item		Parameters
Line Bit Rate		295.6 Mbps
Line Code		24 B1P Scrambled Binary NRZ
Source		InGaAsP/InP, Laser
Photo Detector		Ge-APD
Optical Wavelength		1.31 μm
Output Optical Power		More than -4 dBm
Receiving Level		Less than -36.2 dBm (at BER = 10^{-11})
Over Load Level		More than -13.2 dBm
Receiving Dynamic Range		More than 23 dB
Jitter		Less than 1° (RMS) and less than 15° (P-P)
Repeater Supervisory		In-service and out-of-service supervisory
Repeater Span		Nominal 53 km
Power Feed Current		D.C. ±1.6A ±2%
D.C. Voltage Drop		31 V (at 2-System) Except voltage drop of cable
Power Consumption		Less than 50 W
Surge Resistivity		More than D.C. ±12 kV
High Voltage Resistivity		More than D.C. ±12 kV
D.C. Insulation Resistance		More than 2,000 MΩ
Design Life		25 years
Reliability		Less than 64 Fits (at 2-System)
Redundancy		1 LD spare cold standby
Quality of Housing		Beryllium Copper Alloys
Dimensions*		265 mmø x 1,480 mm
Weight*		Less than 400 kg
Pressure Strength		More than 800 kg/cm²
Shock Strength		No damage on peak 50 G
Vibration Strength		No damage on vibration frequency 5 to 55 Hz/amplitude 1.5 mm
Temperature Condition	In Use	0 to 30°C
	In Storage	-10 to 40°C

* Excluding cable couplings.

(3) OS Terminal Equipment

The OS Terminal Equipment consists of Cable Termination Equipment (CTE), Power Feed Equipment (PFE), Transmission Terminal Equipment (TTE) and Supervisory Equipment (SV).

(3)-1 Cable Termination Equipment (CTE)

The CTE terminates an underwater cable and connects the submarine optical-fibers to the in-station optical-fibers.

Monitoring of the ground voltage and return current, switching over the power line from the ocean ground (power feeding ground) point to the station ground (station earth) and surge protection are other functions which are provided.

An external view of the CTE is shown in Fig. IV-16.

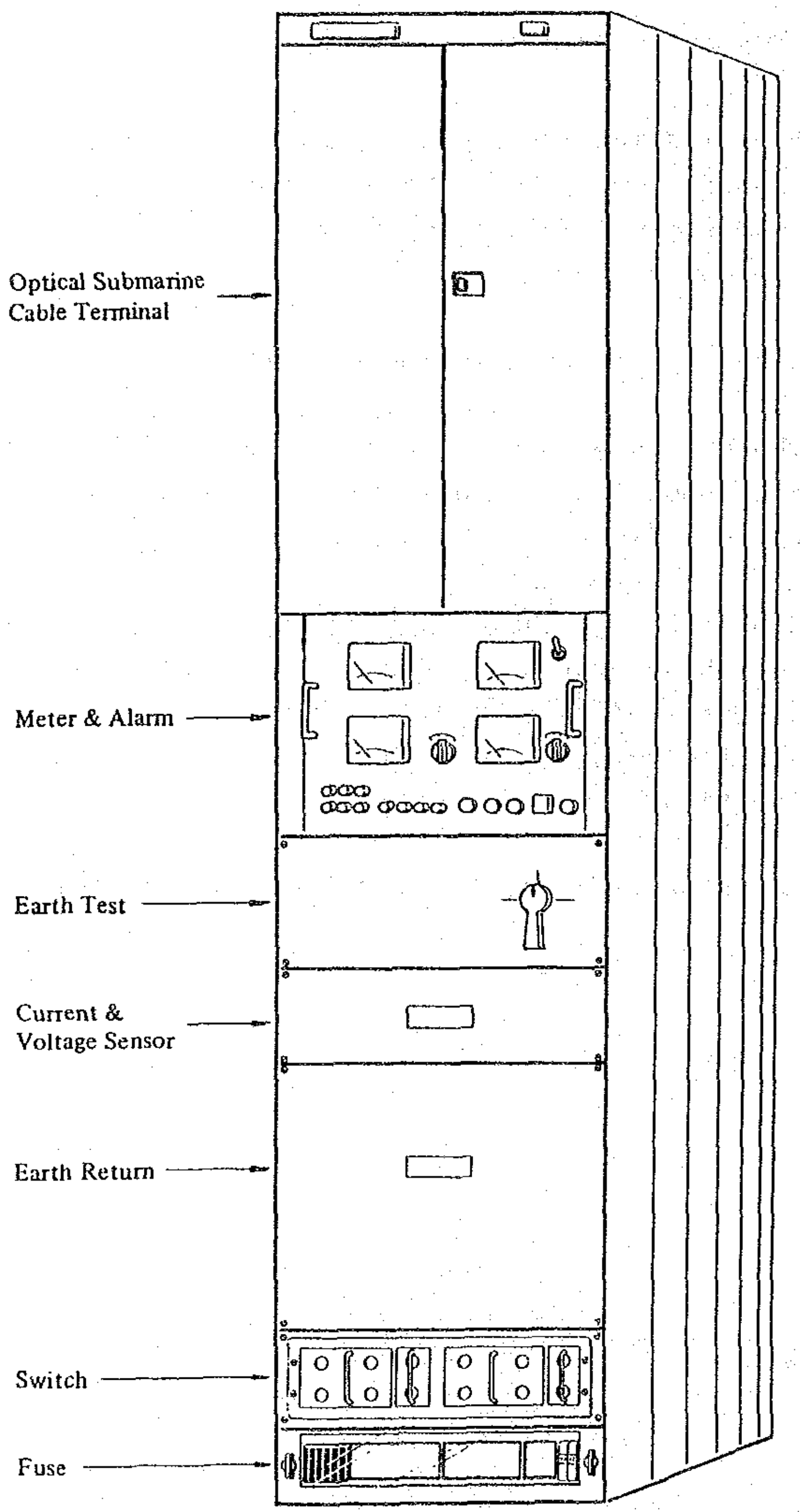


Fig. IV-16 Cable Termination Equipment

(3)-2 Power Feed Equipment (PFE)

The function of the PFE is to provide a constant supply of D.C. current at ±1.6 A to the submersible plant for a period of 25 years lifetime. The maximum output voltage is ±7000 Volts. Full duplication is adopted to achieve high reliability. Use of high efficiency converter makes it possible to reduce the physical size and power consumption of the equipment. Personnel protective techniques are based on conventional coaxial submarine cable system design.

The OS terminal equipment with emphasis on the PFE is given in Fig. IV-17. Fig. IV-18 provides an overview of the equipment.

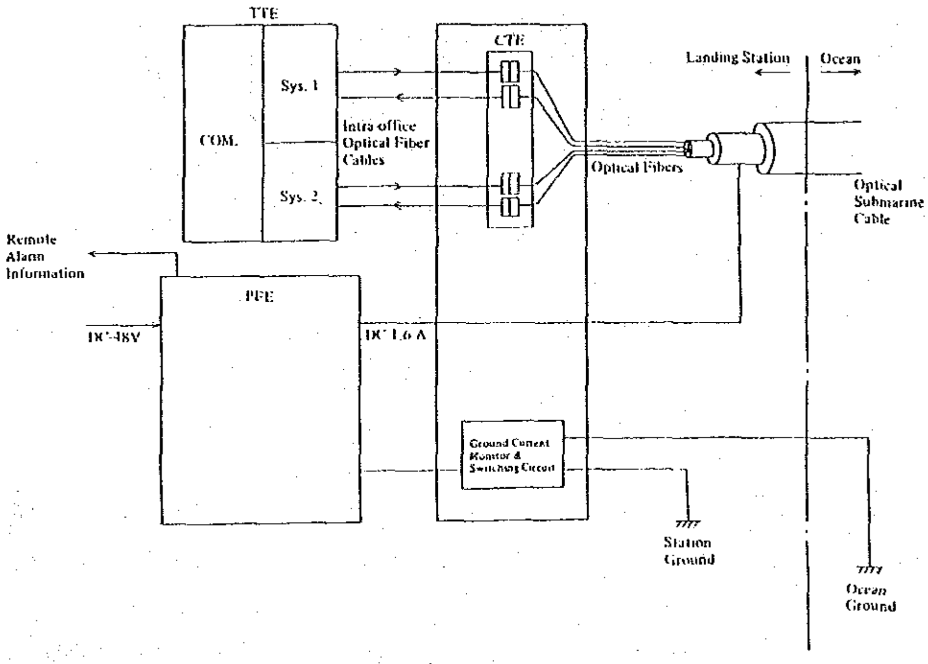


Fig. IV-17 OS Terminal Equipment Connection Diagram, PFE Specific

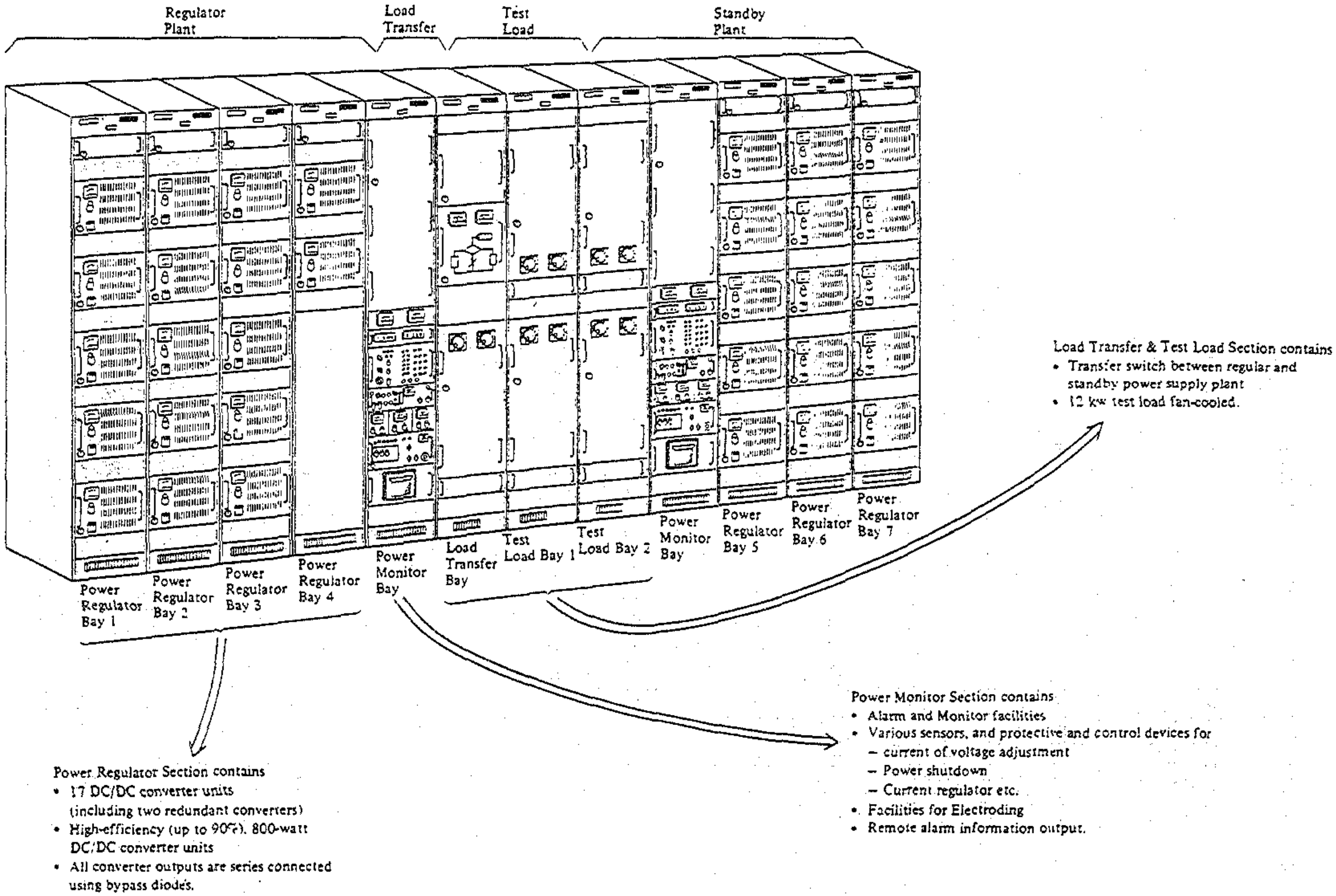


Fig. IV-18 Power Feed Equipment Overview and Features

(3)-3 Transmission Terminal Equipment (TTE)

The TTE conforms to the relevant CCITT standards. Full duplication and bit-by-bit error comparison for detecting performance degradation result in high reliability. The main function of TTE are as follows:

(a) Multiplexing of two CCITT 140 Mbps digital streams and housekeeping bits into a single, formatted 295.6 Mbps digital stream.

(b) Optical/electrical conversion for interfacing the electrical equipment to the optical-fibers.

(c) Provision of the necessary order-wire channels and terminal-to-terminal telemetry circuits for maintenance.

(d) Provision of the required HSU interfacing.

(e) Detection of fault conditions and generation of alarms and Alarm Indication Signals (AIS).

(f) Parity bit insertion and parity violation detection as a means of transmission performance monitoring.

The TTE is composed of two types of devices, the Optical Line Terminal Equipment (OLTE) and the Common Equipment (COM) as shown in Fig. IV-19. The TTE features two OLTEs and one COM to support the two traffic-carrying optical-fiber pairs of the submarine cable system.

OLTE consists of two main functional portions:

* Multiplexer and Demultiplexer (MULDEX) which multiplexes two 139.264 Mbps tributaries into a composite 295.6 Mbps line signal stream and provides the reverse process, and

* Terminal Optical Transmitter (OS)/Receiver (OR) which converts the multiplexed electrical digital signal into the corresponding optical signal and vice versa.

COM provides a common piece of equipment for two traffic optical-fiber pairs as a TTE status message processor. This unit manages the terminal-to-terminal signalling for system maintenance and two sets of order-wire translating devices for the two traffic optical-fiber pairs which are T-bit muldexes to convert from 64 kbps (nominal channel) to the appropriate interface signal bit rate of 211.142 kbps for T-bit in the multiplexing frame format of the OLTE and vice versa.

The block diagram of the TTE includes two OLTEs and one COM equipment is shown in Fig. IV-20.

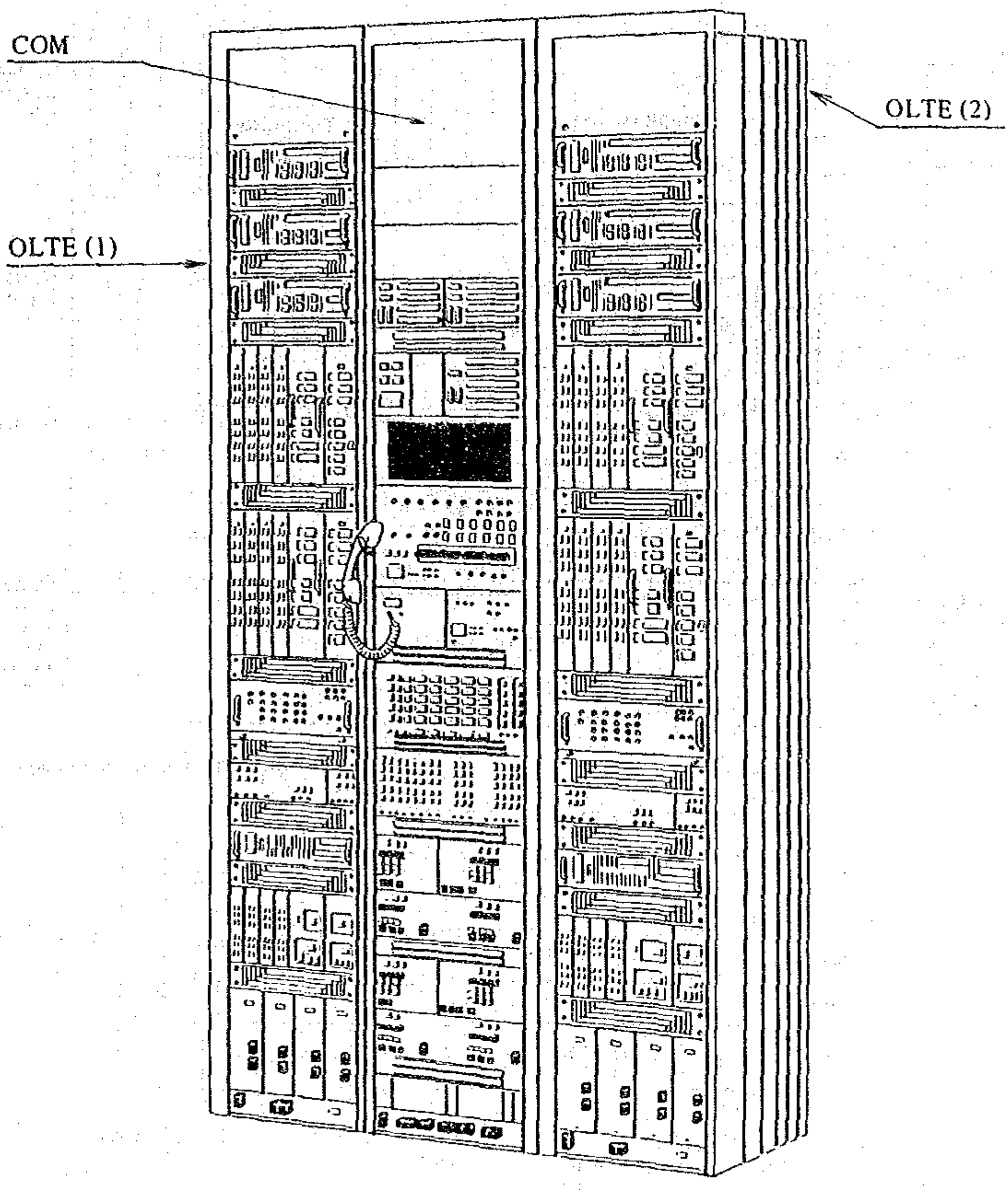


Fig. IV-19 Transmission Terminal Equipment

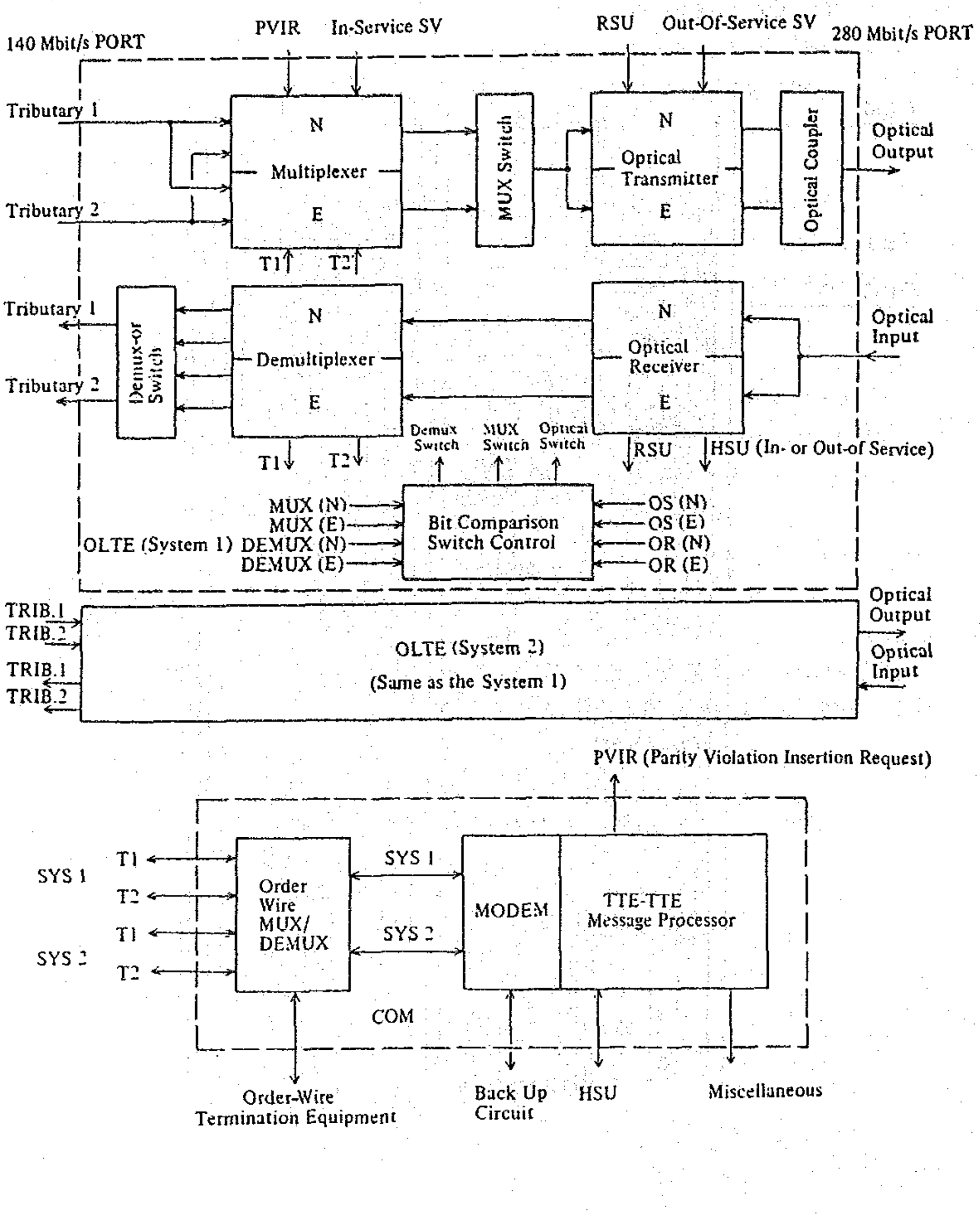


Fig. IV-20 Block Diagram of Transmission Terminal Equipment

(3)-4 Supervisory Equipment (SV)

The SV equipment consists of HSU (Home Supervisory Unit) designed to provide an accurate and simple fault locating system. The main HSU functions are as follows:

(a) Control of repeater monitoring circuits, both in-service and out-of-service.

(b) Supervisory co-ordination through terminal-to-terminal telemetry or dial-up circuits.

The basic configuration of the supervisory system is shown in Fig. IV-21, and Fig. IV-22 shows the SV equipment which monitors the OS system operating with the TTE.

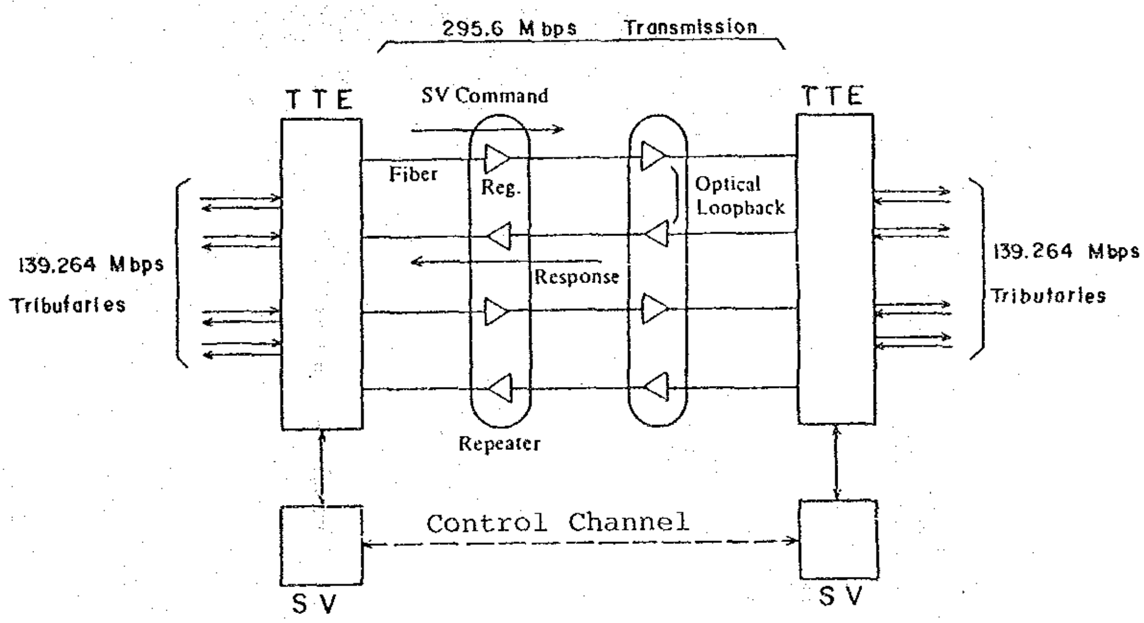


Fig. IV-21 Supervisory System Configuration

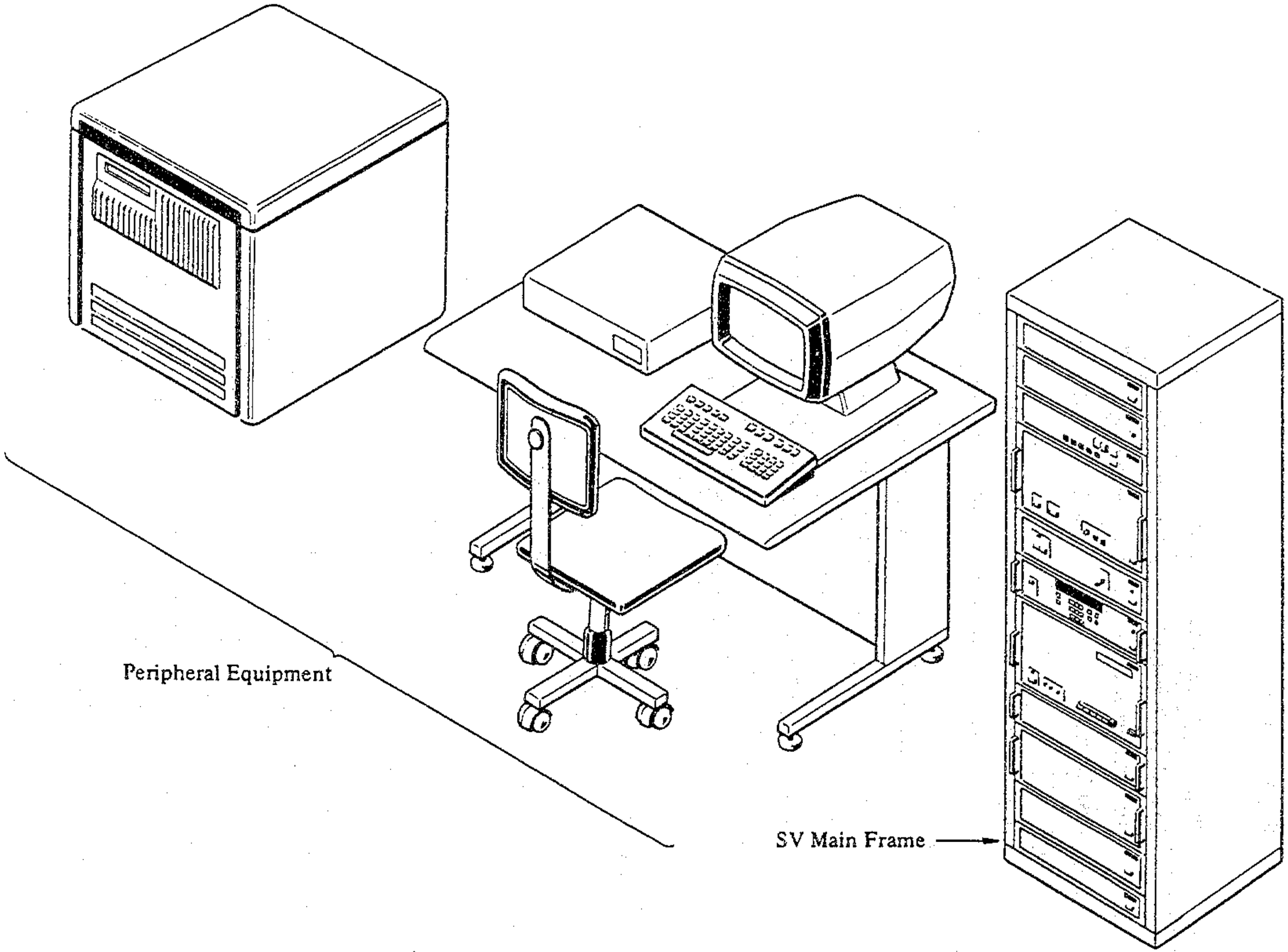


Fig. IV-22 Supervisory Equipment

(4) Cable Fault Location

The OS cable fault location methods, not available in the SV system, are as follows:

(a) The Cable Capacity Measuring Method is used to locate open faults. the measurement accuracy involved is 1% over the entire 8,000 km.

(b) A low-voltage D.C. current is used to locate shorts to ground. Here, the fault will be pinpointed with an accuracy of within one repeater span within the entire 8,000 km.

(c) The back-scatter method is used to locate a break or an increased loss point in the optical-fiber lines. The measurement accuracy is within 10 m for the first repeater section from the landing station. (30 - 40 km).

(d) The Electroding method, by means of feeding a 15 - 25 Hz current into the cable to enable tracking by a submersible vehicle, is used for locating power faults within a distance of 300 km from cable landing station.

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