2. Transmission

2-1 Design of Transmission Lines

The transmission line is designed as per Part III "STANDARDS."

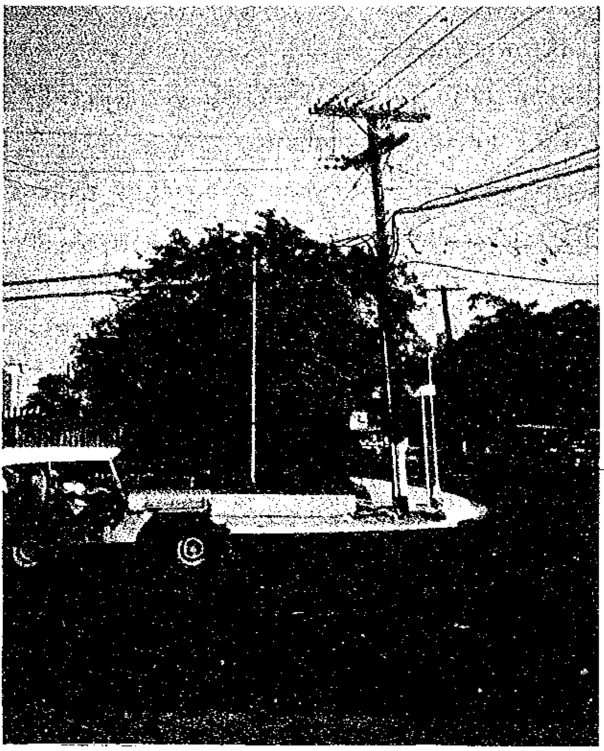
2-1-1 Transmission Lines Between Secondary Center and Primary Center

Although transmission between secondary center and primary center will be made by microwave radio system, it must be discussed what kind of transmission line should be employed between trunk exchange and radio repeater station when the toll switch and radio equipment are not in the same station building. The applicable primary center is only Bayombong PC and the distance between toll exchange and repeater station and required number of channels are as follows.

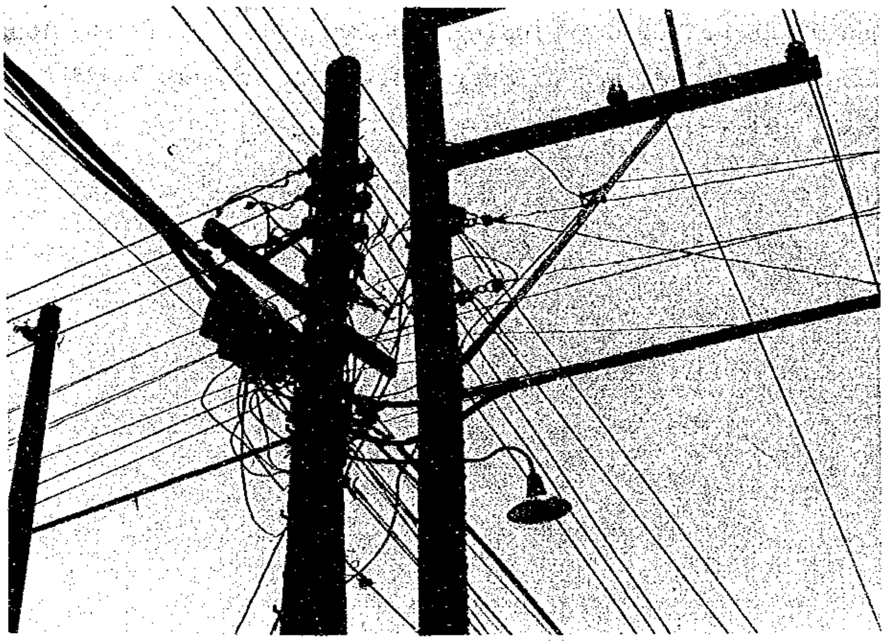
	Distance	Required Number of Channels	
		1990	1997
Bayombong	2.8 km	approx. 80	approx. 110

For applicable type of transmission line, coaxial cable system, cable carrier system, and trunk cable system may be considered. Of these transmission systems however, the trunk cable system is recommended from the standpoint of economical advantage. Since

the loss of the line between the toll exchange and repeater station is about 2.0dB including repeating coil loss, the loss between the secondary center and primary center can be made 3.5dB as required from Fig. III-2-6-3.



Telephone Cable mounted on a pole
(At Manila)

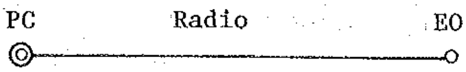


Telephone Cable Mounted on a pole
(At Manila)

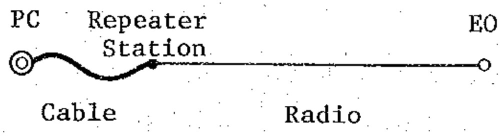
2-1-2 Transmission line Between Primary Center and End Office

The transmission line between primary center and end office should be designed as per Part III, section 7 "Transmission Planning Standard," and the following 8 types of transmission line will be used.

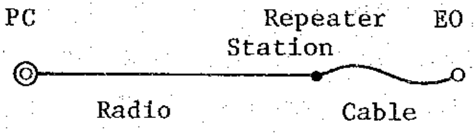
(1) Radio only



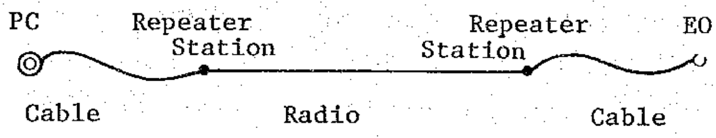
(2) Radio (with entrance cable on PC side)



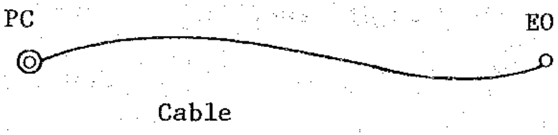
(3)Radio (with entrance cable on EO side)



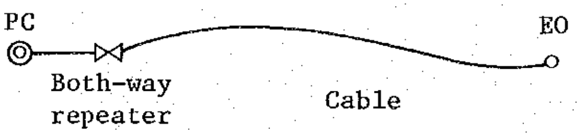
(4) Radio (with entrance cable both PC AND EO sides)



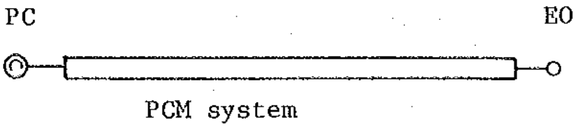
(5) Cable (with boty-way repeater)



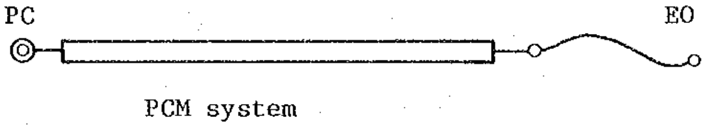
(6) Cable with both-way repeater)



(7) PCM system



(8) PCM system (with entrance cable on EO side)



The type of radio system to be employed has been determined in consideration of the circuit demand to be made by 1997.
In general, loaded trunk cable of0.65mm in core diameter will be used. In order to make the loss between primary center (PC) and end office (EO) 6.0dB as required, a both-way repeater will be installed when the distance between PC and EO is more than 11km in the case of (5). When the distance between PC and EO is more than 20km, PCM system is introduced (case (7) or (8)). In the cases of (2) - (4) and (8), the loss between PC and EO can be made 6.0dB when the cable distance is less than 11km. Except the Tuguegarao-Claveria section (of which cable section will range Sanchez Mira to Claveria), the cable distances are less than 11km and there is no particular problem at all.
In the Sanchez Mira-Claveria section, a 4-wire system using 2 pairs of cable cuares will be applicable and, at the same time, and repeater used, by which the loss between PC and EO can made within the specified range.
The types of transmission lines to be employed in the respective sections in this project are given in Tables VIII-2-1-1 and VII-2-1-2.

Table VIII-2-1-1 Types of Transmission Lines to Be Employed

Phase 1

Type	Local Exchange	IPTS	Existing Local Exchange
1	Binalonan Alaminos Bangued Dinaras Batac, Dingras Narvacan, San Matero Alicia Cabarroguis Tumauini	San Quintin Sanchez Mira Ballesteros Tuao Lal-lo Santa Pasquin Piddig San Manuel Basco	Santiago
2	none	none	none
3	Bontoc Tagudin Paoay, Cabugao	Espiritn Claveria Gonsaga Currimao Sta. Maria(Ilcos Sur)	Candon
4	none	Banaue	none
5	Sarrat, Solana Enrile	St. Domingo	Solano
6	San Fabian	San Jacinto Mapandan	none
7	Bambang	none	none
8	none	none	none

Table VIII-2-1-2 Types of Transmission Lines to Be Employed

Phase 2

Type	Local Exchange	IPTS	Transferred Exchange
1	Alcala (Pangasinan), Bani, Urbiztondo, Sison, San Nicolas, Santa Maria (Pangasinan) Baggao, Alcala (Cagayan) Pinili	Sto.Tomas, Balungao Lazam Sto.Niño, Piat Buguey Bangui, Burgos, Jones, Cabagan, Mallig	Bugallon Umingan
2	none	Mayoyao, Maddela Kiangan	none
3	Mankayan, Bolinao Bolinao Solsona Sinait Pagudpud, Badoc, San Mariano, Angandanan, Diffun	Sagada, Bokod, Aguilar, Bautista, Abulug Camalaniugam, Kabugao, Lubuagan Natividad Marcos, Nueva Eera Sta.Lucia, Aurora San Augustin	none
4	none	Santa Fe	none
5	Vintar, Magsingal Asingan	Caoayan	Pozzorubio
6	Gamu, Naguilian	none	Bacarra Sta. Barbara
7	Bagabag, Aritao Dupax del Sur	none	none
8	none	Dupax del Norte	none

Fig. VIII-2-1-1 TELECOMMUNICATION NETWORK IN NORTHERU LUZON

2-2 Radio

2-2-1 Main Routes

(1) Route selection

The route selection of the main route has been made on condition that the six primary centers, one secondary center in the two regions and Manila will be interconnected by microwave.

Proposed M/W routes in Reg. I and II will be newly constructed and an interconnection M/W between the two regions and Manila is proposed as replacement of the existing route. The main route thus planned by using microwave is shown in Fig. VIII-2-2-1. In route selection, consideration is given so that 100% of the First Fresnel Zone should be cleared at K=4/3 and 30% thereof at K=2/3.

The courseprofiles of the respective radio sections are shown in Figs. VIII-2-2-2 through VIII-2-2-17. The locations, elevations, required tower heights of the respective repeater stations are shown in Table VIII-2-2-1.

Table VIII-2-2-1 Site Locations of Microwave Stations

Microwave Station	Longitude [E]	Latitude [N]	Elevation [m]	Antenna Height [m]	Course Distance [km]
Laoag	120°35'51"	18°12'48"	50	95	38.0
Sinait	120°28'17"	17°53'34"	65	50	36.6
Vigan	120°23'18"	17°34'25"	8	60	29.6
Bigbiga	120°26'59"	17°18'51"	200	15	44.1
Tagudin	120°27'44"	16°55'04"	110	15	25.0
Guinguinabang	120°22'29"	16°42'32"	165	15	46.0
Sto. Tomas	120°33'35"	16°25'07"	2,250	15	10.6
Baguio	120°36'33"	16°25'05"	1,460	20	31.4
Binalonan	120°35'14"	16°03'15"	35	20	23.7
Mt. Balungao	120°41'23"	15°51'53"	160	15	38.9
Kitakita	121°02'59"	15°49'05"	360	30	38.8
Dalton Pass	120°55'17"	16°08'11"	940	50	44.1
Bayombong	121°08'00"	16°28'52"	445	30	26.2
Diadi	121°19'35"	16°37'37"	516	20	40.3
San. Mateo	121°35'43"	16°52'41"	75	30	40.8
Ilagan	121°52'29"	17°08'00"	80	70	56.4
Tuguegarao	121°42'29"	17°36'56"	20	110	
Mt. Balungao					45.0
Tarlac	120°35'10"	15°29'14"	41		38.3
Dau	120°34'67"	15°07'34"	95		45.0
Pandi	120°56'56"	14°54'56"	20		33.0
Manila	120°58'39"	14°35'47"	3		
				Total	731.8

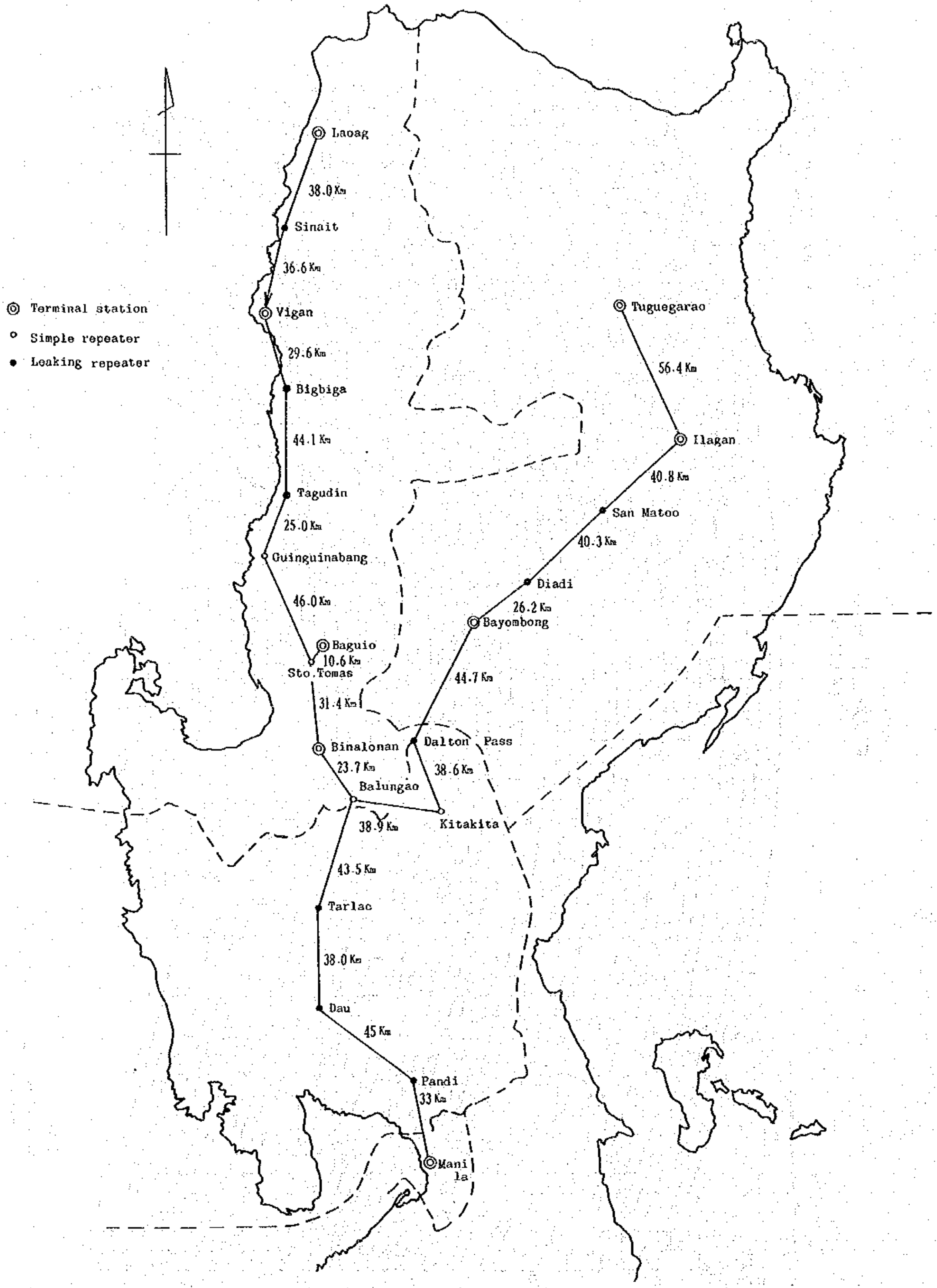


Fig. Ⅷ-2-2-1 Route Plan of Microwave System

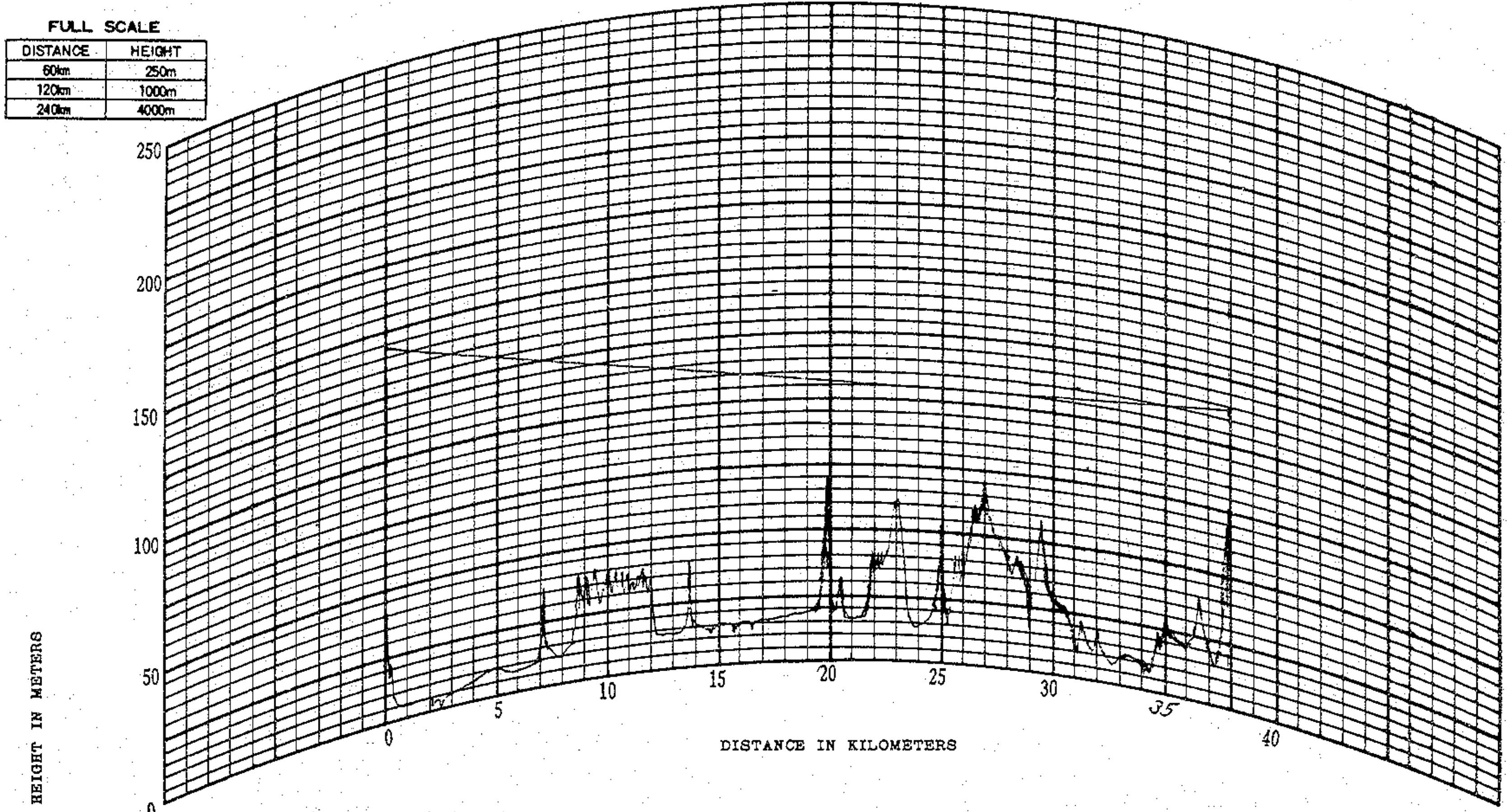
PROFILE MAP
(4 / 3 RADIUS)

ROUTE: ____________________

DRAWING NO.: Fig Ⅷ-2-2-2

FULL SCALE

DISTANCE	HEIGHT
60km	250m
120km	1000m
240km	4000m



SITE: LAOAG
LATITUDE: ____________
LONGITUDE: ____________
GROUND ELEVATION: 50 m
ANTENNA HEIGHT: 95 m

DISTANCE: 38.0 km

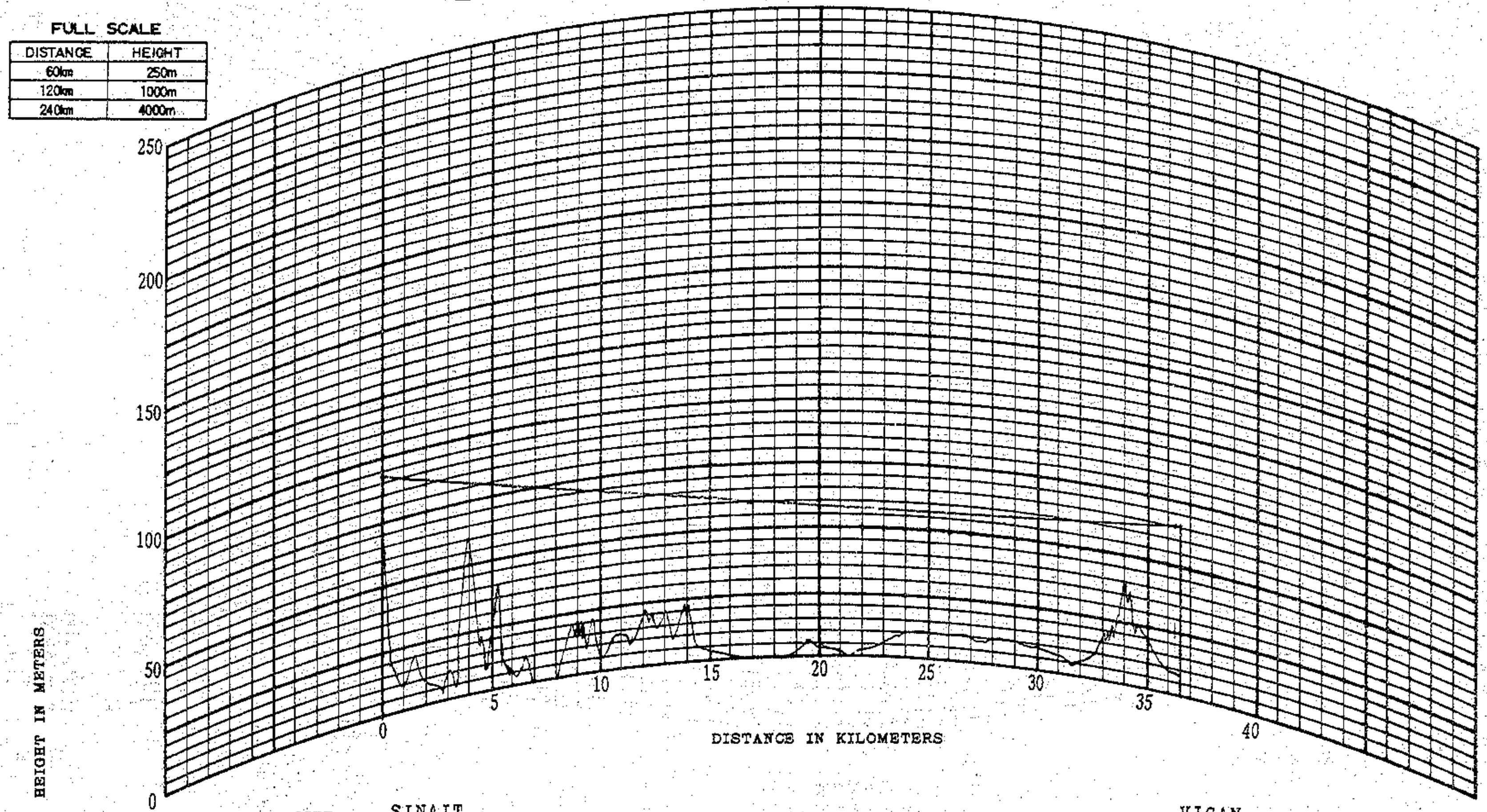
HOP NO.: ____________

SITE: SINAIT
LATITUDE: ____________
LONGITUDE: ____________
GROUND ELEVATION: 65 m
ANTENNA HEIGHT: 50 m

PROFILE MAP
(4 / 3 RADIUS)

ROUTE: ____________

DRAWING NO.: Fig Ⅷ－2－2－3



FULL SCALE

DISTANCE	HEIGHT
60km	250m
120km	1000m
240km	4000m

SITE: SINAIT
LATITUDE: ____________
LONGITUDE: ____________
GROUND ELEVATION: 65 m
ANTENNA HEIGHT: 30 m

DISTANCE: 36.6 km

HOP NO. : ____________

SITE: VIGAN
LATITUDE: ____________
LONGITUDE: ____________
GROUND ELEVATION: 8 m
ANTENNA HEIGHT: 60 m

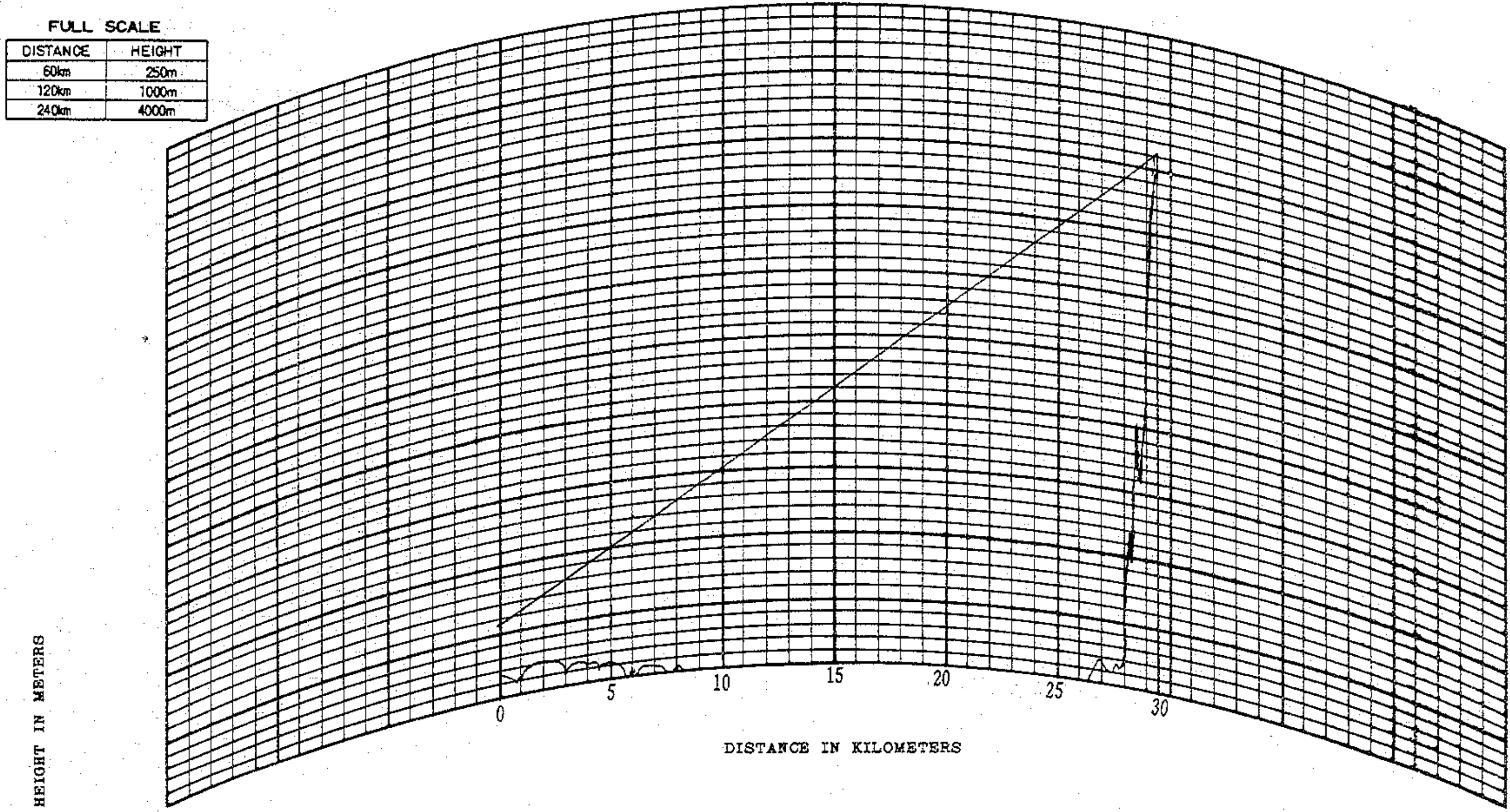
PROFILE MAP
(4 / 3 RADIUS)

ROUTE: ______

DRAWING NO.: Fig Ⅷ－2－2－4

FULL SCALE

DISTANCE	HEIGHT
60km	250m
120km	1000m
240km	4000m



SITE: VIGAN
LATITUDE: ______
LONGITUDE: ______
GROUND ELEVATION: 8 m
ANTENNA HEIGHT: 20 m

DISTANCE: 29.6 km

HOP NO.: ______

SITE: BIGBIGAO
LATITUDE: ______
LONGITUDE: ______
GROUND ELEVATION: 200 m
ANTENNA HEIGHT: 5 m

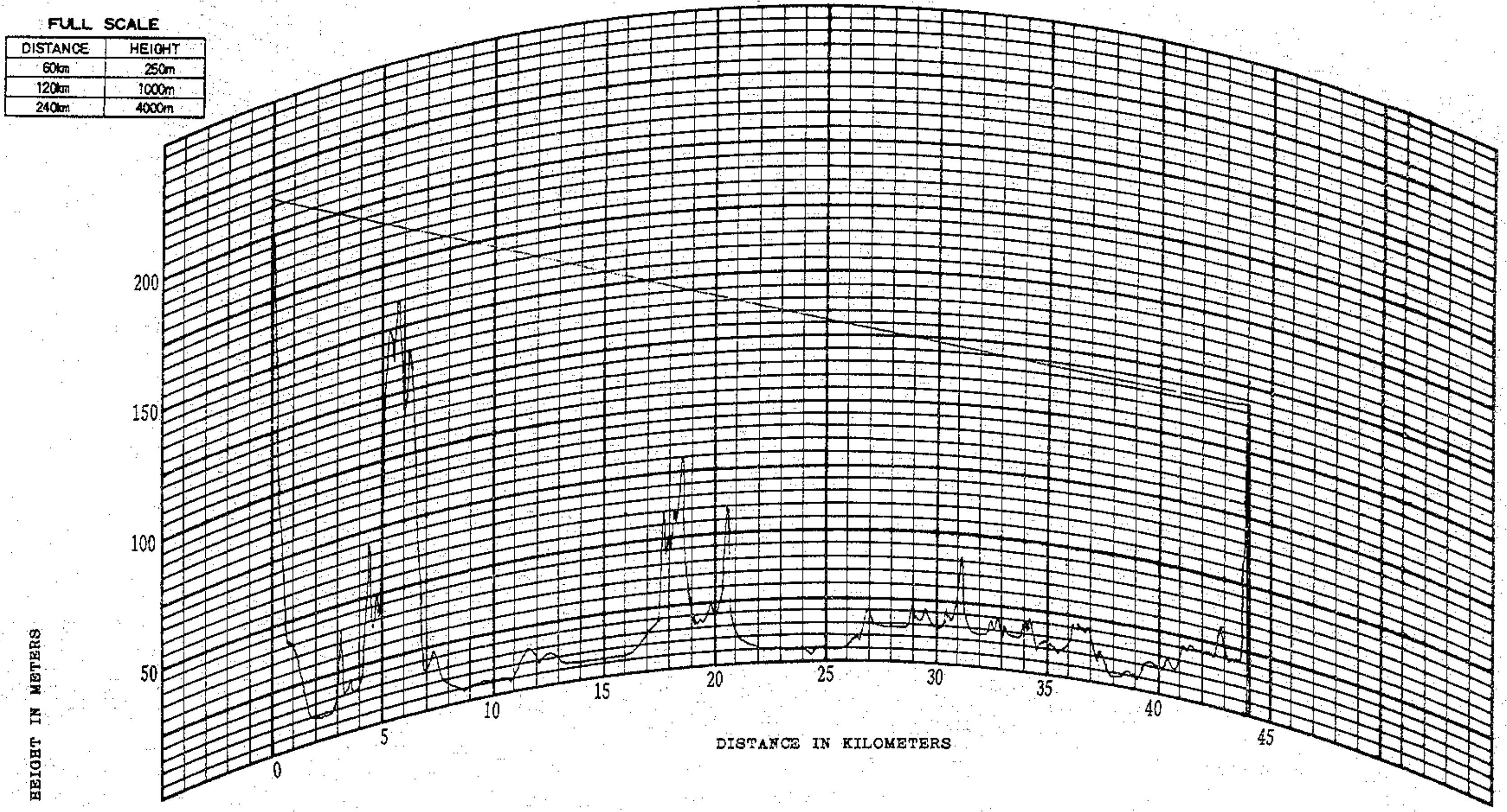
PROFILE MAP
(4 / 3 RADIUS)

ROUTE:

DRAWING NO.: Fig Ⅶ-2-2-5

FULL SCALE

DISTANCE	HEIGHT
60km	250m
120km	1000m
240km	4000m



SITE: BIGBIGAO
LATITUDE:
LONGITUDE:
GROUND ELEVATION: 200 m
ANTENNA HEIGHT: 15 m

DISTANCE: 44.1 km

HOP NO. :

SITE: TAGUDIN
LATITUDE:
LONGITUDE:
GROUND ELEVATION: 110 m
ANTENNA HEIGHT: 10 m

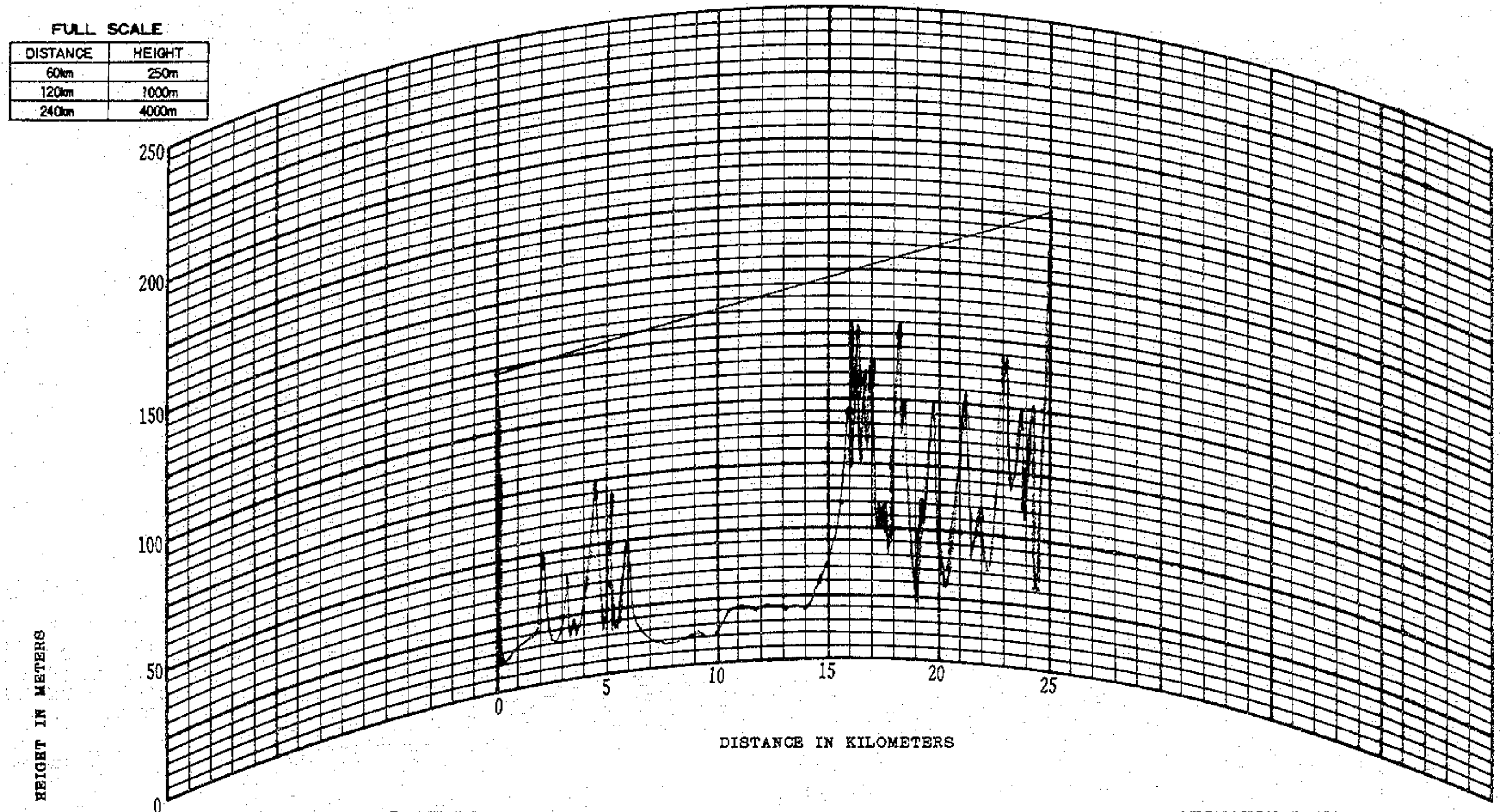
PROFILE MAP
(4 / 3 RADIUS)

DRAWING NO.: Fig Ⅷ－2－2－6

ROUTE:

FULL SCALE

DISTANCE	HEIGHT
60km	250m
120km	1000m
240km	4000m



SITE: TAGUDIN
LATITUDE:
LONGITUDE:
GROUND ELEVATION: 110 m
ANTENNA HEIGHT: 15 m

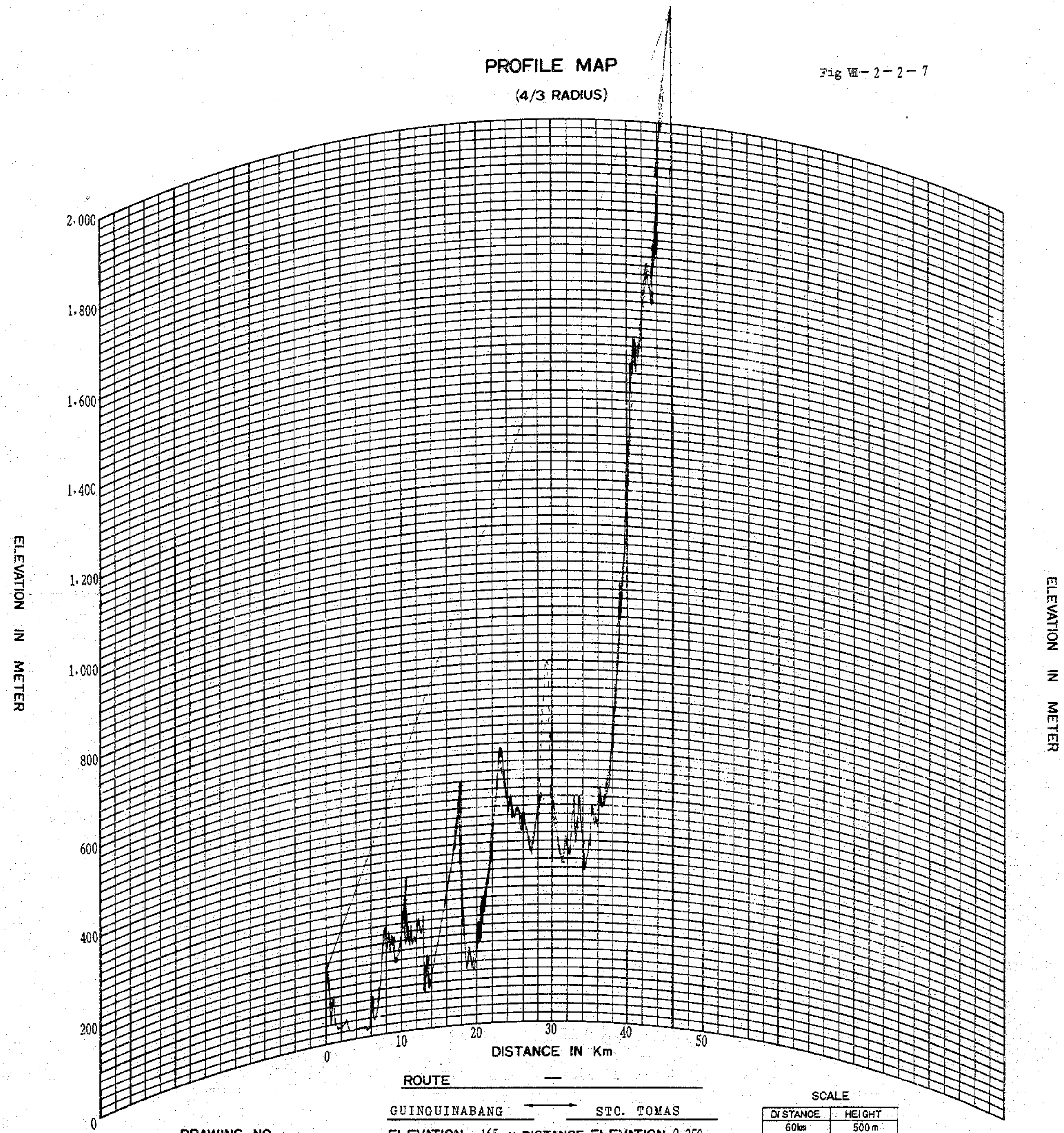
DISTANCE: 25.0 km

HOP NO. :

SITE: GUINGUINABANG
LATITUDE:
LONGITUDE:
GROUND ELEVATION: 165 m
ANTENNA HEIGHT: 15 m

Fig Ⅷ-2-2-7

PROFILE MAP
(4/3 RADIUS)



ROUTE —

GUINGUINABANG ⟷ STO. TOMAS

DRAWING NO.
DATE . . .

ELEVATION 165 m **DISTANCE** 46.0 Km **ELEVATION** 2.250 m
ANTENNA HEIGHT 10 m **ANTENNA HEIGHT** 15 m

SCALE

DISTANCE	HEIGHT
60㎞	500 m
120㎞	2000 m
240㎞	8000 m

FORM-1

PATH PROFILE

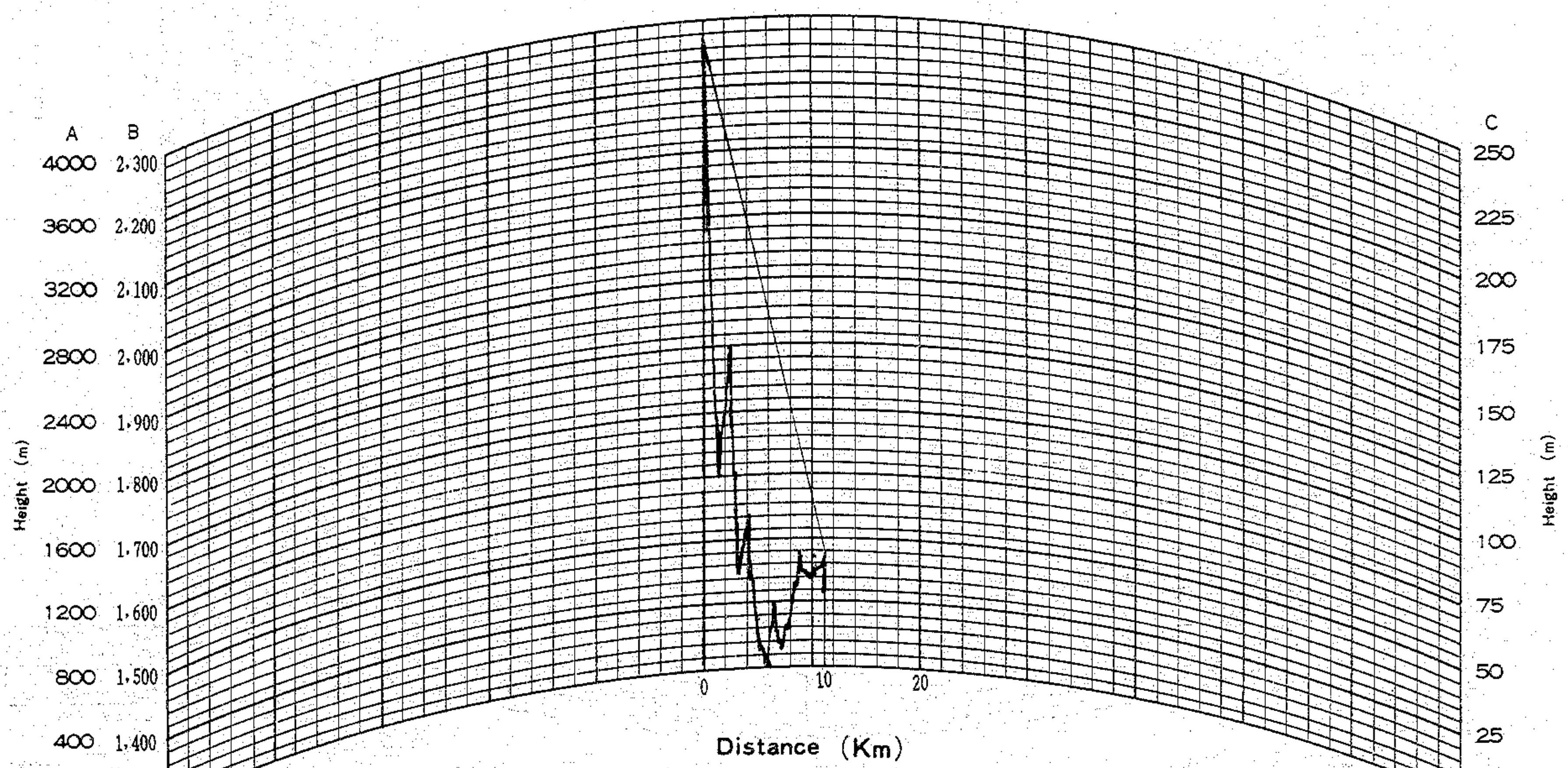
Name of Route :

No. : Fig Ⅷ-2-2-8

Drawer :

Date :

(K=4/3)



Frequency : ________ MHz

Power : ________ W

Full Scale: A = 240Km

Full Scale: ⓑ = 120Km

Full Scale: C = 60Km

Site : STO. TOMAS -------- BAGUIO

Height : 2,250 m 10.6 km 1,460 m

Antenna height : 10 m 20 m

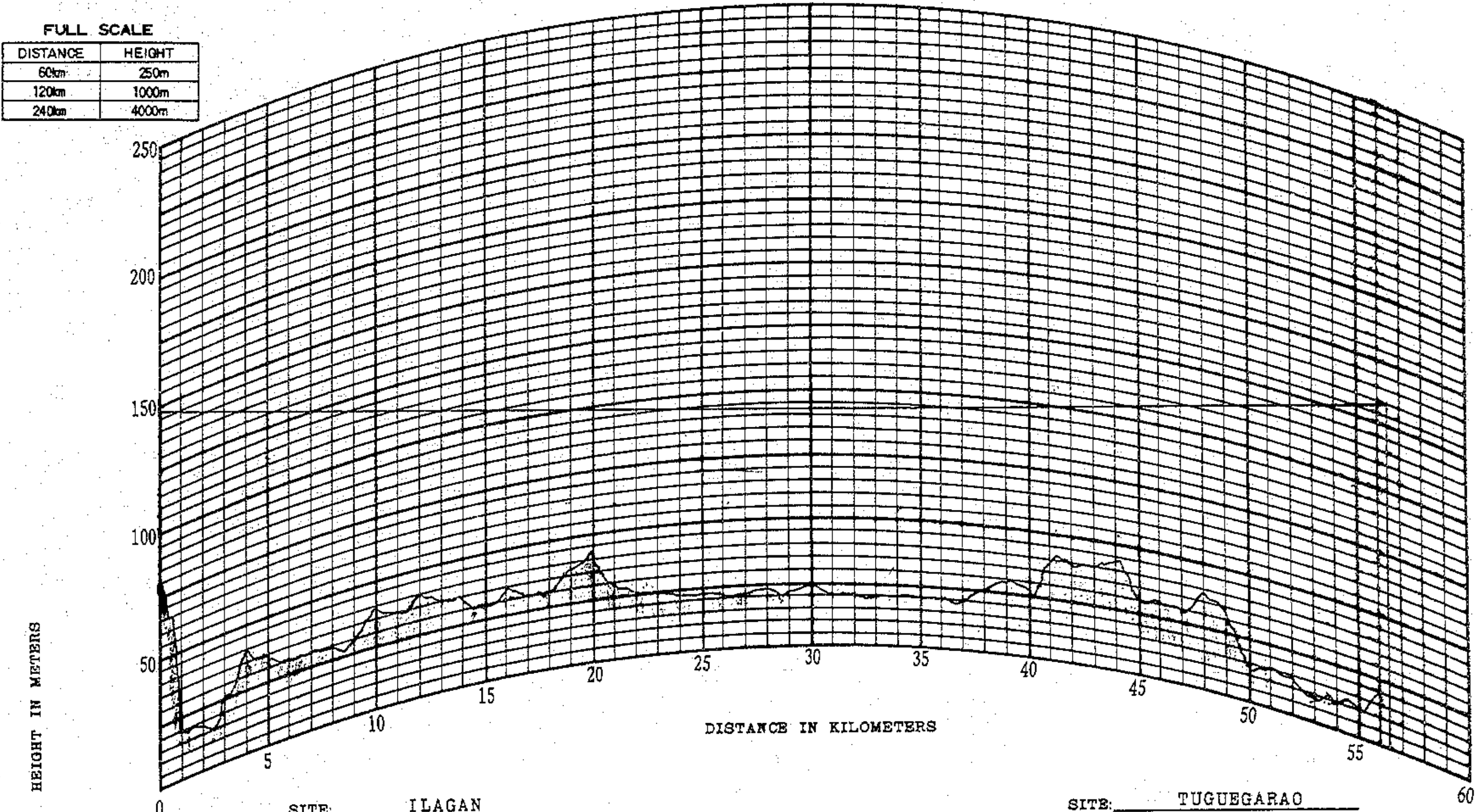
PROFILE MAP
(4 / 3 RADIUS)

DRAWING NO.: Fig Ⅷ－2－2－9

ROUTE:

FULL SCALE

DISTANCE	HEIGHT
60km	250m
120km	1000m
240km	4000m



SITE: ILAGAN
LATITUDE:
LONGITUDE:
GROUND ELEVATION: 80 m
ANTENNA HEIGHT: 70 m

DISTANCE: 56.4 km

HOP NO.:

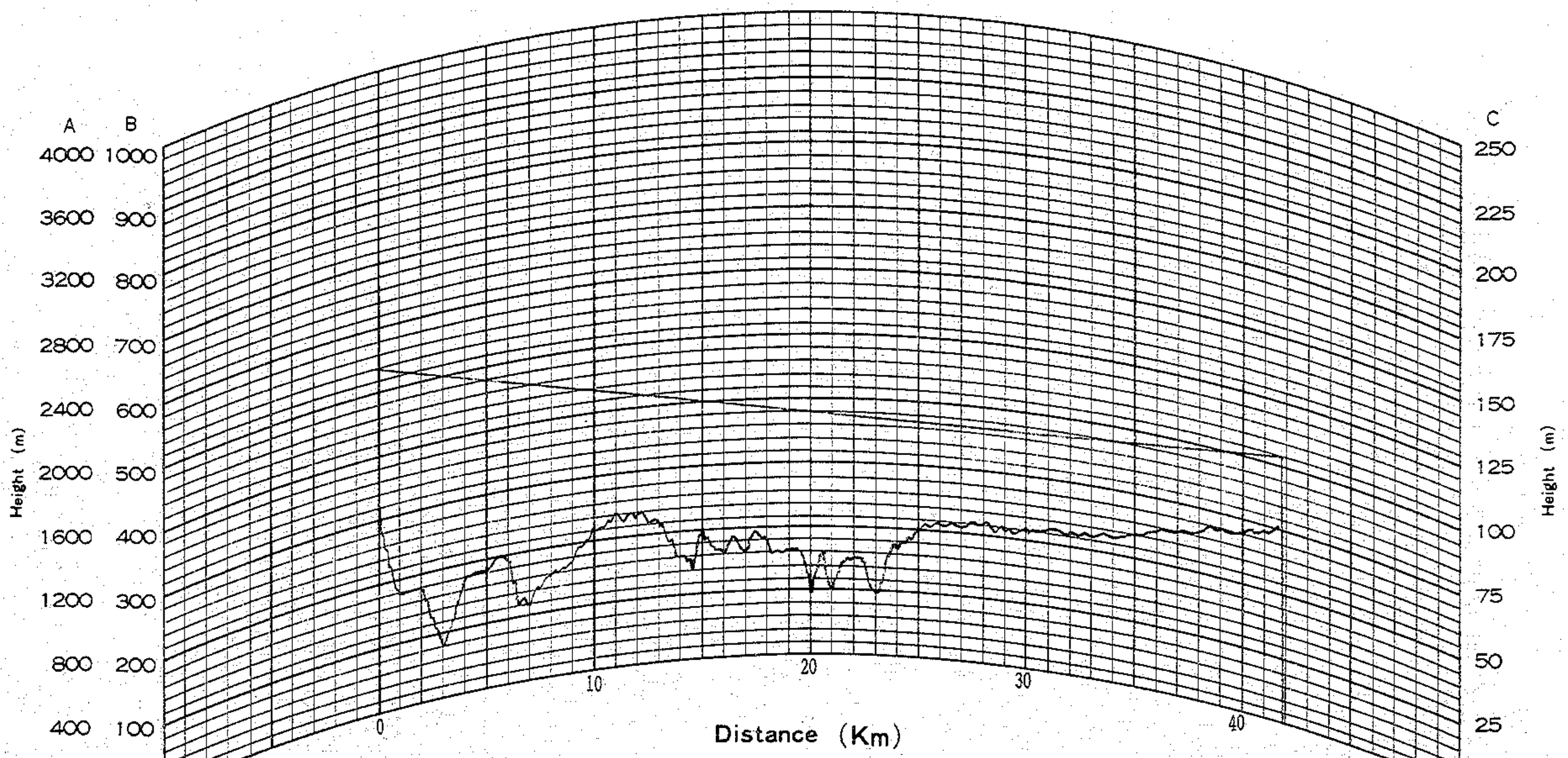
SITE: TUGUEGARAO
LATITUDE:
LONGITUDE:
GROUND ELEVATION: 20 m
ANTENNA HEIGHT: 110 m

FORM-1

PATH PROFILE

(K=4/3)

Name of Route :
No. : Fig VIII-2-2-10
Drawer :
Date :



Frequency : MHz
Power : W

Full Scale A = 240Km
B = 120Km
Ⓒ = 60Km

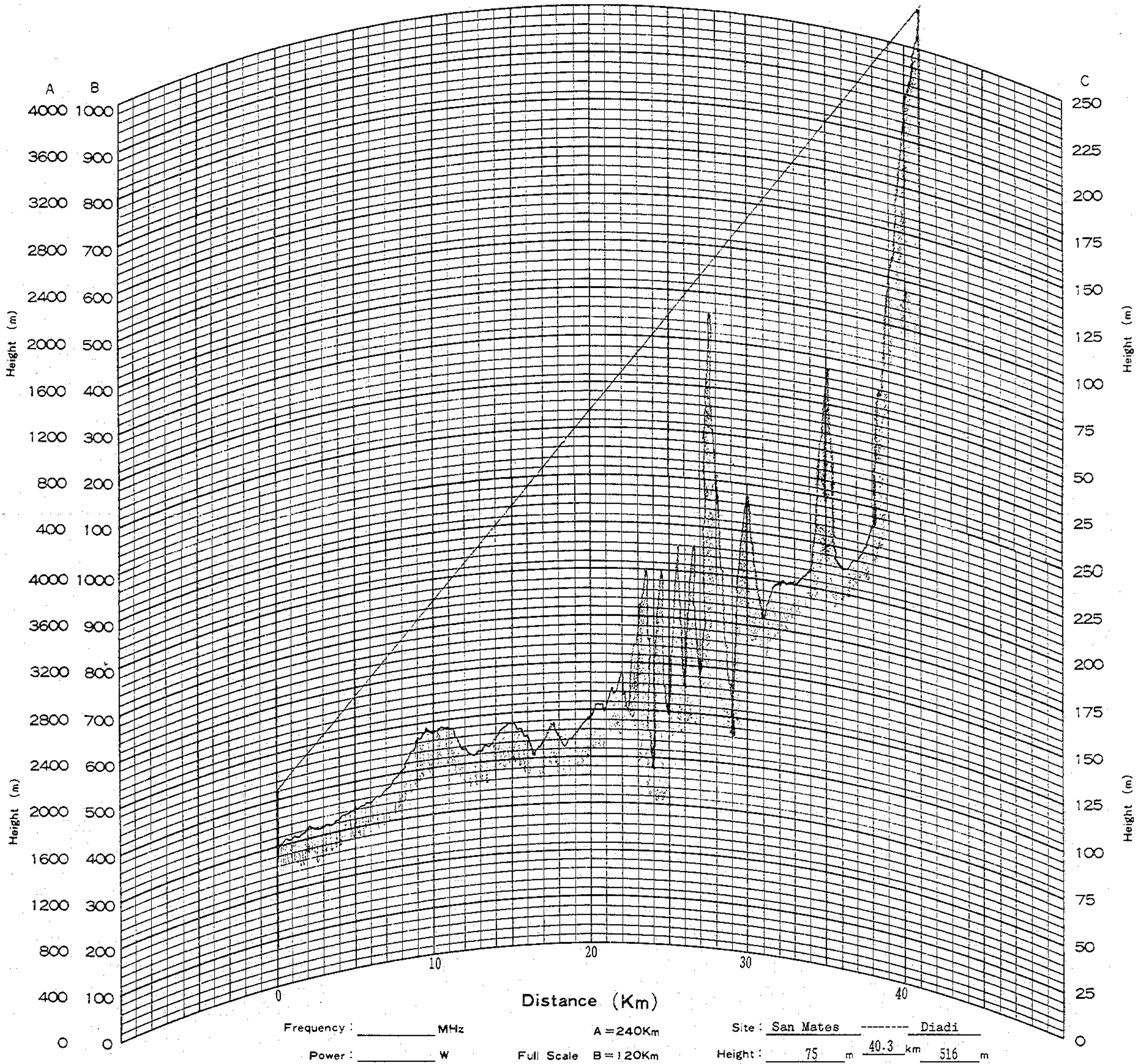
Site : Ilagan -------- San Mates
Height : 80 m 40.8 km 75 m
Antenna height : 55 m 25 m

FORM-1

PATH PROFILE

(K=4/3)

Name of Route :
No. : Fig Ⅷ-2-2-11
Drawer :
Date :



Frequency : MHz
Power : W
Full Scale A=240Km B=120Km C=60Km
Site : San Mates -------- Diadi
Height : 75 m 40.3 km 516 m
Antenna height : 30 m 15 m

FORM-1

PATH PROFILE

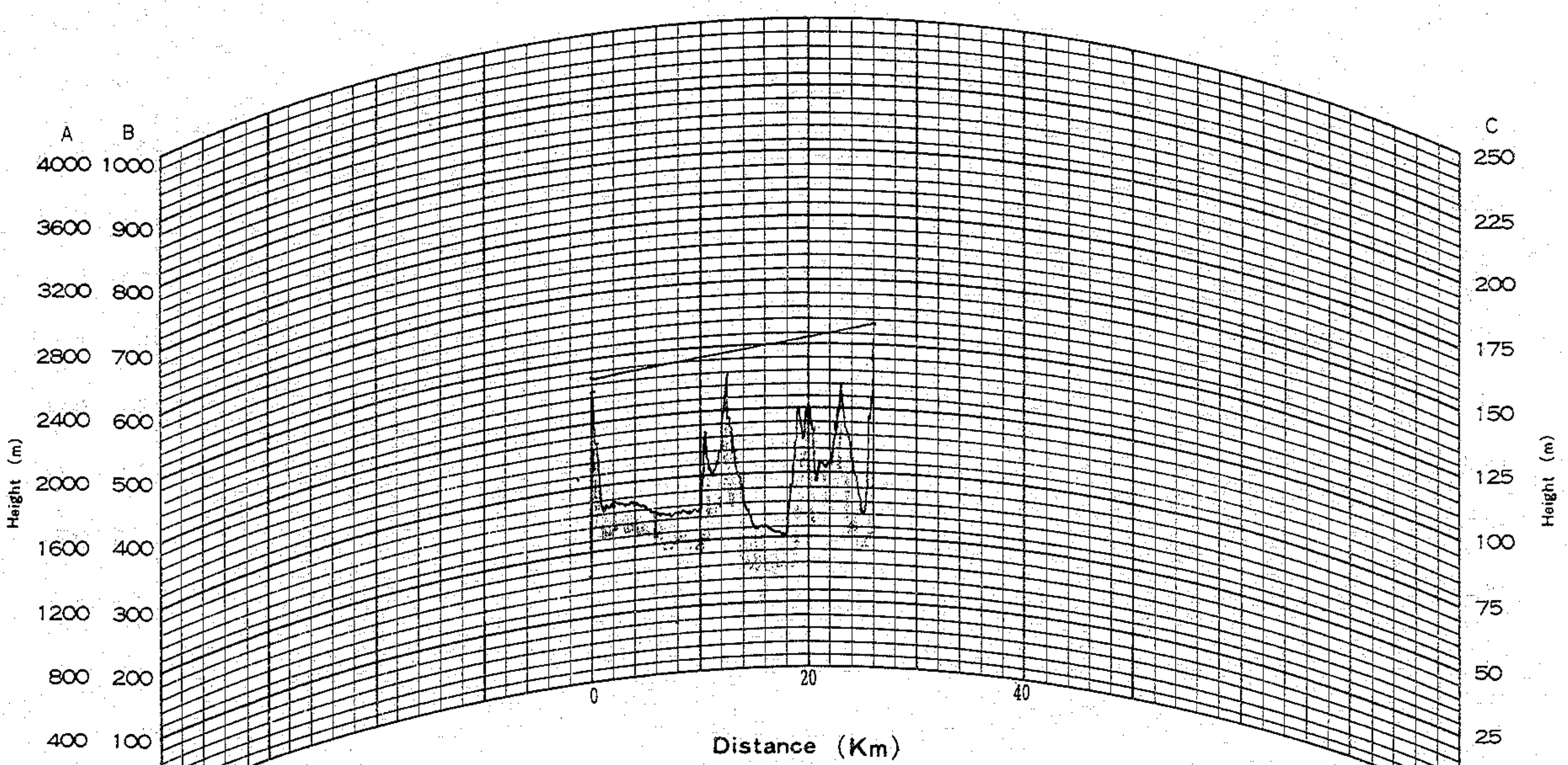
(K=4/3)

Name of Route :

No. : Fig Ⅷ- 2 - 2 - 12

Drawer :

Date : July 17.1978



Frequency : ______ MHz

Power : ______ W

Full Scale
A = 240Km
Ⓑ= 120Km
C = 60Km

Site : Bayombong -------- Diadi

Height : 445 m 26-2 km 516 m

Antenna height : 30 m 20 m

Name of Route :

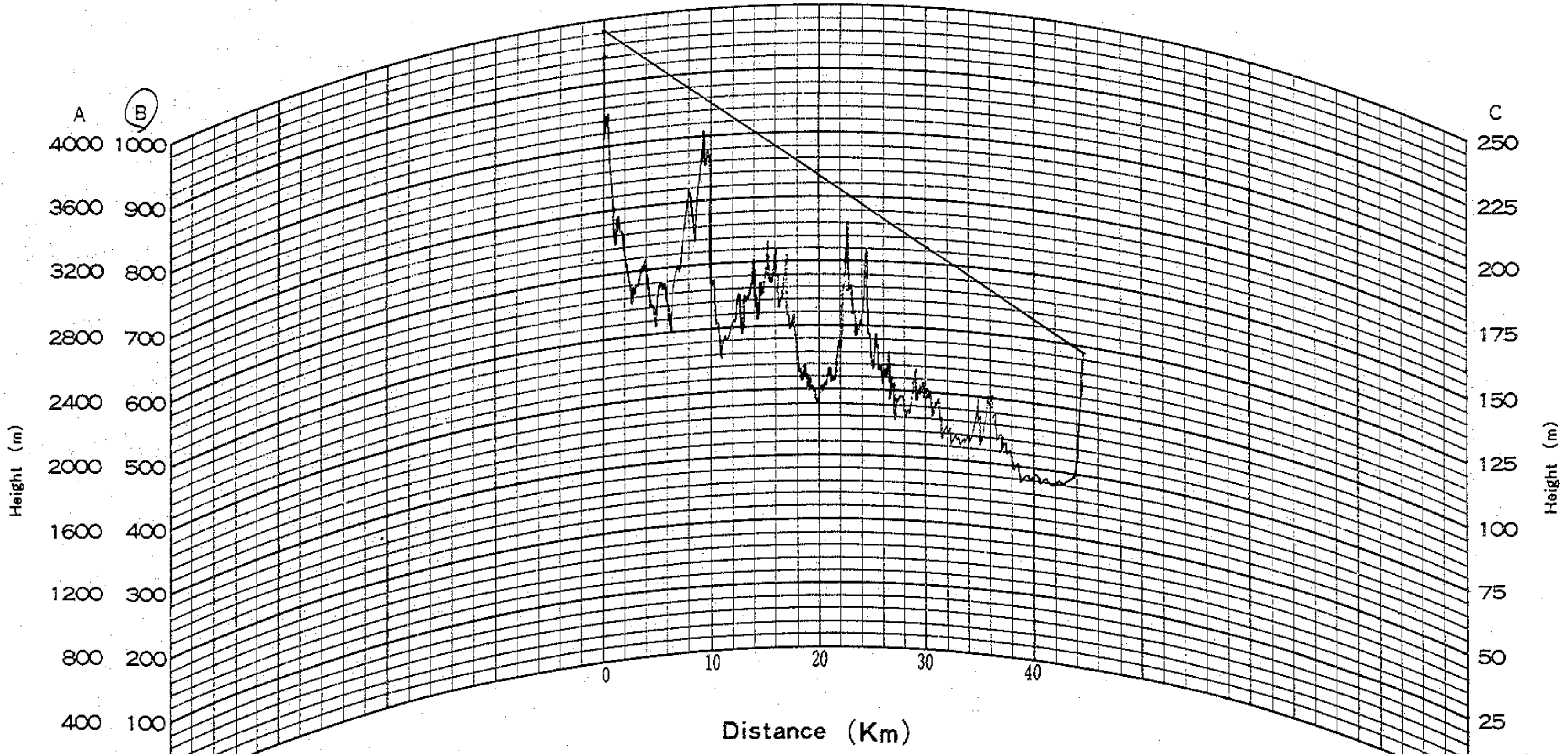
No. : Fig Ⅷ－2－2－13

Drawer :

Date :

PATH PROFILE

(K=4/3)



Frequency : ______ MHz

Power : ______ W

Full Scale A =240Km B=120Km C= 60Km

Site : Dalton Pass ------- Bayombong

Height : 940 m 44.5 km 440 m

Antenna height : 40 m . 50 m

(早野堂) 651165 RT-1

Name of Route : ____________

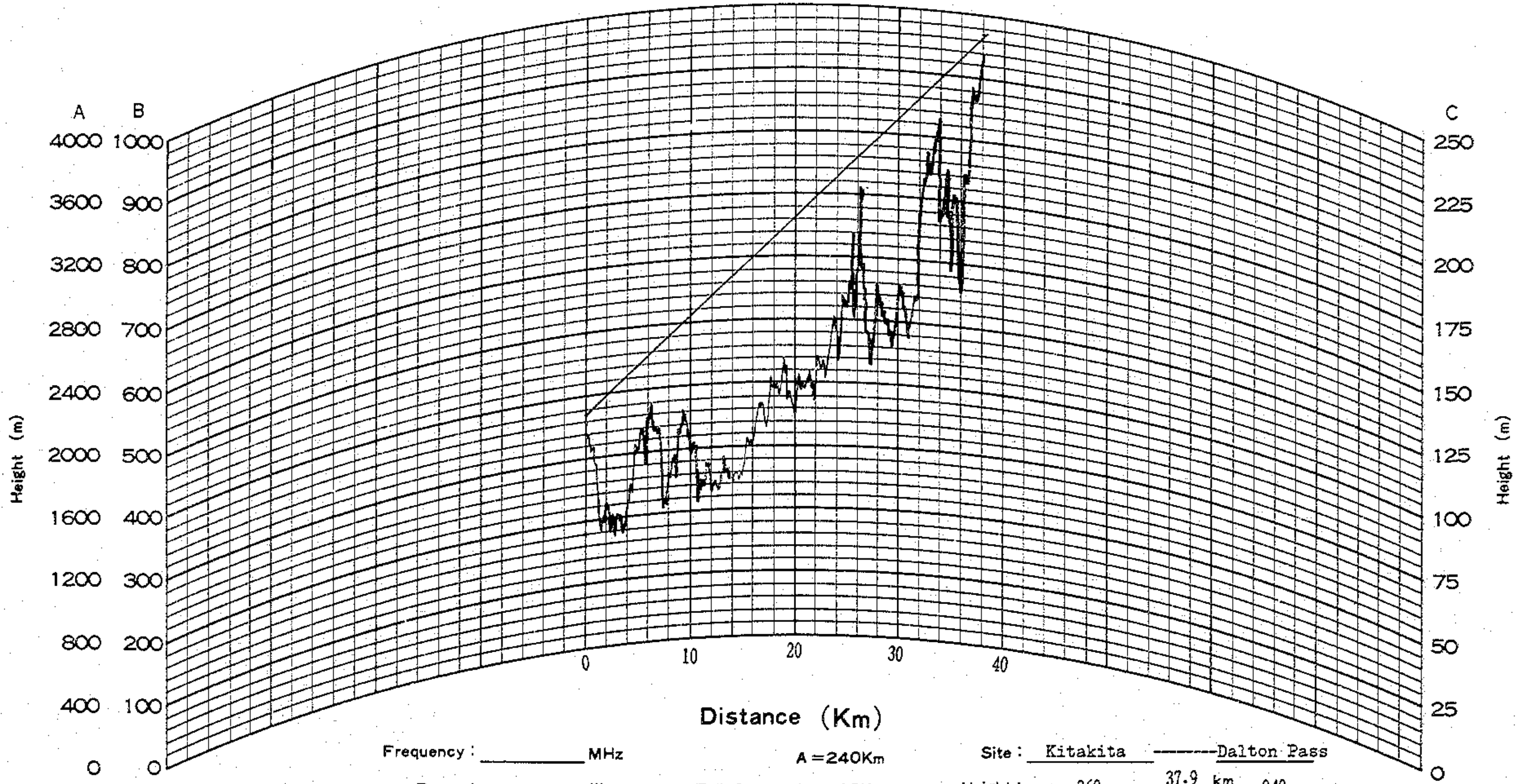
No. : Fig Ⅷ－2－2－14

Drawer : ____________

Date : ____________

PATH PROFILE

(K=4/3)



Frequency : ________ MHz

Power : ________ W

Full Scale A＝240Km
B＝120Km
C＝ 60Km

Site : Kitakita ——— Dalton Pass

Height : 360 m 37.9 km 940 m

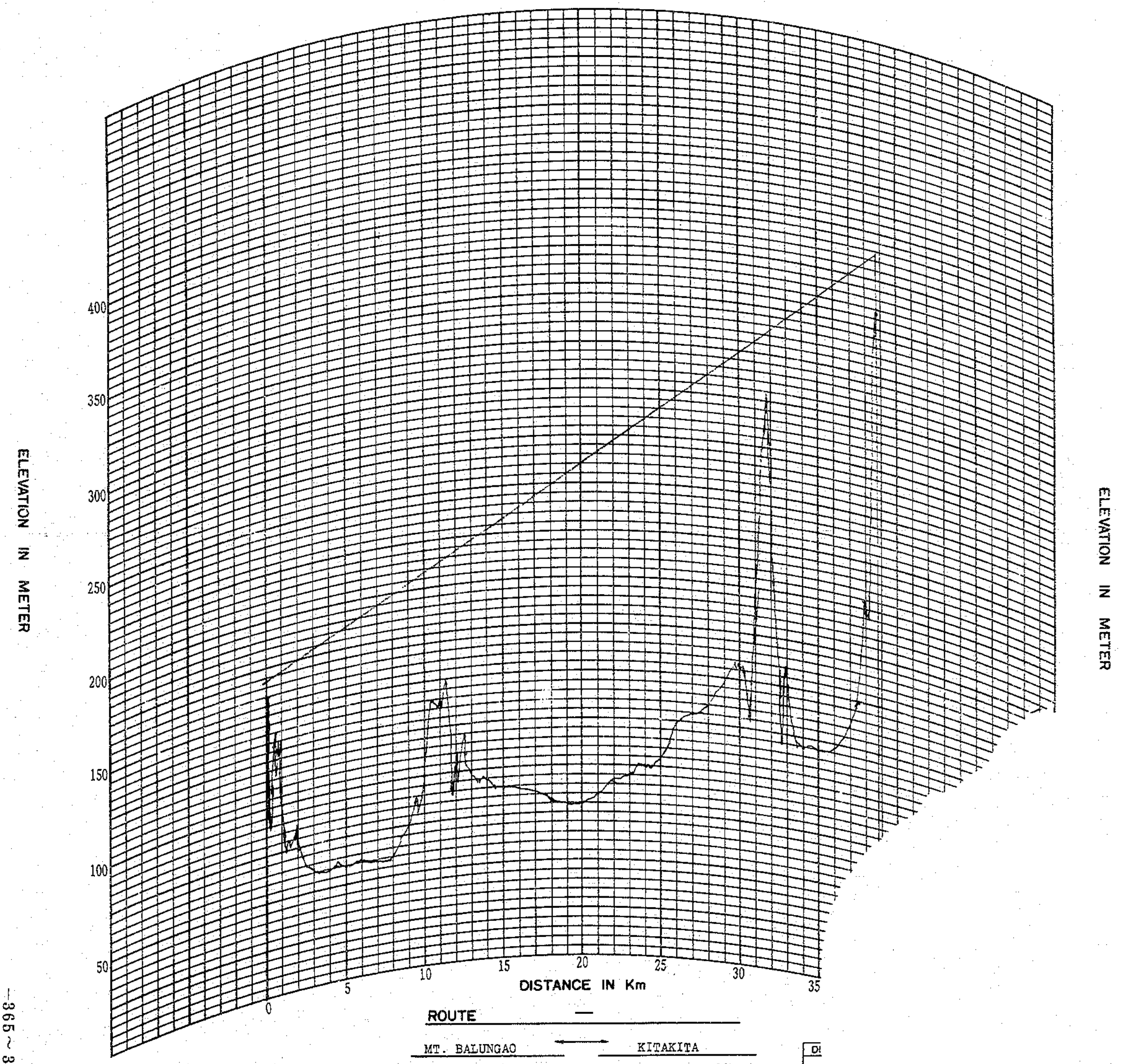
Antenna height : 10 m 30 m

(米寿堂) 651165 RT－1

PROFILE MAP

(4/3 RADIUS)

Fig Ⅶ-2-2-15



ROUTE —

MT. BALUNGAO ⟷ KITAKITA

ELEVATION 160 m DISTANCE ELEVATION 360 m

ANTENNA HEIGHT 15 m 38.9 Km ANTENNA HEIGHT 30 m

DRAWING NO.

DATE . . .

FORM-1

PATH PROFILE

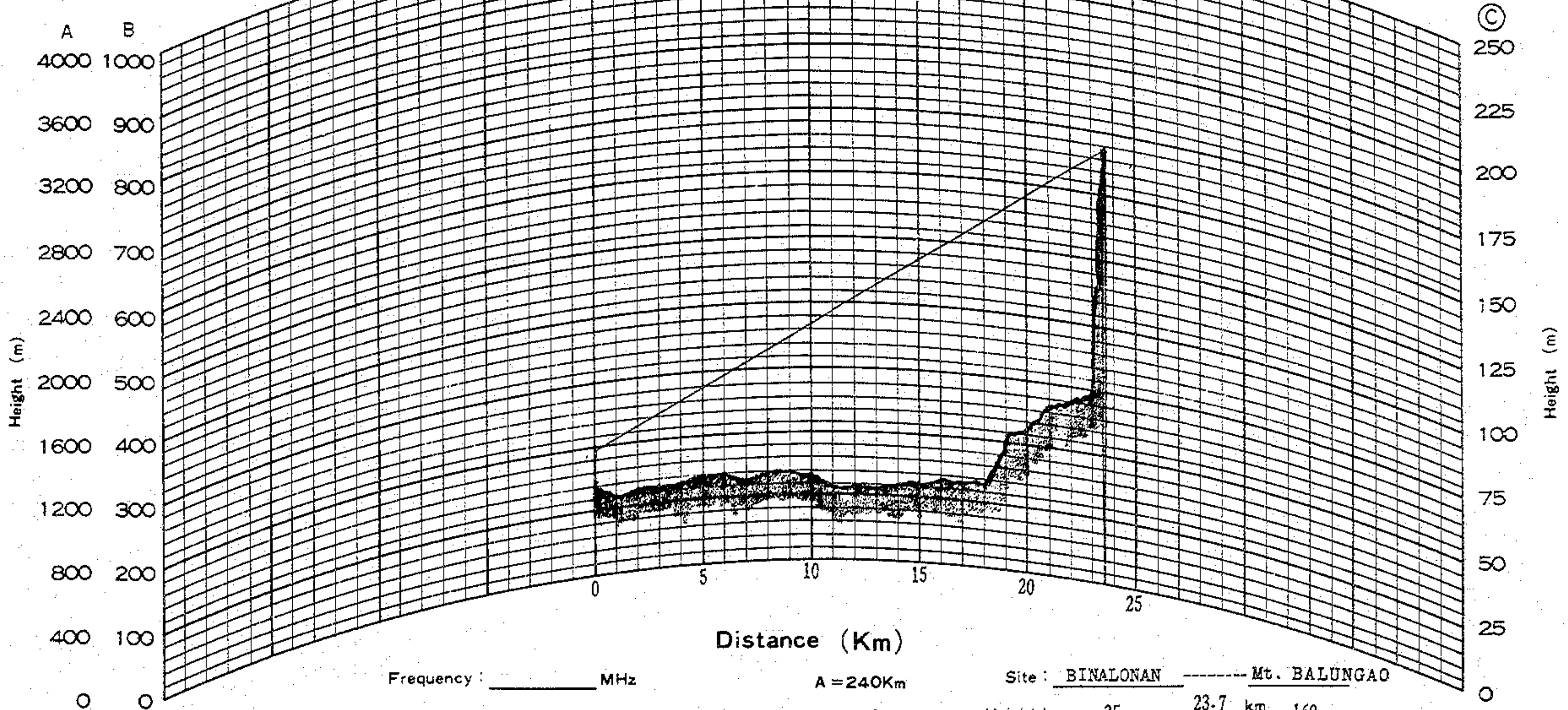
(K=4/3)

Name of Route :

No. : Fig Ⅷ-2-2-16

Drawer :

Date :



Frequency : ______ MHz

Power : ______ W

Full Scale A = 240Km B = 120Km © = 60Km

Site : BINALONAN -------- Mt. BALUNGAO

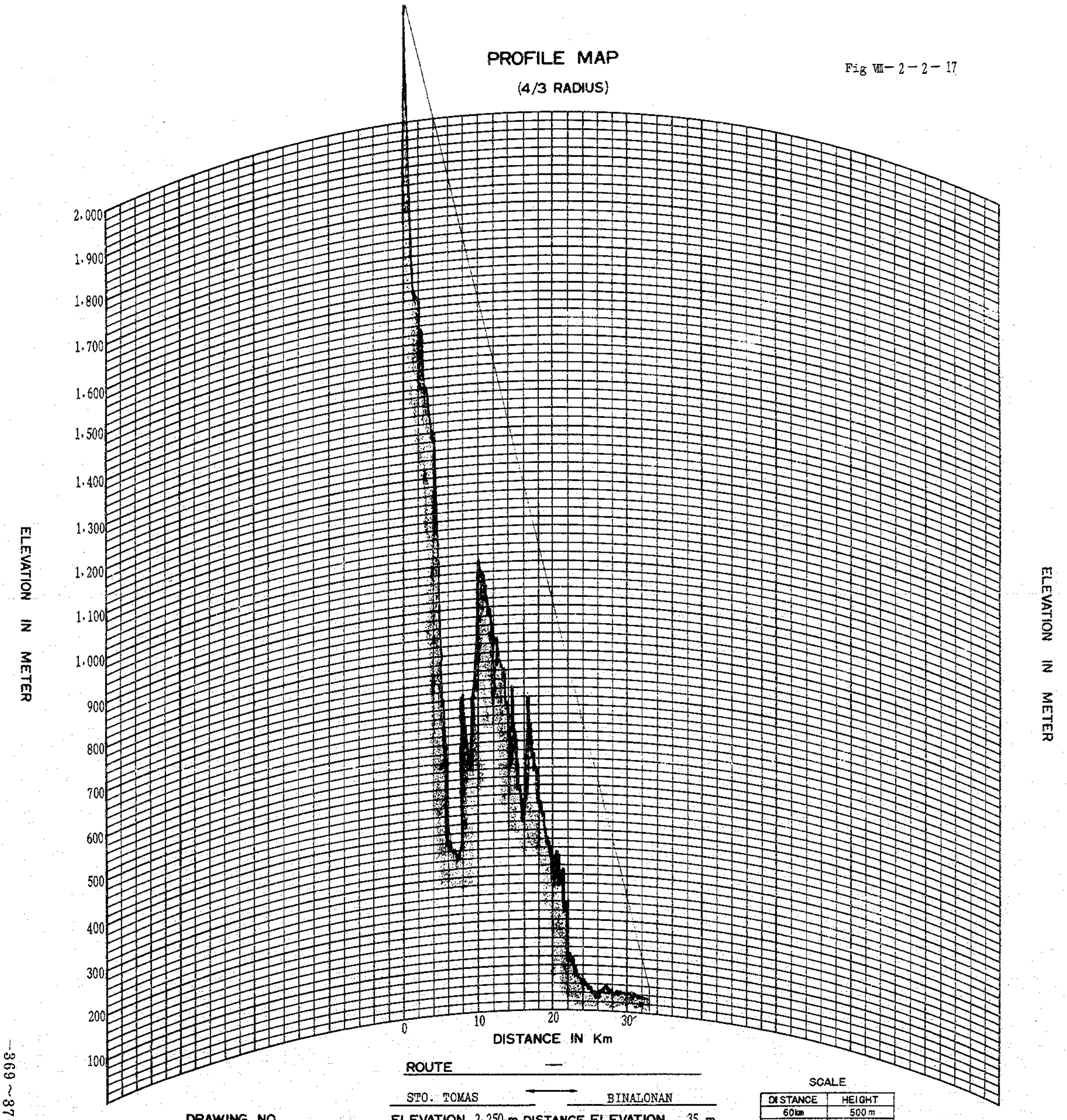
Height : 35 m 23.7 km 160 m

Antenna height : 20 m 10 m

Fig Ⅷ-2-2-17

PROFILE MAP

(4/3 RADIUS)



ROUTE —

STO. TOMAS ⟷ BINALONAN

DRAWING NO.

DATE . . .

ELEVATION 2,250 m	DISTANCE	ELEVATION 35 m
ANTENNA HEIGHT 10 m	31.4 Km	ANTENNA HEIGHT 15 m

SCALE

DISTANCE	HEIGHT
60km	500 m
120km	2000 m
240km	8000 m

(2) System design

From telephone demand forecast, a maximum of 960 channels to be obtained by frequency division multiplex - frequency modulation using microwave will be adopted for the telephone system of the all routes. In addition, transmission of one color TV signal will be conducted using the protection channel.

The Fig.VIII-2-2-1 shows that there are three kind microwave routes. One is for a communication to Region I area from Baguio, second is for a communication to Region II area, and third is an interconnection between the two Regions and Manila.

Actually, the routes of Laoag-Vigan-Baguio is proposed as the first idea, of Tuguegarao - Ilagan - Bayombong - Binalonan - Baguio is as the second idea, and of Binalonan - Manila is as the third. Actual interconnection to there two Regions from Manila will be made at Binalonan.

(2)-1 System configuration

For the microwave link the following switching sections will be provided.

Laoag-Vigan:	74.6 km	(2 radio sections)
Vigan-Baguio:	155.3 km	(5 ")
Baguio-Binalonan;	42.0 km	(2 ")
Binalonan Bayombong:	145.5 km	(4 ")
Bayombong-Ilagan:	107.3 km	(3 ")
Ilagan-Tuguegarao:	56.4 km	(1 radio section)
Binalonan-Manila	185.0 km	(5 radio sections)

The existing microwave route, 7GHz band used, is now operated by BUTEL through Baguio, Sto. Tomas, Balungao, Tarlac, Dau, Pandi, and Manila. Of course, this is the microwave route of Baguio - Manila. These existing microwave sites, except Baguio, will be used by the project as replacement. The case of Baguio, present station has too norrow land to accommodate the plan in the project. Another site for Baguio will be proposed.

At first these sections will be started to operate by a 1 + 1 route stand-by system (one working channel + one protection channel). Video switching will be employed as the switching method in these switching sentions. In Baguio-Sto. Tomas section, the route toward Vigan and the route toward Bayombong will lay concurrently. Although the problems of this route are discussed in detail in item (2)-2-4, this section will be anyway used commonly by a microwave route to Vigan and a microwave route to Bayombong, which are quite independent from each other. Accordingly, this section will include two different proteciton channels.

Concrete system configurations of the respective sections are shown in Fig. VIII-2-2-18. As shown in the figure, all sections but the Ilagan-Tuguegarao section will be branched from repeater stations on the way in units of supergroup. Branching repeaters to be employed are detailed in item (2)-2-3, and their functions are given in Table 2-2-2.

Table VIII-2-2-2 Functions of Microwave Stations

Microwave Station	Switching Station	Repeater	
		Simple Repeater	Leaking Repeater
Laoag	○		
Sinait			○
Vigan	○		
Bigbiga			○
Tagudin			○
Guinguinabang		○	
Sto. Tomas		○	
Baguio	○		
Binalonan	○		
Balungao		○	
Kitakita		○	
Dalton Pass			○
Bayombong	○		
Diadi			○
San Mateo			○
Ilagan	○		
Tuguegarao	○		
Tarlac			○
Dau			○
Pandi			○
Manila	○		
Total	8	4	9

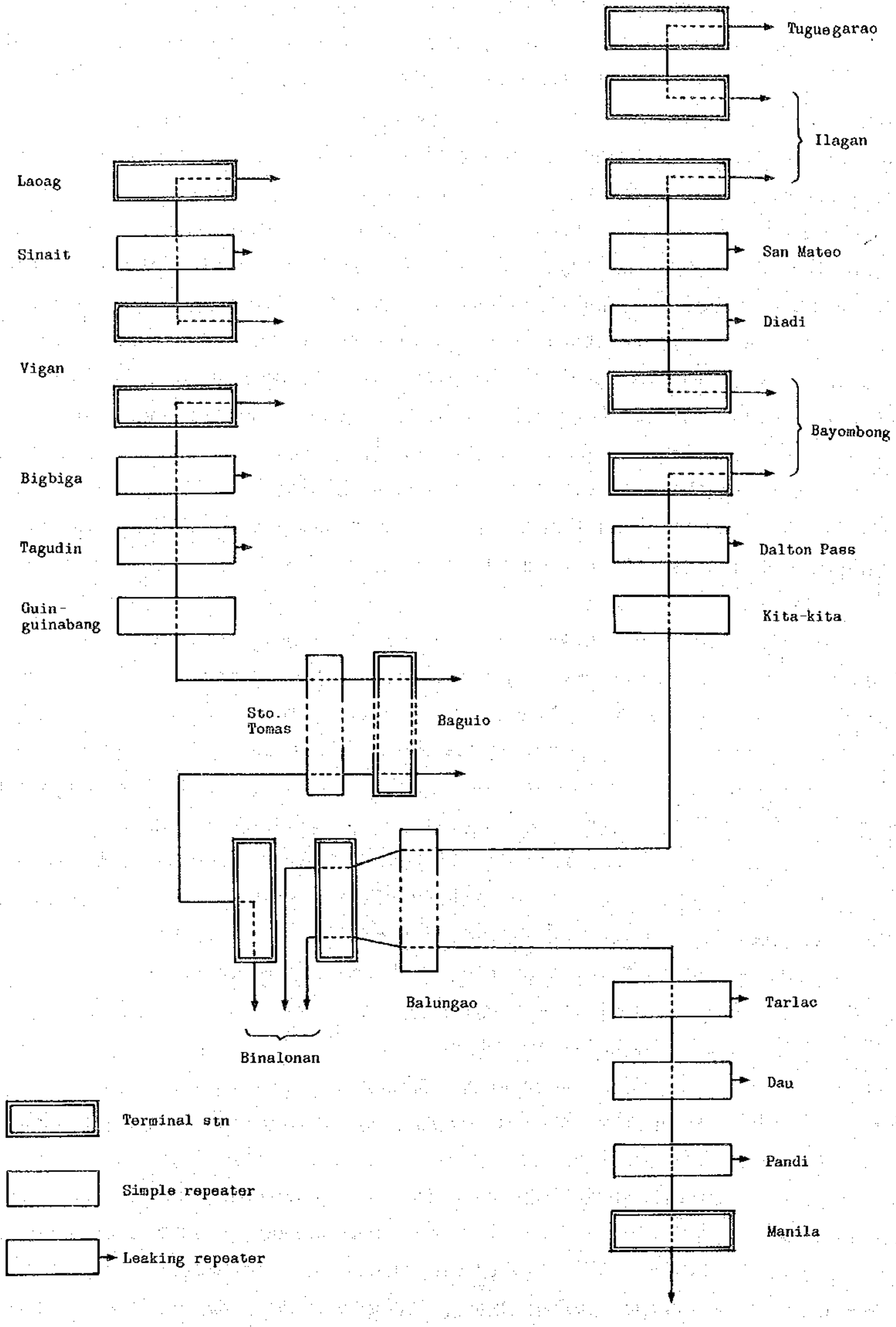


Fig.Ⅷ-2-2-18 System configuration of microwave routes

The microwave route to be established by this project is composed of seven switching sections as understood from Fig. 2-2-18, and route protection is employed against transmission failure such as by failure of equipment in use. For this purpose, a protection channel will be provided separately from the working channel in each section. This protection channel will normally be unused but will be alive. That is, the protection channel is entirely in an idling conditon. On the sending side of the working channel at a switching station, a 8.5MHz pilot signal is applied continuously, then received by a receiver, and continuously monitored. If the level of the pilot signal lower by a certain extent (usually by 6 to 8dB) or if the signal-to-noise ratio of the pilot signal or its neighborhood lower to some extent (useually to 30 dB), supervisory equipment will detect it and the working channel will be determined to be abnormal, which will follow automatic switchover from the working to the protection channel.

Switchover is conducted in one of the following three methods.

- o A method in which switching command is given through detection of pilot signal level lowing
- o A method in which switching command is given through detection of the signal-to-noise ratio in the neighborhood of the pilot signal
- o A method in which switching command is given through detection of either pilot signal level lowering or signal-to-noise level degradation.

These three switching methods are respectively called

- o Pilot switching
- o Noise switching
- o Pilot-noise switching

Among the three methods, pilot-noise switching is considered the best method.

In pilot switching, switching is actually initiated after the pilot signal level lower exceedingly, that is, after channel failure is detected and channel interruption of 50 to 100 milliseconds is involved. Noise switching is a better method where switching is initiated by detection of quality degradation and channel interruption is limited to the duration of turn-over of

the switching element in the channel switchover equipment. Usually, switching elements use diodes or transistors and interruption of only several micro-second is required.
On the other hand, protection channel setting is made by either route stand-by or preset method. In the preset method, protection equipment of the same frequency as the working channel equipment is provided at each repeater station for use in case the working channel equipment fails. However, this method is scarcely used in recent microwave communication systems because of its troublesome problem in determining to which frequency the protection channel should be turned when plural working channels are used and because of the absence of diversity effect to fading mentioned later herein. In the route protection method, however, channel switchover is made for each working channel, so that this method is extremely favorable for use in microwave systems having numbers of working radio channels. In addition, the frequency of the protection channel is different from the frequencies of all working channels, so that sufficient switching effect is achievable against fading. Thst is, although a certain frequency may be subject to fading, the frequency used for the protection channel may be free from fading. The route protection method has advantages over the preset method but its disadvantage is that it requires another couple of frequencies additionally. However, if this disadvantageous is overcome, the route stand-by method will become an unparalleled protection method.
Consideration should also be taken, in system configuration, for the transmission of a color TV signal by the protection channel. An ordinary color TV signal has a bandwidth of 4MHz or So, which is nearly equivalent to 960 telephone channels in capacity.
Thus one radio channel of 960 channels capacity is usually allocated for the transmission of one color TV signal. However, when the demand for transmission of TV programs is so little as 20 to 30 minutes a day, it is rather unfavorable for the operating efficiency of equipment to exclusively allocate one radio channel for the transmission of TV signal. In this latter case, the transmission of TV signal should be made by using the protection channel which is usually in the idling condition. This method of sending TV signal, called the TV signal transmission on the

protection channel, involves the problem that in case the working radio channel for telephone use fails, it must be determined whether the telephone signal transmission or the TV signal transmission on the protection channel should be sacrificed.
This selection is very important in the basic design of the control system in the microwave system.
When, in general, system failure is prevented by automatic switchover even in the route stand-by method, protection by automatic switchover may not be achievable under certain conditions, of which some are given hereunder.

- o When plural working channels fail, some of them can not be relieved.
- o When the protection channel is occupied by occurrence of a preceding channel failure, the channel failed later can no more be switched over to the protection channel.
- o If the working channel fails while the protection channel is used for some purpose, the signal having been transmitted on the protection channel, which is usually low in priority order, is driven out from the protection channel and, instead, switchover from the failed channel to the protection channel is conducted generally. Accordingly, the signal having been transmitted on the protection channel will generally be interrupted.
- o In addition, power plant failure must be considered separately as a cause of system failure.

We have considered system failure which may be encountered in the microwave system. In many developed countries, an objective of reliability (or nonavailability) is determined depending on the importance of the transmission lines which operates as the main route, and it is generally considered recommendable to set the objective of maintenability at 0.25×10^{-4} /500 km or so.
In consideration of the reliability of actual equipment and the standard of failure rate, the required nonavailability is actually achieved by using both wired and radio systems, that is, by the adoption of a 2-route system. In this project, it is not recommendable to attempt to just meet such a value of nonavailability immediately. Instead, it should be discussed to what extent the reliability of the microwave system itself which incor-

porates the basic facilities in the main route should be raised for the achievement of the objective in future. For this purpose, it is recommended to set the objective of the nonavailability of the microwave system at 0.1%/2500km in one direction in this project. This value of the objective is still divided into a portion to be alloted to the section composing directly the signal transmission path such as the transmitter-receiver, modulator and demodulator and a portion to be alloted to the power supply equipment. A value of 0.05%/2500km in one direction is alloted equally to both former and latter portions.

However, the power supply equipment supplies power to equipment in both directions irrespective of the transmission direction, the value to be alloted to the power supply equipment is 0.1%/2500km in both directions. It can be considered that transmission path failure occurs most frequently in the following csse, that is, when another working channel fails while the protection channel is occupied since a working channel has already failed.

However, this project will initially start on a 1+1 abasis, such case will not occur at all. Consideration should rather be given to the probability of the occurrence of the working channel.

Let us now consider the reliability of the transmission path portion (excluding power supply equipment) of Baguio-Bayombong switching section (containing 6 radio sections) or the longest section among the 5 switching sections. Suppose each station is composed of two sets of transmission equipment (one modulator-demodulator + one transmitter-receiver in the case of a switching station and one transmitter + one receiver in the case of a repeater station).

When the failure rates of all equipments are equal to each other and is equally "p" per equipment, the probability of automatic switchover to the protection channel due to failure of the working channel is given by

$$\sum_{n=1}^{14} {}_{14}C_n \, p^n \quad \text{[times/hour]}$$

The Baguio-Bayombong section will actually employ 14 sets of equipment to compose the transmission path. Usually, p is extremely small that we can rewrite the above probability to

$$\Sigma_{14}C_n p^n \approx 14p \quad \text{[times/hour]}$$

$$= 14p \times 168 \text{ [times/week]}.$$

The probability that failure expected to be encountered as frequently as given by the above expression occurs during TV signal transmission on the protection channel is then be given by

$$14p \times 168 \times \frac{1.5}{168} \qquad \text{[times/week]}$$

Now let us suppose tentatively, although it may be considerably rough supposition, that TV signal transmission on the protection channel will be performed once a week for one hour and a half. Since broadcasting by TV signal transmission on the protection channel is continued for one hour and half every time, the expected duration in which the use of the protection channel and failure of the working channel coincide with each other is given by

$$1.5 \times 14p \times 168 \times \frac{1.5}{168} \quad \text{[hours/week]}$$

Since the value of the objective is 0.05%/2500km, the allowable time per week for the 6 radio sections is given by

$$168 \times 0.05 \times 10^{-2} \times \frac{6}{50}$$

All that is required is that the expected duration in which failure occurs during the use of the protection channel does not exceed the above value. Thus, the following reltion holds.

$$1.5 \times 14p \times 168 \times \frac{1.5}{168} \leqq 168 \times 0.05 \times 10^{-2} \times \frac{6}{50}$$

Then, we have

$$p \leqq 3.2 \times 10^{-4} \qquad \text{[times/hour]}$$

This value of p corresponds to an MTBF (Mean Time Between Failure) of 3125 hours.

Since the MTBF of microwave equipment is usually considered to be 25,000 hours, the use of the protection channel to this extents will be of no problem for the reliability. Now let us consider at what extent of TV program transmission demand one radio channel for exclusive use by TV programs should be provided additionally when the MTBF per set of equipment is supposed to be 25,000 hours. By the same procedure as mentioned before, we have

$$H \times 14p \times 168 \times \frac{H}{168} \leqq 168 \times 0.05 \times 10^{-2} \times \frac{6}{50}$$

if $p = 1/25,000$, then we have

$$H \leqq 4.25 \text{ [hours]}$$

Thus, if it is required to secure a reliability of 0.05%/2500km, another radio channel should be provided when TV program transmission duration comes to exceed 4 hours and 15 minutes per week.

(2)-2 Station configuration

Station confuguration of respective microwave repeater stations are described hereunder.

(2)-2-1 Terminal stations

A station configuration of a switching station is shown in Fig. 2-1-19. This configuration is applicable to Laoag, Vigan, Baguio, Binalonan, Bayombong, Ilagan, Tuguegarao, and Manila.

However, transmission will be made in two different directions at Vigan, Bayombong, Binalonan and Ilagan, so that another set of the same configuration will actually be required.

It is to be noted that two types of signals, i.e., sometimes telephone and sometimes TV signals, will be transmitted on the protection channel and a modulator and a demodulator for telephone use and a modulator and a demodulator for TV use should be provided separately so as to allow proper use of provided modulators and demodulators separately in the respective cases.

The reason why different modulators and demodulators will be used separately for telephone and TV signals is that different modulators and demodulators will be required because of difference in automatic frequency control of the intermediate frequency, necessariness or unnecessariness of DC component restoration, difference in emphasis circuit. These differences between TV and telephone modulators and demodulators are given in Table VIII-2-2-3. Control signal will be inserted in the lower band of the multiplex telephone signal on the working channel.

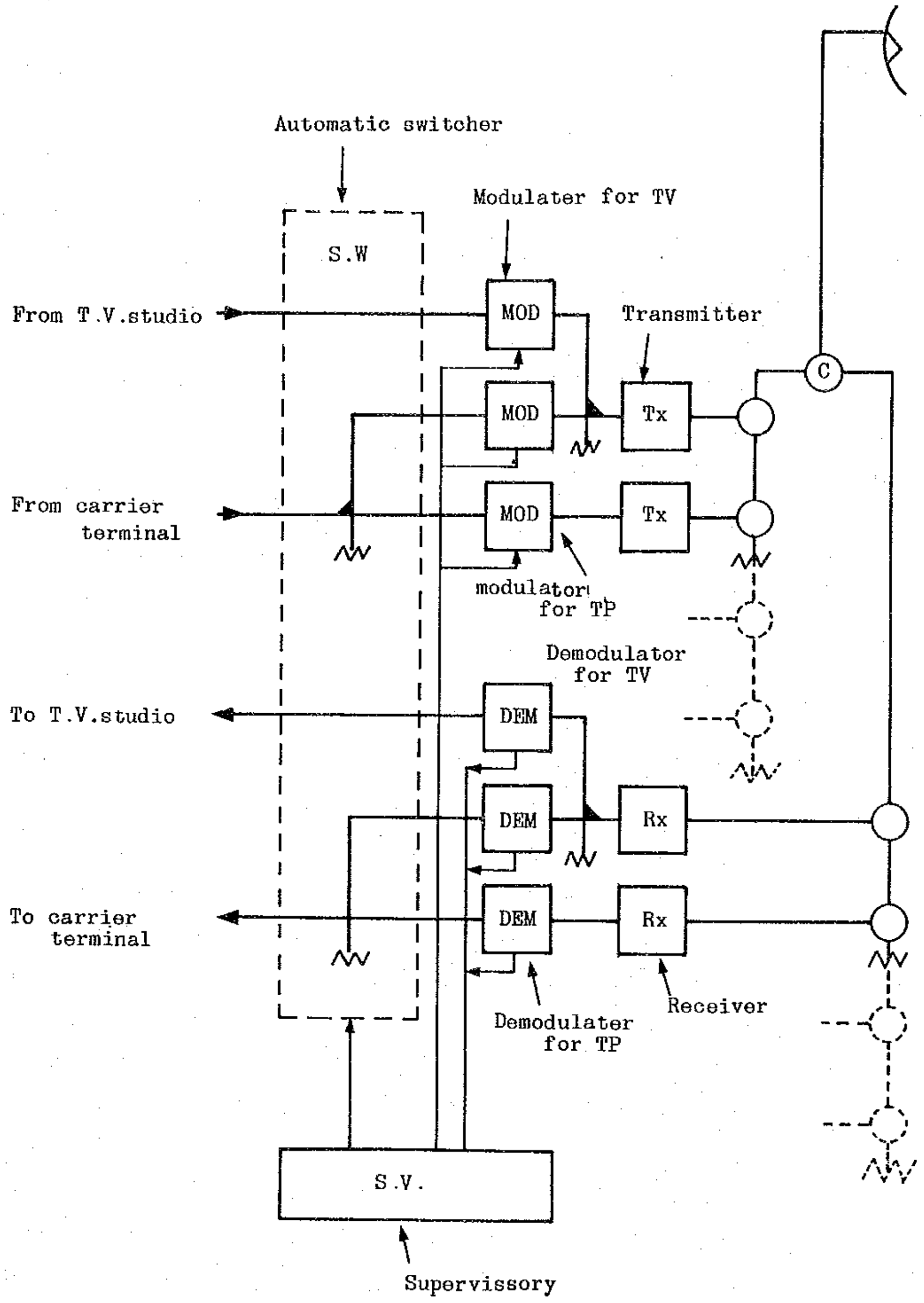


Fig. Ⅷ−2−2−19 Configulation of microwave terminal station

Table VIII-2-2-3 Differences between TV and Telephone Modulators and Demodulators

Modulator/ Demodulator Components	Modulator/Demodulator for TV Signal	Modulator/Demodulator for Telephone Signal
Emphasis Network	Emphasis is employed to improve differential gain and phase. Thus, lower spectrum is reduced. Especially, frame and line components should be reduced.	Emphasis is employed to improve triangular thermal noise characteristics. Thus, signal components contained in high-frequency portion of the mulitplexed telephone signal spectrum are emphasized.
A.F.C	The intermediate frequency is controlled relative to peak level of TV video signal.	The intermediate frequency is controlled relative to mean level of a multiplexed telephone signal.
Clamper	DC component of TV signal is essential. DC component should be transmitted. A clamper is intended to avoid losing the DC component.	Clamper is not necessary, because the DC component is not essential for a telephone signal.

(2)-2-2 Repeater stations

Fig. VIII-2-2-20 shows the configuration of a simple repeater station. Although not shown in the figure, a modulator and a demodulator for orderwire use and a supervisory signal insertion equipment will also be used. This configuration will be applied to Guinguinabang, Sto. Tomas, Balungao, and Kitakita.

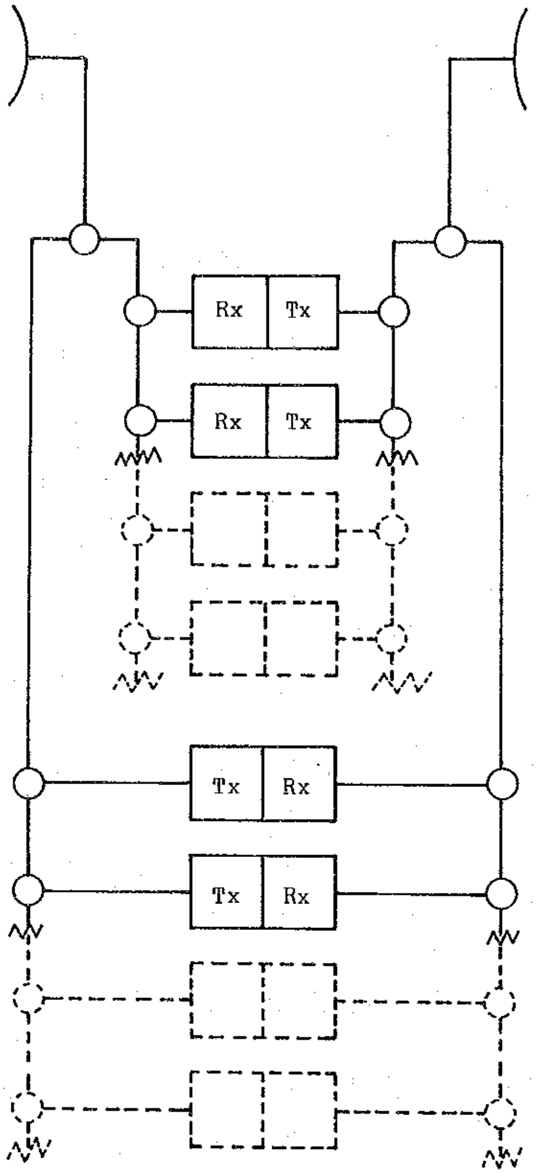


Fig.Ⅷ−2−2−20 Configuration of simple microwave repeater

(2)-2-3 Branching Repeaters

In general, a TV signal or telephone signal is inserted into or extracted from the microwave system at a switching station but when there is telephone demand near a repeater station on the way, a portion of the multiplex telephone signal can be taken out at a nearby repeater station. In such cases, telephone signal will be extracted or inserted in blocks of 60 channels. That is, when the demand is for a single channel or for 60 channels, the signal band corresponding to 60 channels will be taken out or inserted. Furthermore, it is to be noted that when signals on 60 channels (corresponding to one supergroup) are extracted or inserted (hereinafter referred to as branching), the frequency spectrum of the signal portion branched can not be used at lower-ranking stations. That is, when channels corresponding to one supergroup are branched at a certain station, the branched supergroup signal portion will still be left to lower-ranking stations. Branching of a certain supergroup portion does not mean taking out the frequency spectrum of the portion but means leaking of the spectrum of the portion. As already mentioned, when even one channel is branched, the transmission capacity will be reduced by one supergroup (60 channels) between switching stations. When there is a demand for branching, it is necessary to properly grasp the number of channels desired to be branched. Otherwise, the number of channels to be essentially transmitted between switching stations on the microwave system may become insufficient. It is also to be noted that branching will be made in blocks of 60 channels and ordinary carrier terminal equipment will be required after branching. It is not that any supergroup can be branched. From the standpoint of filter price, the first or 16th supergroup is most advantageous. Since the first supergroup is located to provide the best channel quality, it is rather too good for being branched. Since the channels to be bracnched will belong to channels ranking lower than the primary center, they need not be so good as the main route channels. Although local channels can be provided for branching from the economical standpoint, it can not be said a good method from the

standpoint of design technique. In systems where stress is put on economical advantage, the number of branching repeaters is considerably large. In the present project too, 9 stations out of 13 repeater stations are branching repeater stations. (See Table VIII-2-2-2.) Configuration of a branching repeater station is shown in Fig. VIII-2-2-21.
The maximum number of channels that can be branched is 120 channels (2 supergroups) per one repeater on usual case.

(2)-2-4 Problems of Baguio-Sto. Tomas Section

Let us now consider the problems of the BaguioSto. Tomas section. In this section, the microwave system to be directed to Vigan and that to Bunalonan will run in parallel. Since 2 radio channels will be assigned to each of directions toward Vigan and Bunalonan, a total of 4 radio channels will be in the Baguio-Sto. Tomas at first. If 3 working radio channels + 1 protection radio channel are finally assigned to both directions, this section will require a total of 8 radio channels. In this section, the 6GHz and 7GHz bands are used by PC/DND, PLDT (Philippines Long Distance Telephone Company) and BUTEL. Fortunately, however, the frequency range specified in CCIR Recommendation 384-2 is not used except PC/DND. But PC/DND now uses 6660/6740MHz and 7000/7080MH. It is necessary to assign this frequency range specified in the Recommendation for use by BUTEL in the project. Especially, the Sto. Tomas-Baguio might finally require 8 radio channels or at least 4 radio channels at the time of commencement of the project, and it is very important to accomplish the frequency assignment by BOC as soon as possible. The 6 - 7 GHz frequencies used by BUTEL, PC/DND and PLDT are give below for reference's sake.›w for reference's sake.

BUTEL	No.1 Channel	Sent from Baguio:	7137.5MHz
		Received at Baguio:	7452.5MHz
	No.2 Channel	Sent from Baguio:	7377.5MHz
		Received at Baguio:	7692.5MHz
PLDT	No.1 Channel	Sent from Baguio:	6278.8MHz
		Received at Baguio:	6026.7MHz
	No.2 Channel	Sent from Baguio:	6338.1MHz
		Received at Baguio:	6086.0MHz

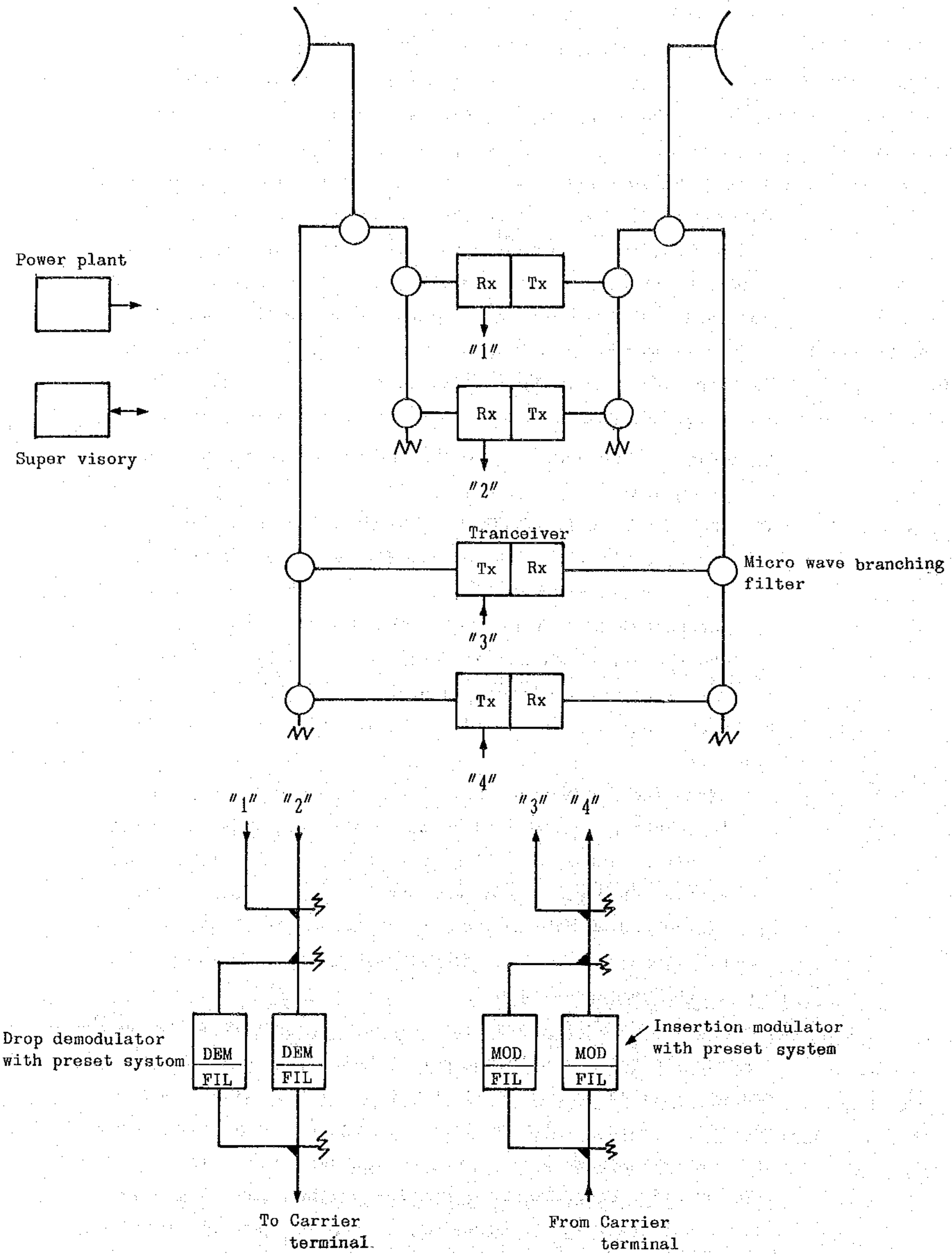


Fig. Ⅷ−2−2−21 Configulation of branching microwave repeater.

PC/DND	No.1 Channel	Sent from Sto. Tomas:	6660MHz
		Received at Sto. Tomas:	7000MHz
	No.2 Channel	Sent from Sto. Tomas:	6740MHz
		Received at Sto. Tomas:	7080MHz

The frequency range specified by CCIR Recommendation 384-1 is: 6430MHz to 7110MHz. Since the frequency range specified by CCIR Recommendation 384-2 can be used in the Baguio area, it is necessary to hasten authorized assignment by BOC as mentioned above. For radio transmission in the Baguio-Sto. Tomas section, the microwave system toward Vigan and that toward Binalonan will run in parallel. It may be possible to allow the protection channel to be used in common by the two microwave systems in this section.

Advantages to be provided by the use of the protection channel in common are:

1) The number of frequencies to be used in the Baguio-Sto. Tomas can be reduced by one. This will contribute to saving in radio frequencies.
2) Accordingly, the number of protection systems can be reduced by one, allowing reduction in the number of transmitter-receiver equipment by one.

Disadvantages to be provided by sharing the protection channels are:

Since the protection channels in this section will be used in common by the microwave systems to Binalonan and that to Vigan, automatic switchover from a working to the protective channel will no more be achievable in the Baguio-Vigan section if the protection channel in the Baguio-Binalonan section has been already used. The same applies in the reverse case too.

The problem is as follows. If for example, one repeater whichever in the Bagio-Binalonan section fails, the failed working channel will be automatically switched over to the protection channel in this section as the function of a microwave system and transmission will be conducted without interruption. However, if another repeater station in the Baguio-Vigan section should fail in the meantime, switchover from the working to the Baguio-Vigan section since the protection channel has been already occupied. This will result in disabling repeatering. Such a phenomenon as this will be caused when both sections fail at a time or when one section fails while the other section having failed has not yet been restored to normal. Now, let us estimate the number of such cases by calculation.

Suppose:

1) the MTBF (Mean Time Between Failure) per microwave equipment is 25,000 hours,
2) the number of equipment is 3 at a repeater station (one transmitter + one receiver + one other type of equipment) and 4 at a terminal station (one modulator and demodulator + one transmitter and receiver + 2 other types of equipment), and
3) one section comprises 2 terminal stations and 5 repeater stations (corresponding to Baguio-Bayombong section).

Then,

Number of failures per month:

$$\frac{1}{25{,}000} \times 720\ [\text{hours}] = 0.036 \times [\text{failures/month}]$$

Number of equipments per section:

$$2_{[\text{stations}]} \times 4_{[\text{sets}]} + 5_{[\text{stations}]} \times 3_{[\text{sets}]} = 23_{[\text{sets/section}]}$$

Number of failures per section per month:

$$0.036\ [\text{failures/month}] \times 23[\text{sets}] = 0.83\ \text{failures/section} \cdot \text{month}$$

Thus, for 0.83 cases/section month, automatic switchover to the protection channel will be conducted and transmission will be maintained without interruption. However, repair will be necessary. Suppose the average time required for repair is one hour and a half in the case of a terminal station and 3 hours (one hour and a half for repair and the same time interval for attenuation from the base station, then we have

$$\frac{1.5[\text{hours}] \times 8[\text{sets}] \times 3[\text{hours}] \times 15[\text{sets}]}{23[\text{min.}]} = 2.5[\text{hours/set}]$$

Hence, the duration in which the protection channel is occupies due to failure is as follows per month.

$$2.5[\text{hours}] \times 0.83[\text{cases/month}] = 2.1[\text{hours/month}]$$

If, unfortunately, another section fails in this duration, in the Baguio-Sto. Tomas section using the protection channel common system, the transmission path incorporating the section having failed later will fail.
Now, let us obtain the probability of this case.
First, the number of failures per month is:

0.83[failures/month].

On what day failure is caused is not known at all. From long-term standpoint, it can be considered that failure is caused every day uniformly. All that is required then is to obtain the possibility that a failure out of 0.83 failures unfortunately occurs during repair on account of preceding failure, that is, during the 2 hours and a half in a month. This possibility is given by

$$0.83[\text{failures/month}] \times \frac{2.5[\text{hours}]}{720[\text{hours}]} = 2.9 \times 10^{-3} [\text{failures/month}]$$

From our common sense this is rather a rare case and the fear for the occurrence of system failure by the simultaneous occurrence of two failures should scarcely be taken into consideration. Disadvantages to be brought about by the use of the protection channel in common are as follows.

1) Supervisory and control equipment to be used at Sto. Tomas Repeater Station will become extremely complicated in configuration because of the use of the protection channel in the Baguio-Sto. Tomas section in common.
2) Accordingly, supervisory and control operations at Baguio, Bayombong, and Vigan will sometimes become extremely complicated.
3) This will be led to increase in cost of the supervisory and control equipment.
4) Maintenance operations (such as inspection and servicing) will be subjected to the influence of the operating condi-

tions of other sections, making it difficult to make the maintenance operation plan. When, for example, the protection channel is used on account of servicing at Binalonan, servicing by switchover to the protection channel at Vigan will not be achievable.

As stated above, considerable disadvantages will be involved. In particular, inconveniences arising from items 1), 2), and 4) can be said considerable demerits from Japan's experience in microwave operarion over 20 and several years. Accordingly, when there is a margin in frequency allocation and an additional investment of a pair of radio equipment is allowed, the supervisory and control system should be made as simple as practivable. To summarize, it is more advantageous to construct the microwave system between Baguio and Binalonan and that between Baguio and Vigan as separate systems.

(3) Required numbers of telephone channels

The required numbers of telephone channels between primary centers in the microwave system to be adopted for the main route are shown in Fig. VIII-2-2-21(b). In the figure the numbers of required telephone channels between switching sections are parenthesized. The maximum channel capacity will be determined in consideration of the numbers of telephone channels required in years ranging to 1997. The required numbers of channels to be actually required in the radio transmission path will be determined by the telephone channel group configuration of the carrier multiplex equipment in use and will be slightly more than the numbers required between switching sections. Anyway, it can be understood that a maximum capacity of 16 supergroups or 960 telephone channels per a radio channel will be sufficient. Branching will be usually planned to a maximum of 2 supergroups or 120 channels per switching section. Branching of more than this is, of course, possible.

Branching will be planned to be made as follows.

- o 2 supergroups (120 channels) at Sinait
  (one is for Laoag and the other for Vigan.)
- o 1 supergroup (60 channels) at Bigbiga
  (This is for Vigan)

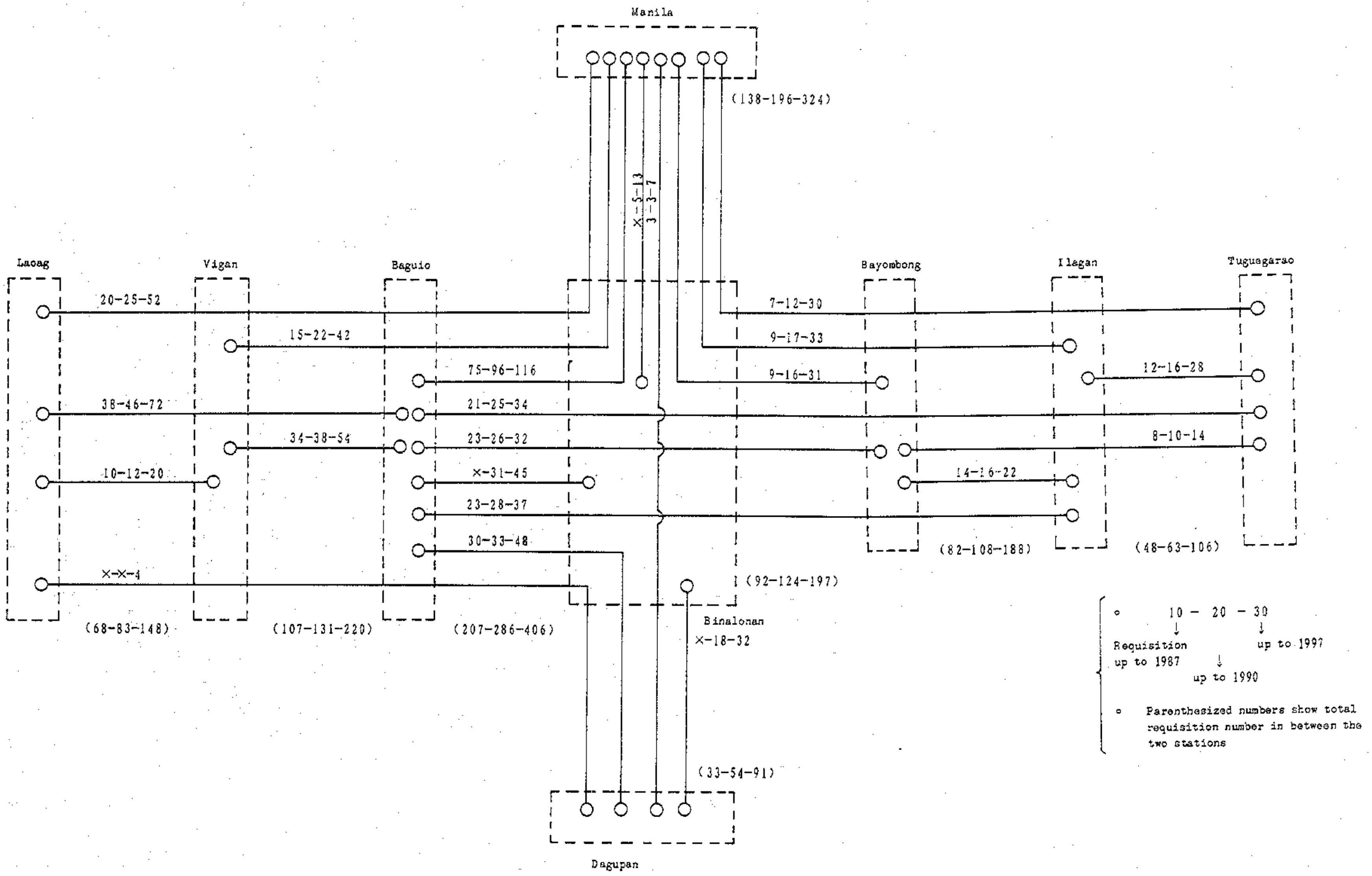


Fig.Ⅷ-2-2-21(b) Required numbers of telephone channels among primary centers

- 1 supergroup (60 channels) at Tagudin
  (This is for Vigan)
- 1 supergroup (60 channels) at Dalton Pass
  (This is for Bayombong)
- 1 supergroup (60 channels) at Diadi
  (This is for Bayombong)
- 5 supergroups (300 channels) at San Mateo
  (These are for Ilagan)
- 2 supergroups (120 channels) at Tarlac, Dau and Pandi respectively
  (one is for Binalonan and the other for Manila)

It is then to be noted that the maximum transmission capacities as a main route (3 pw/km) in each switching sections are as shown below.

Laoag-Vigan	14 supergroups
Vigan-Baguio	14 supergroups
Baguio-Binalonan	16 supergroups
Binalonan-Bayombong	15 supergroups
Bayombong-Ilagan	10 supergroups
Ilagan-Tuguegarao	16 supergroups
Binalonan-Manila	10 supergroups

To conclude, it can be understood that a 6GHz, 960-channel system is sufficient for the main route in consideration of the required number of channels in years ranging to 1997 and the necessity of some channels for branching.

(4) Allotment of Mean Channel Noise

Noise allotment of microwave systems has been set out by a CCIR recommendation. CCIR Recommendation No.392 allots a mean noise power of 7500pW (weighted) to a 2500km hypothetical reference circuit in any time zone. This value is equal to 13350pW in unweighted value. According to another CCIR recommendation which sets out the method of allotment, the following equation should be actually applied to the Laoag-Baguio and Tuguegarao-Baguio and Binalonan -Manila sections respectively.

$$(3L + 200)\text{pW} \quad \text{(weighted)}$$

L: Radio section length in km

These sections will consist of two video sections 4 video sections and one video section respectively. For details, see Table VIII-2-2-4.

Table VIII-2-2-4 Discription of M/W route

Unit of M/W route	Laoag - Baguio	Tuguegarao - Baguio	Binalonan - Manila	Remarks
Video section composed	o Laoag - Vigan 2 hops 74.6 Km Repeater: Sinait* o Vigan - Baguio 5 hops 155.3 Km Repeater: Bigbiga*, Tagudin* Guinguinabang St. Tomas	o Tuguegarao - Ilagan 1 hop 56.4 Km o Ilagan - Bayombong 3 hops 107.3 Km Repeater: San Mateo* Diadi* o Bayombong - Binalonan 4 hops 134.9 Km Repeater: Dalton Pass,* Kitakita, Balungao o Binalonan - Baguio 2 hops 42 Km Repeater: St. Tomas.	o Binalonan -Manila 5 hops 183.2 Km Repeater: Balungas Tarlai* Dau* Pandi*	Sign of * shows a repeater with leaking
Total length	229.9 Km	351.6 Km	183.2 Km	
Grand total	764.7 Km			

Hence, noise allotment to the Laoag-Baguio will be:

$$(3 \times 229.9 + 200) \times 1.78 = 1583\text{pW}$$

Coefficient for conversion
to unweighted noise power

Noise allotment to the Tuguegarao-Baguio section will be given by

$$(3 \times 351.6 + 200)\text{pW} \times 1.78 = 2233\text{pW}$$

And similarly in Binalonan Manila case,

$$(3 \times 183.2 + 200)\text{pW} \times 1.78 = 1334\text{pW}$$

Mean noise alloted to each section should usually be divided into the following three types of noise from the standpoints of rational design and economy.

- o Thermal noise
- o Distortion noise
- o Interference noise

Thus, noise allotment for the two sections will be as follows.

Laoag-Baguio section;

1583pW (Unweighted) (58.0dB)
- Thermal noise; 592pW (62.8dB)
- Distortion noise; 527pW (62.8dB)
- Interference noise; 527pW (62/8dB)

Tuguegarao-Baguio section;

2233pW (Unweighted) (56.8dB)
- Thermal noise: 745pW (61.3dB)
- Distortion noise; 744pW (61.3dB)
- Interference noise; 744pW (61.3dB)

Binalonan-Manila section;

1334pW (Unweighted) (58.7dB)
- Thermal noise: 445pW (63.5dB)
- Distortion noise; 445pW (63.5dB)
- Interference Noise; 445pW (63.5dB)

Thermal noise depends on the maximum channel capacity, transmitter output power, modulation index, receiver noise figure, and antenna diameter, and also, depends on the radio wave transmission course. Distortion noise is determined mostly by the performance characteristics of the equipment in use in the case of 960 channels. That is, distortion noise is determined mostly by the linearity of the modulator and demodulator and amplitude and delay characteristic of repeater equipment.

Interference noise is, like thermal noise, partially produced from the equipment in the microwave transmission system but also is ascribable to the radio wave transmission course. Belonging to the former is interference noise caused by the echo of the antenna system. Belonging to the latter are interference from other systems, interference from adjacent channels, front-to-back coupling of antennas, overreach interferences, etc. This paragraph describes a type of thermal noise that is ascribable to the radio wave transmission course.

The mean thermal noise allotment to the Laoag-Baguio section should be 529pW (62.8dB), that to the Tuguegarao-Baguio section should be 745 (61.3dB), and that to the Binalonan-Manila section should be 445pW (63.5dB).

In the case of the route determined as per Fig. VIII-2-2-1, the discussion is the main conclusion of this paragraph whether these values can apply to the proposed routes mentioned in the Figure or not.

First, microwave equipment expected to be adopted in the respective section of the microwave system are supposed to have the following specifications.

Equipment specifications

- o Antenna: Parabolic type having a 3.3-meter diameter
  Aperture efficiency: 50%
- o Transmitter output power: 30dBm (1W)
- o Receiver noise figure: 7 dB
- o Modulation index of modulator: 200kHz rms/channel
- o Bandwidth per telephone channel: 0.3kHz - 3.4kHz

o Feeder system length: 60m/hop per pair
(including both sending and receiving sides)
(Feeder loss: 0.06dB/m)

o Loss other than feeder loss: 5 dB per pair

Now, free space loss in each microwave section is given by

$$\Gamma o = \left(\frac{4\pi\ell}{\lambda}\right)^2$$

ℓ: Transmission length

λ: Wavelength

$$= 109.05 + 20 \log \ell \text{ [dB]}$$

(at 6770MHz and ℓ in km)

Then, let us obtain the microwave receiving level at the receiver input terminal from the free space loss thus obtained. The microwave receiver input terminal is given by

$$P_r = P_t + G_t - \Gamma o + G_r - \text{Lant} \quad \text{[dB]}$$

P_r: receiving input level
P_t: transmitter output
G_t: transmitting antenna gain
$_o$: free space loss
G_r: receiving antenna gain
Lant: Feeder loss

When the receiving input level is thus obtained, the signal-to-noise ratio (S/N) of the frequency division multiplex-frequency modulated signal on account of the thermal noise of the microwave transmission path is given by

$$S/N = 10 \log \frac{Pr}{KT \triangle fF}\left(\frac{So}{fm}\right)^2 \quad \text{[dB]}$$

Where Pr: receiving input level (W)
K: Boltzmann's constant (= 1.38×10^{-23} Joul/°K)
T: ambient temperature of receiver (300°K)
f: bandwidth of one telephone channel (3.1kHz)
F: noise figure of receiver (7dB)
So: modulation index per telephone channel (200kHz rms/CH)
fm: maximum modulation frequency (4.1MHz in the case of 960-channel system)

As already mentioned, all parameters other than Pr are given in an equipment specification. Thus, due care should be taken so as to achieve the required value upon preparing the specification. The results of calculation of the S/N on account of the thermal noise of each section are given in Table VIII-2-1-5. The sum of S/N values in the Laoag-Baguio section and that in the Tuguegaras-Baguio section are also given respectively in the table.
In this case, adoption of emphasis circuits in conformity to CCIR Recommendation 275-2 will allow the S/N on account of thermal noise to be improved by 4dB, although the margin of 4dB for the all-together fading described later herein should be considered. The Laoag-Baguio section will be a 2-video sections, the Tuguegaras-Baguio section a 4-video sections and the Binalonan-Manila section one-video section. Supposing the noise per demodulator is 20pW, therefore, allotting 40pW for the Laoag-Baguio section, 80pW for the Tuguegarao-Baguio section, and 20pW for the Binalonan-Manila section we have

68.2dB + 40pW = 67.2dB
66.1dB + 80pW = 64.9dB
69.0dB + 20pW = 68.4dB

at the expected S/N values for the respective sections, which are given in Table VII-2-2-5. In both sections, the objectives are met with margins of 4 ~ 5dB.

Table VIII-2-2-6 S/N on Account of Thermal Noise

Microwave Section	S/N Value	
	Expected	Stipulation
Laoag-Baguio	67.2dB	62,8dB
Tuguegarao-Baguio	64.9dB	61.3dB
Binalonan-Manila	68.4dB	63.5dB

Here, the amount of improvement by exphasis is supposed to be 4dB. In a frequency modulation system the ferquency component in the modulation system the frequency component in the modulation section usually corresponds to the amplitude component obtained after demodulation. Accordingly, when the signal component contains flat noise (that is, when thermal noise is caused), higher spectrum com-

Radio section	Free space loss [dB]	M/W receiving power [dB]	Signal to thermal noise ratio [dB]	Course distance [km]
Laoag-Sinait	140.6	-30.6	75.5	38.0
Sinait-Vigan	140.3	-29.9	76.2	36.6
Vigan-Bigbiga	138.5	-28.1	78.0	29.6
Bigbiga-Tagudin	141.9	-31.5	74.6	44.1
Tagudin- Guinguinabang	137.0	-26.6	79.5	25.0
Guinguinabang-Sto. Tomas	142.3	-31.9	74.2	46.0
Sto. Tomas-Baguio	129.2	-19.2	80.9	10.6
Laoag- Baguio			68.2dB (151pW)	229.9km
Tuguegarao-Ilagan	144.1	-33.7	72.4	56.4
Ilagan-San Mateo	141.3	-30.9	75.2	40.8
San Mateo-Diadi	141.2	-30.8	75.3	40.3
Diadi-Bayombong	137.4	-27.0	79.1	26.2
Bayombong-Dalton Pass	142.1	-31.7	74.4	44.7
Dalton Pass-Kitakita	140.8	-30.4	75.7	38.6
Kitakita-Balungao	140.8	-30.4	75.7	38.9
Balungao-Binalonan	136.5	-20.1	80.0	23.7
Binalonan-Sto. Tomas	139.0	-28.6	77.5	31.4
Sto. Tomas-Baguio	129.6	-19.2	86.9	10.6
Tuguegarao-Baguio			66.1 (245pW)	351.6
Binalonan-Balungao	136.5	-26.1	80.0	23.7
Balungao-Tarlac	141.8	-31.4	74.7	43.5
Tarlac-Dau	140.6	-30.2	75.9	38.0
Dau-Pandi	142.1	-31.7	74.4	45.0
Pandi-Manila	139.4	-29.0	77.1	33.0
Binalonan-Manila			69.0 (126pW)	183.2

Table VIII-2-2-5

Results of thermal noise calculation

ponents appear as high power components after demodulation. That is, the demodulated power component proportional to the square of the frequency appears as noise. The use of exphasis circuit is intended to exphasize in advance telephone channels allocated at high frequencies in the spectrum not to be overcome by noise after demodulation in the case of a multiplex telephone signal.

It is to be noted that the purpose of this emphasis circuit is greatly different from that of the emphasis for the television signal which will be descrived later herein. Now, let us briefly consider the margin of 4dB for alltogether fading.

The receiving input field strength of the micrewave system varies with various factors. At frequencies nearly equal to the 6GHZ band, attenuation owing to fading can be one of the factors to be picked up first. Since the degradation in the receiving input nearly corresponds to the signal-to-noise ratio (S/N) at the demodulator output, the variation of the receiving input field strength variation envolves increase in thermal noise power. Now, let us consider how many sections in a 2500km hypothetical reference circuit set out in CCIR Recommendation 392 will be subject to fading.

The probability that a certain section is subject to deep fading (such that the average receiving input field strength lowers by over 10dB) in a microwave system is empirically given by

$$P = (\frac{f}{4})^{1.2} \times Q \times \ell^{3.5}$$

Where f: transmitting frequency [GHz]

Q: constant determined by the transmission course (2.1×10^{-9} for mountaneous areas and 5.1×10^{-9} for plains)

ℓ: transmission course length [km]

The probability that deep fading is caused only in k sections among a total of Z sections is represented by binominal distribution as follows.

$$Pk = \frac{Z!}{k!(Z-k)} P^k(1-P)^{Z-k}$$

Let us now obtain P by assuming a transmission through a transmission course length of 50km over a plain at 6.77GHz, as a typical case. Then, we have

$$P = (\frac{6.77}{4})^{1.2} \times 5.1 \times 10^{-9} \times 50^{3.5}$$
$$= 1.88 \times 5.1 \times 10^{-9} \times 8.84 \times 10^{5}$$
$$= 8.48 \times 10^{-3}$$

For k = 1 ~ 5, we obtain the values of Pk as follows.

k	0	1	2	3	4	5
Pk [%]	65.3%	27.9	5.85	0.801	0.081	0.0063

It can be said that in 30% of all time fading is necessarily caused in some section or sections (among 50 sections) and that the probability of causing fading in more than 5 sections simultaneously is about 0.01%. Letus now examine increase in thermal noise to be caused when fading is encountered in 4 sections as the worst case. For simplicity's sake, let us suppose that all of the 50 sections cause an equal amount of thermal noise (N) so that the total thermal noise of 50 sections with no fading caused in any section can be represented by 50N. Let us also suppose that deep fading is caused only in 4 sections and not caused in the remaining 46 sections. However, the number of 46 sections is considerably large. In other words, it can be said rather rare that all of 46 sections are simultaneously quite normal. For example, shallow fading (which is quite different, in the mechanism of occurrence, from deep fading the latter of which causes the average receiving input to drop by more than 10dB) may be caused or more or less receiving input level variation may be caused on account of equipment level variation, etc. Accordingly, it is usually employed, empirically and in consideration of safety, to assume an amount of noise equal to 1.4 times the amount of noise caused normally for the 46 sections. Then, the total amount of noise to be caused in 50 sections when 4 sections are subject to deep fading is

$$(1.4 \times 46[\text{sections}] + 10 \times 4\ [\text{sections}])N$$
$$= 104.4N$$

By taking the ratio of the above value to the amount of noise caused when all of the 50 sections are normal we can obtain the ratio of noise increase as follows.

$$10 \log \frac{104.4N}{50N} = 3.2 \quad [dB]$$

This means that in a time zone with a ratio of risk of about 0.01% or about 99.9% the average noise increase is about 3.2dB at the maximum. This is equivalent to the occurrence of fading in all sections together with as much average noise degradation as 3.2dB. Accordingly, a fading margin of 4dB will be allotted to each of the Laoag-Baguio, Binalonan-Manila and Baguio-Tuguegarao sections. The problems of thermal noise which are discussed from the standpoint of transmission are described in item (7).

(5) Frequency allocation and interference noise

(5)-a General discussion

What frequency band should be employed for the microwave route specified in Fig. VIII-2-2-1 is a big problem. CCIR recommends frequency allocation in each frequency bands of 1.5GHz to 11GHz range. This project will adopt the higher 6GHz band as the operating frequency band (in conformity to CCIR Recommendation 384-2).

For the replacement plan of the Baguio - Manila section, 7GHz band is employed at present in this section. Accordingly to the CCIR recommendation, the maximum channel capacity of the 7GHz band is 300 channel pera radio frequency but this channel capacity will be insufficient in consideration of future demand increase in this section. Accordingly, it is recommend to employ the 6GHz upper band instead of the 7GHz band for the Baguio-Manila section (actually Binalonan-Manila). By this, Region I microwave route, Region II microwave route, and Binalonan-Manila route will all employ the same frequency band, which will assure much advantage in maintenance.

In this case, the allocated band is 6430MHz to 7110MHz and it is necessary to check whether the frequencies in this range are used by any existing system on the proposed route and whether the DOMSAT needs the band. That is, around Sto. Tomas and between Sto. Tomas and Manila, the 6GHz higher band is now used by PC/DND.

Therefore, this is first checked item. In Regions I and II, microwave is not used but at Sto. Tomas. Let us consider the operating condition of microwave at Sto. Tomas.

At Sto. Tomas the 6GHz band is used by BUTEL, PC/DND and PLDT. Detailed frequency usage has been already described in item (2)-2-4. PLDT uses the lower 6GHz and BUTEL the 7GHz band. Fortunately, the higher 6GHz band remains except PC/DND. It can be said from this standpoint before everything that the use of the higher 6GHz band may be achievable.

On the other hand, 6680 - 6706MHz and 6980 - 7013MHz band are assigned for DOMSAT TV link. Therefore, the Laoag, Sinait and Tuguesgarao station should avoid the frequency band use.

About present use of the 6GHz band in Manila area, the use is so congested. Because, the band is now used PC/DND, PLDT and other several broad casting companies, and further more, DOMSAT is now also propose to occupy the part of the band in Manila area.

In future, some adjustment of the use in the band by BOC must be necessary. Details will be mentioned latterly.

The advantages of the higher 6GHz band for this project are:

- o Being the main transmission route.
- o The maximum transmission capacity required per radio channel from channel demand will be 960 channel.
- o Most transmission paths will be over plains or mountainous areas and most sections will be less than 50km/hop.
- o Reflected waves will be cut in most sections
- o Considration is given also to future color TV signal transmission

In consideration of these advantages, the high 6GHz band is proposed to be employed.

(5)-b Channel Assignment

Let us now allocate radio channels shown in Fig.VIII-2-2-22 to the radio sections. In this case, various restrictions exist. Firstly, the 6GHz band proposed to DOMSAT's microwave link (transmitting group of 6680 - 6706MHz and receiving group of 6980 - 7013MHz MHz) should be kept out of in Laoag, sinait, Tuguegarao, and Manila. Secondly, in the Sto. Tomas-Manila section PC/DND, US Navy, PLDT, Radio Phil. Network ABS-CBN MBC, Inter Island Broadcasting Corp.

KANLAON and NMPC have been already employing a microwave link using 6GHz band and this frequency group should be kept out of.

Thirdly, interference between the Guinguinabang-Sto. Tomas-Baguio section and Balungao-Kita Kita-Dalton Pass section should be examined. That is, since the angle formed at Sto. Tomas between the direction of Guinguinabang and that of Baguio and the angle formed at Kita Kita between the direction of Balungao and Dalton Pass are both as small as less than 90°, there is a fear of interference, which may restrict the channel assignement.

Fourthly, overreach in the Sto. Tomas-Bigbiga should be examined.

Of the frequency allocations set out by CCIR Recommendation 384-2, such allocation that provides channel separation for a maximum transmission capacity of 1260 channels and uses antennas of single polarization are mainly proposed on the project. This frequency allocation is shown concretely in Fig. VIII-2-2-22.

Fig. VIII-2-2-24(b) ~ 27 show the actual frequency assignment under the consideration of the obove various conditions.

Especially between Sto. Tomas and Baguio and between Balungao and Binalonan, the frequency band will be so congested due to double use of the routes. Fig. VIII-2-2-22(b) and 22(c) show details of present frequency situation at a section between Sto. Tomas and Manila.

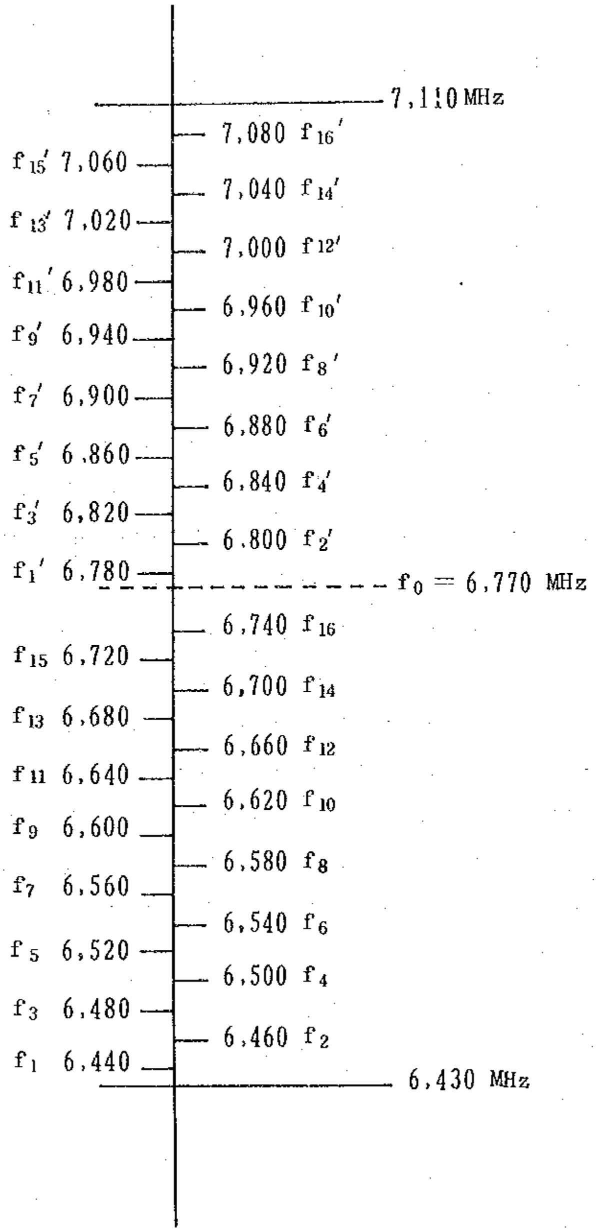


Fig.Ⅷ−2−2−22 Frequency allocation recommended by CCIR Rec. 384−2

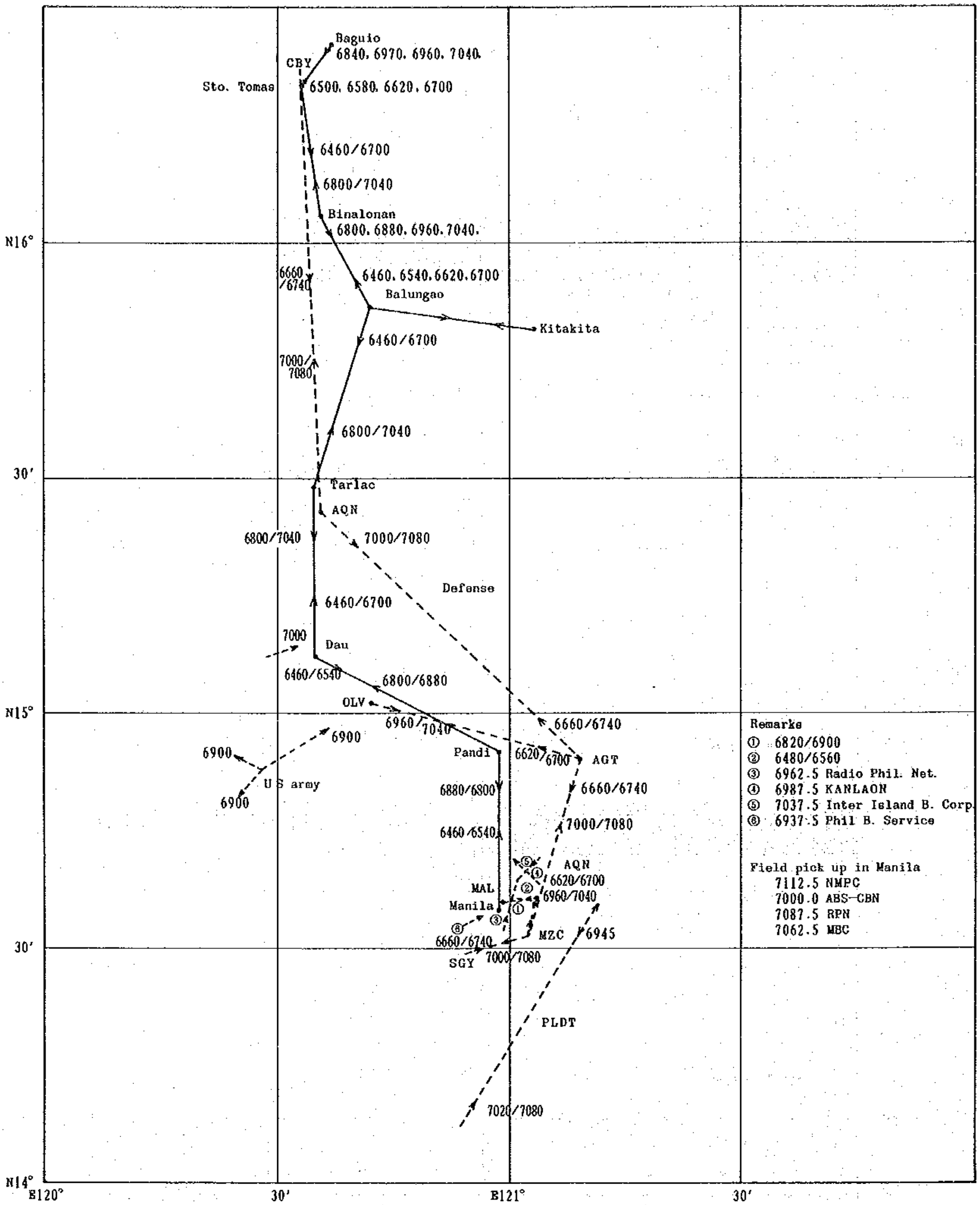


Fig. Ⅷ-2-2-22(b) 6 GHZ band situation between Baguio and Manila

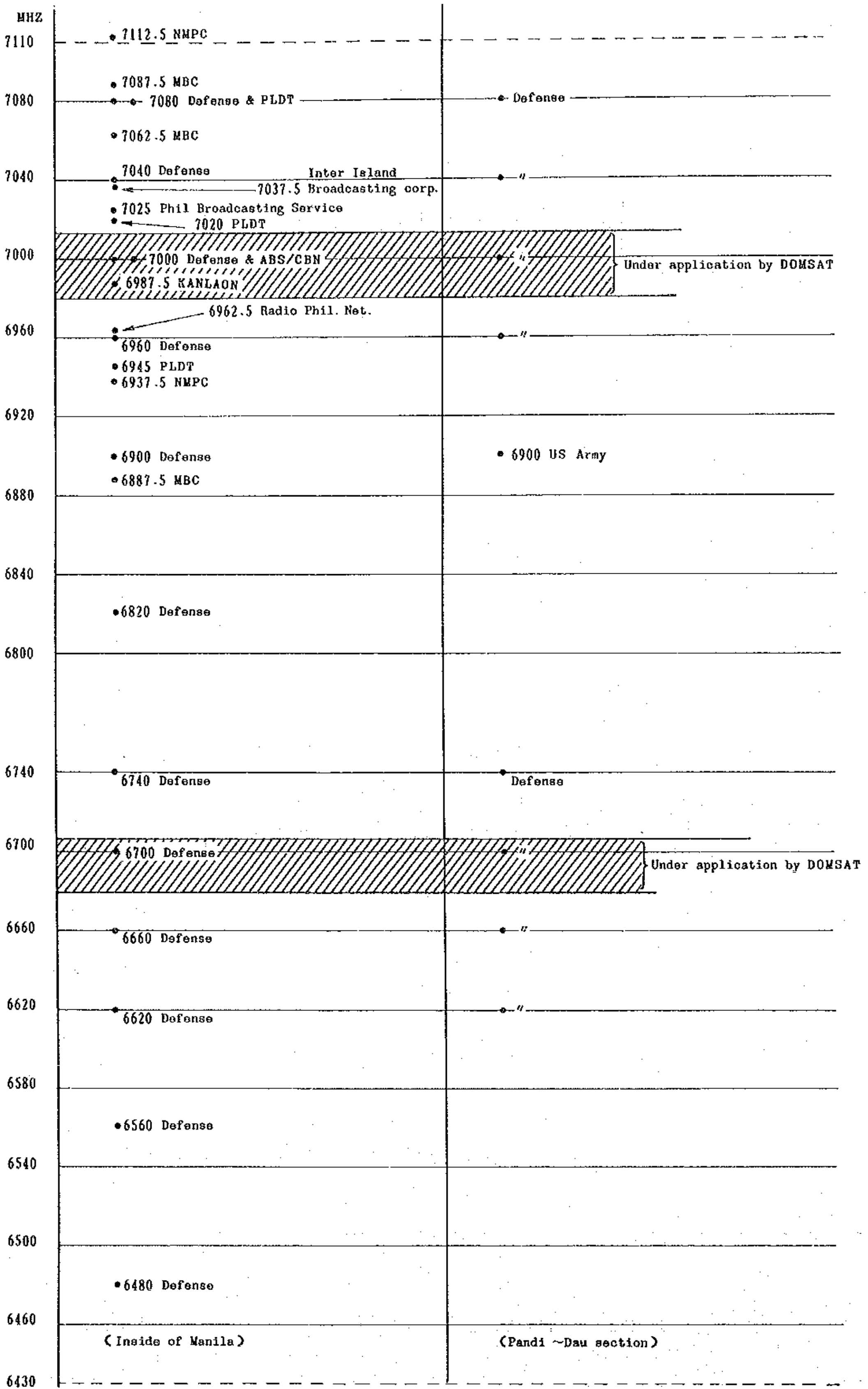


Fig. Ⅷ-2-2-22(C) Situation of 6 GHZ band channel assignment in Manila and in Pandi ~ Dau section

For the working channels, 6820, 6480, for Laoag - Sto. Tomas section, 6840, 6500 for Tuguegaras - Kitakita section and Balungas - Manila section will be employed.

These assignment are considered to avoid DOMSAT assigned channel of the terrestrial link.

The problem is in the Sto. Tomas-Baguio section and Kitakita-Baguio sections. Let us first consider the problem in the Sto. Tomas-Baguio section. As shown in Fig. VIII-2-2-23, the angle formed by the paths toward Baguio and Guinguinabang from Sto. Tomas is about 54 degrees.

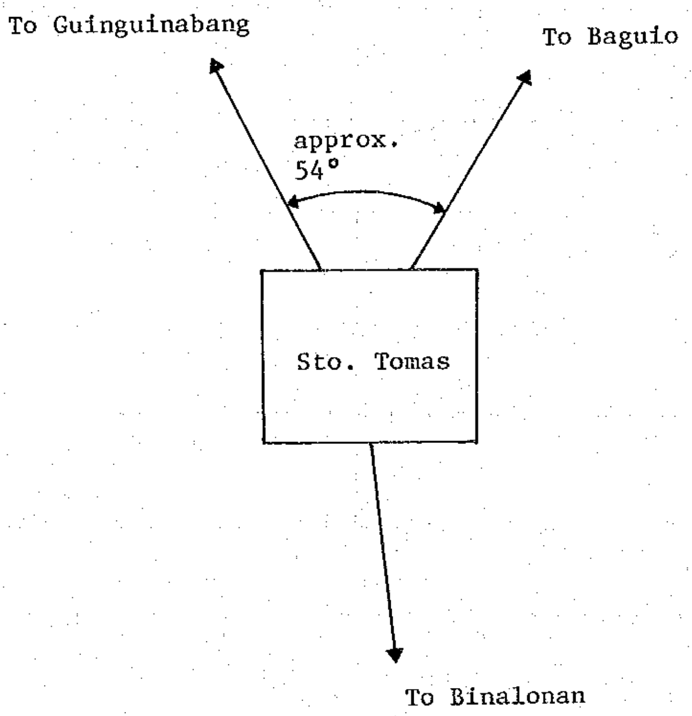


Fig. VIII-2-2-23 Orientation to Three Directions at Sto. Tomas

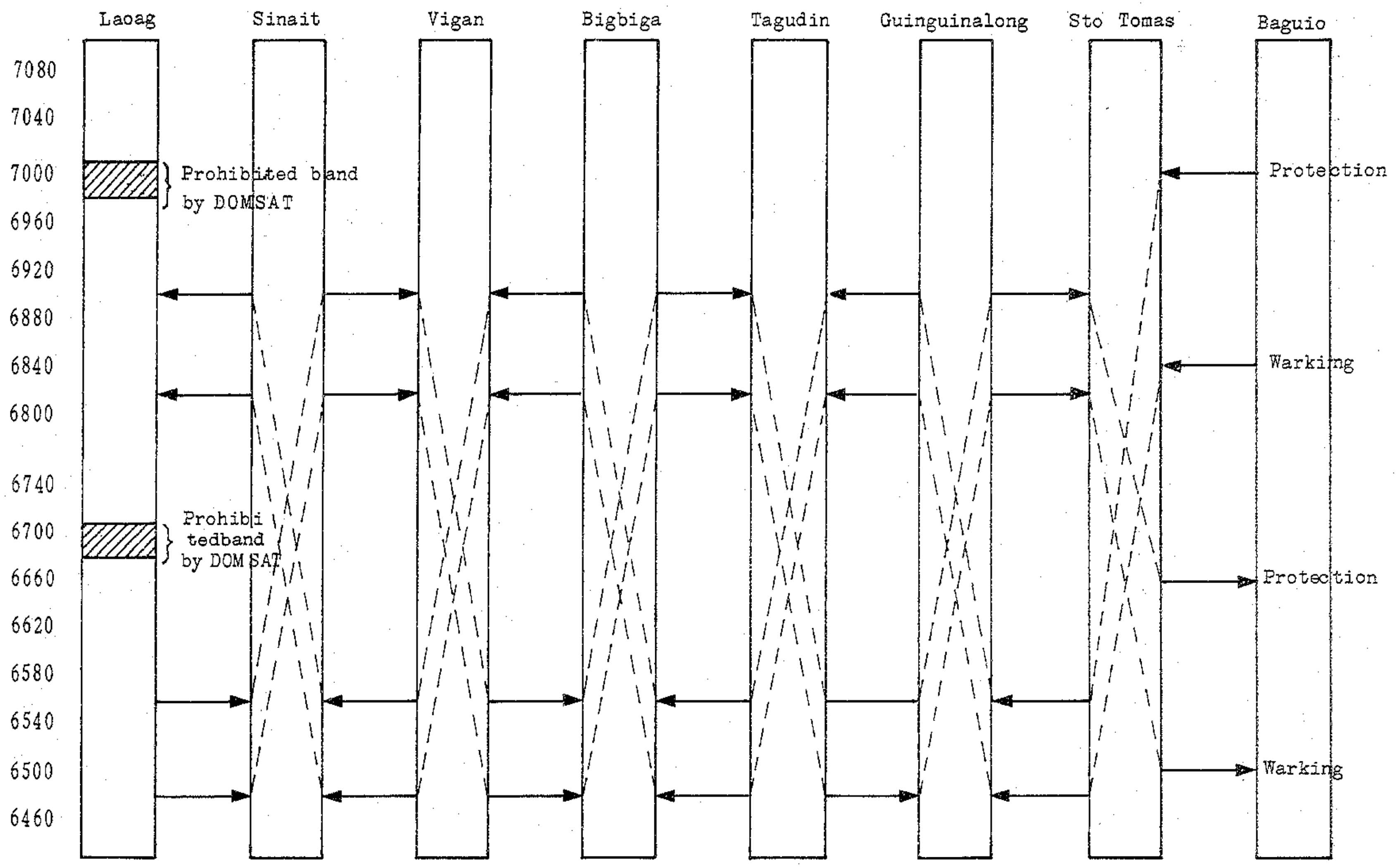


Fig.Ⅷ−2−2−24(b) Frequency allocation for Region I route

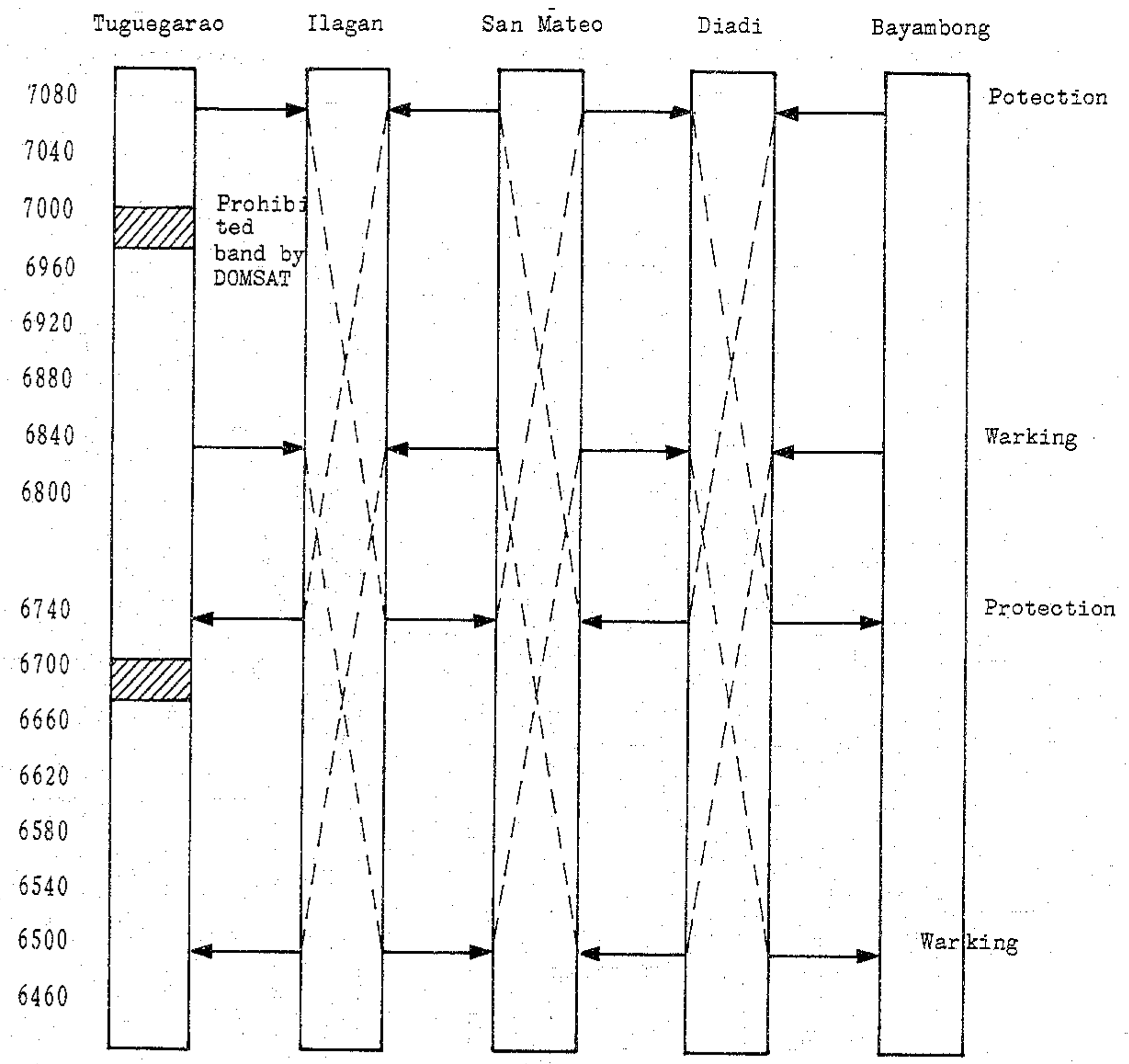


Fig. Ⅷ−2−2−25 Frequency allocation for Tuguegarao ～ Bayombong

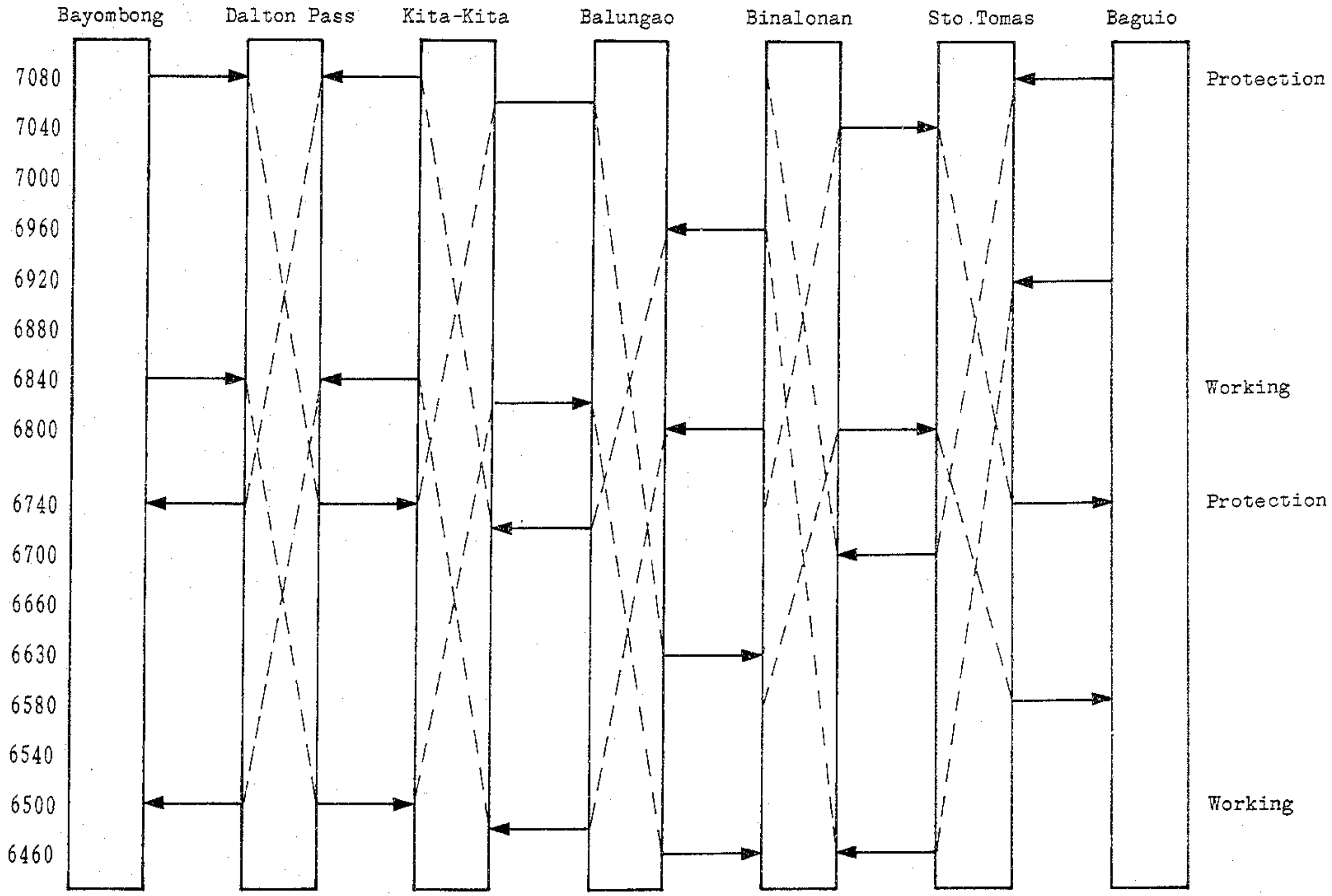


Fig.Ⅷ-2-2-26 Frequency allocation for Bayombong ~ Baguio of Region Ⅱ route

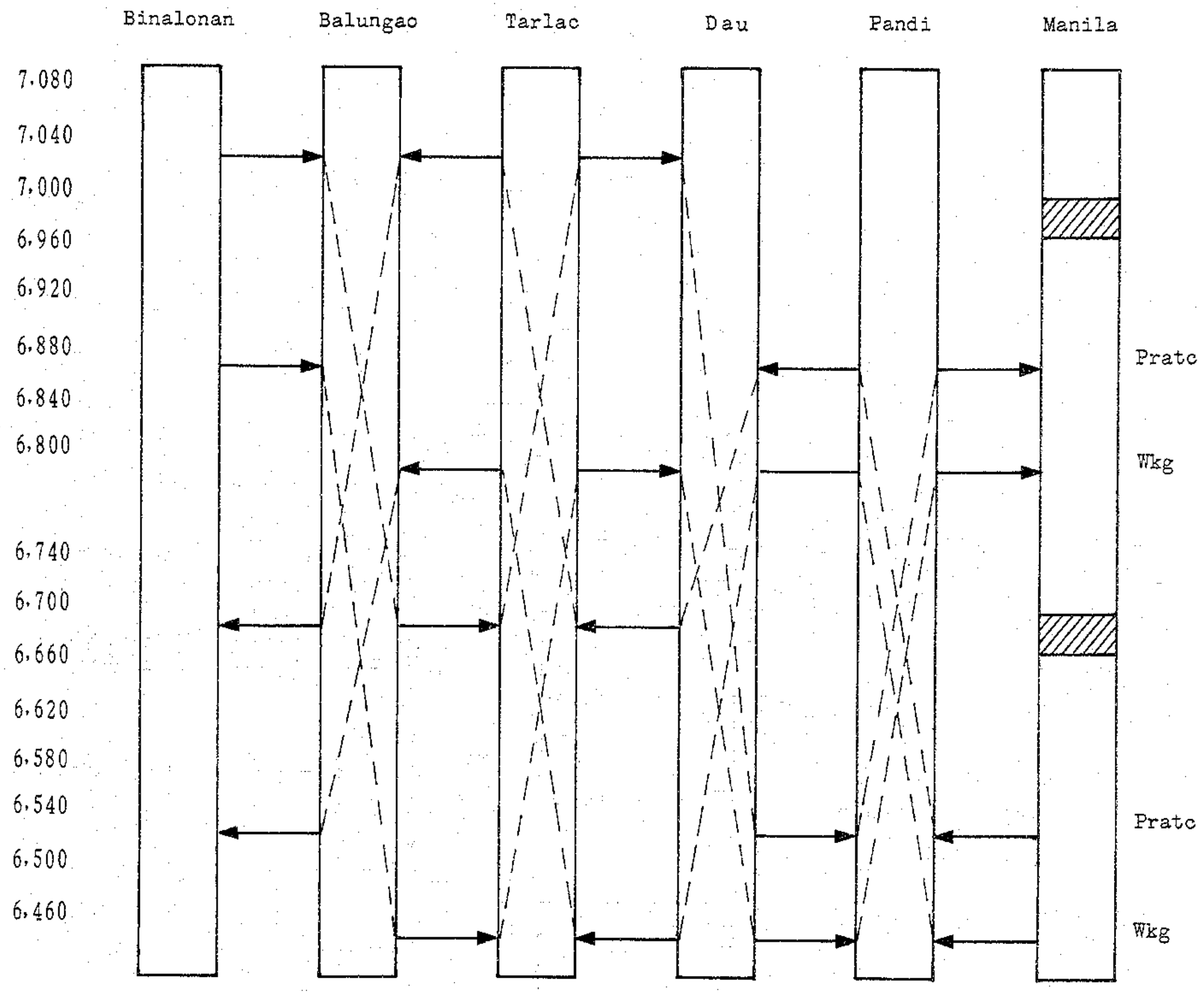


Fig.Ⅷ−2−2−27 Frequency allocation for Binalonan ∼ Manila

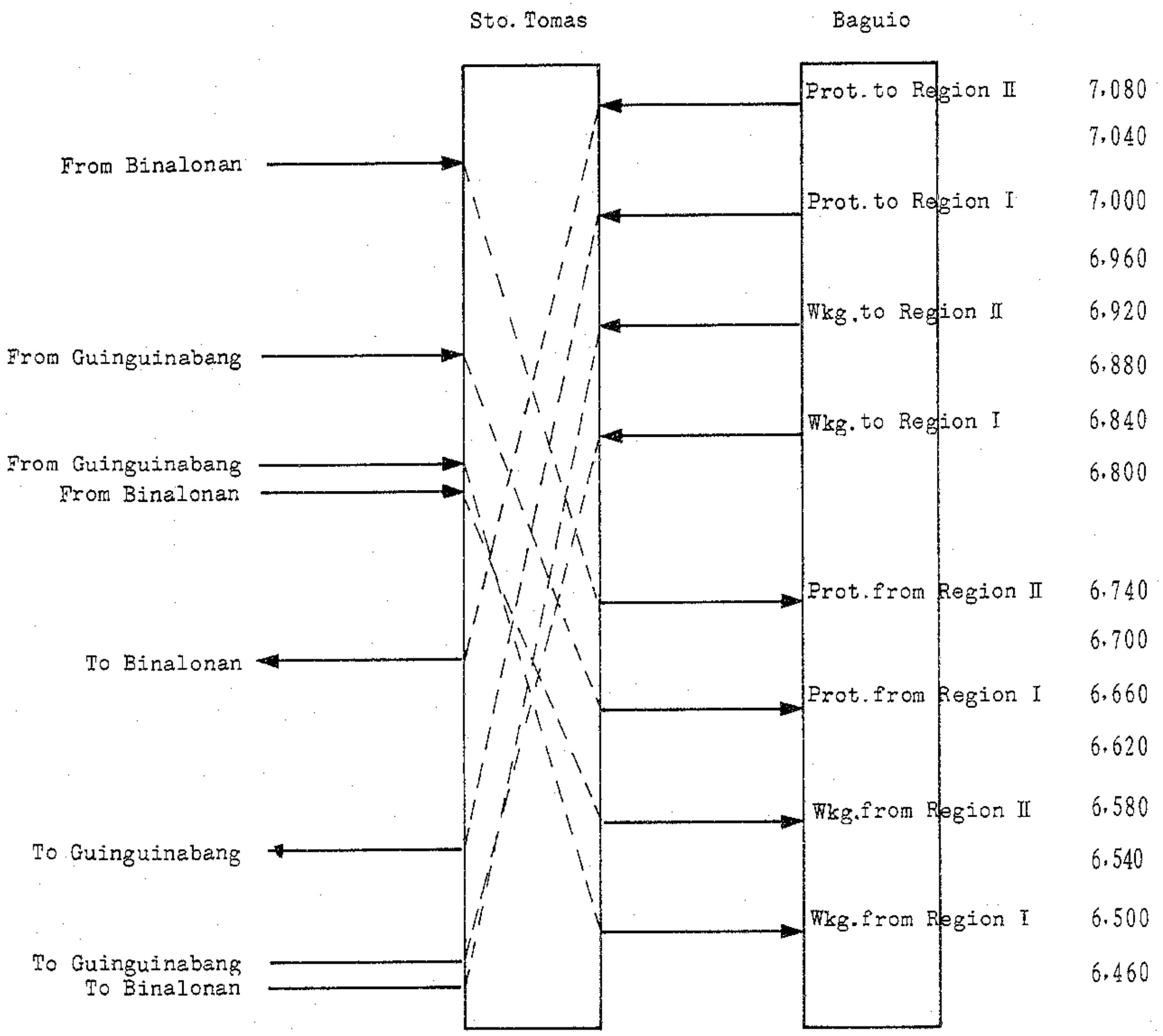


Fig. Ⅷ-2-2-27(b) Frequency relation at Sto. Tomas — Baguio section

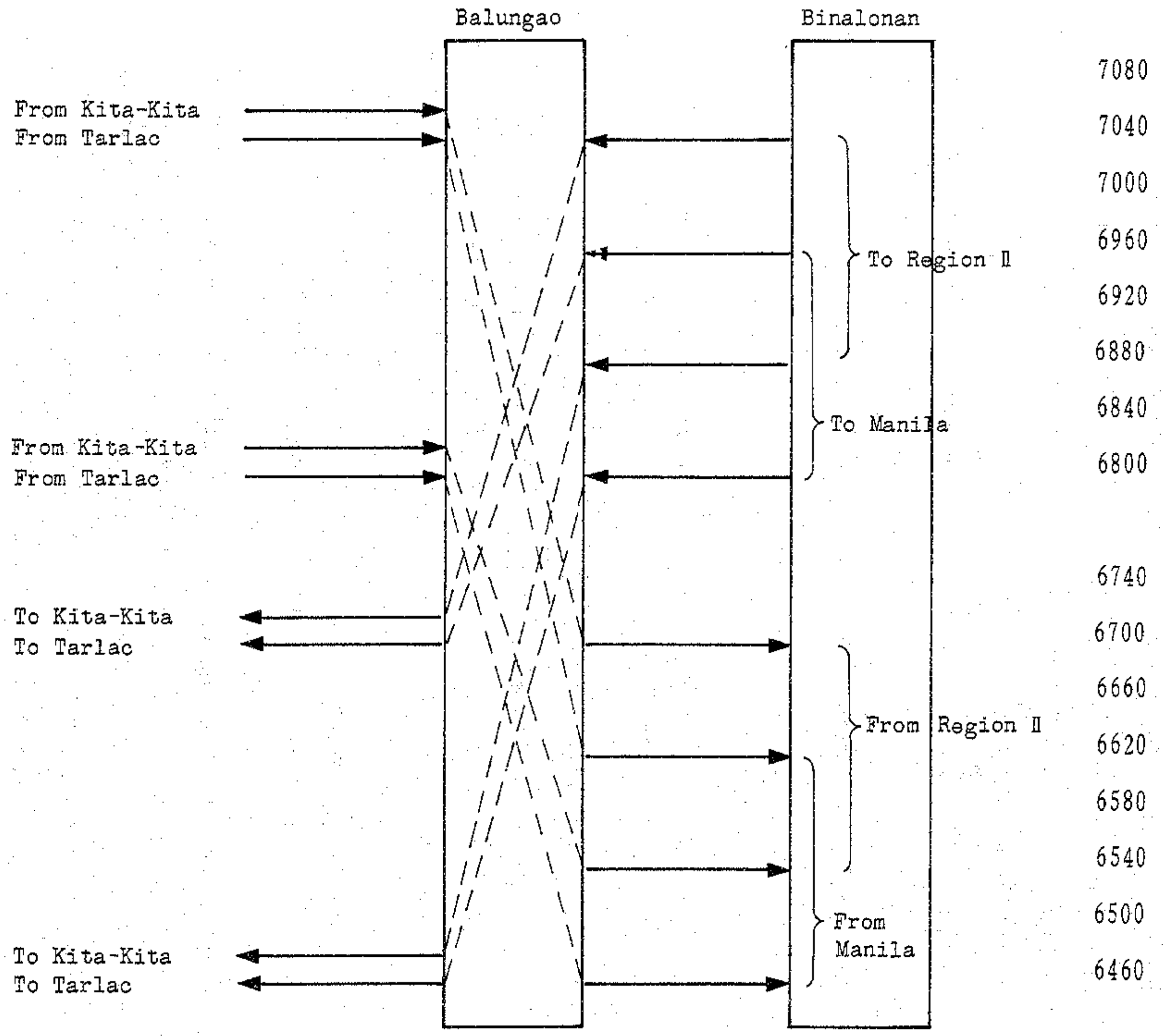


Fig. VIII—2—2—27(c) Frequency relation at Balungas ~ Binalonan section

Accordingly, radio wave from Baguio and that from Guinguinabang may interfere each other. By calculating the interference of the radio wave from Baguio to the antenna for Guinguinabang, we have

Receiving input at Sto. Tomas from Guinguinabang

$= -31.9\text{dBm} - \underbrace{5\text{dB}}_{\text{Differential fading}} = -36.9\text{dBm}$

Amount of leakage of radio wave from Baguio to the the antenna for Guinguinabang

$= -19.2\text{dBm} - \underbrace{55\text{dB}}_{\text{Attenuation due to antenna directivity at 54 degrees.}} = -74.2\text{dB}$

Desired to undesired signal ratio (D/U)

$D/U = -36.9 - (-74.2) = 37.3\text{dB}$

$S/N = D/U + 16 = 53.3\text{dB}$

Suppose the receiving signal level from Baguio is weakened by 12.7 dB (= -19.2dBm - (-31.9dBm) (span equalization), we have

$S/N = 53.3 + 12.7 = 66\text{dB}$ (250pW)

The S/N seems to be somewhat larger than the amount allotted to interference niose stated in item (4), 774pW. For the transmission course to Laoag, the frequency allocation of the Sto. Tomas-Baguio section should be in a "slot" relationship with that of the Laoag-Sto. Tomas section, and the polarization plane of the Laoag-Sto. Tomas section and that of the Sto. Tomas-Baguio section will be directed to be orthogonal to each other.

On the basis of this concept, the frequency allocation of the Sto. Tomas-Baguio section should be followed as Fig.VIII-2-2-27.

The D/U at Sto. Tomas when the frequencies in the "slot" relationship can be given by

$$D/U = (-31.9 - \underbrace{5}_{\text{Differential fading}})\text{dBm} - \{-19.2 - \underbrace{12.7}_{\text{Differential equalization}} - \underbrace{55}_{\text{Antenna directivity}} - \underbrace{10}_{\text{Selectivity for opposite polarity}} - \underbrace{20}_{\text{Receiver selectivity for 20MHz}}\} = 81\text{dB}$$

Thus the amount of noise is as amall as negligible.
There will be caused no particular problem also even if the noise of the transmitter at Baguio station is not reduced by 12.7dB (span equalization) since we have

$$S/N = D/U + 16 = 81 - 12.7 + 16 = 84,3\text{dB} \ (\leq 10\text{pW})$$

Next, the section between Kitakita and Balungao in Dalton Pass will be discussed. For Kitakita, the angle formed by the transmission path in the direction to Dalton Pass and that to Balungao is about 60 degrees, as shown in Fig. VIII-2-2-24.

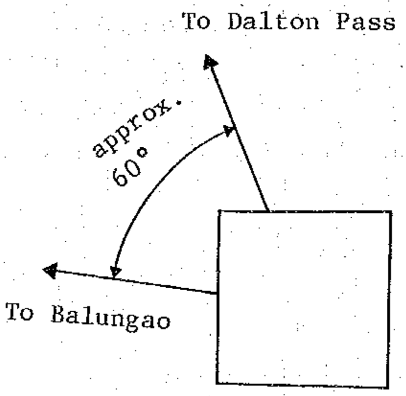


Fig. VIII-2-2-24 Orientation to Two Directions at Kitakita

Since the expected attenuation due to antenna directivity at Kitakita can be as small as about 55dB. The frequencies in the Balungao-Kitakita should be 20 MHz deviated from the Kitakita-Dalton Pass section or the Balungao-Binalonan section.
The frequency allocation thus obtained for all microwave stations in Regions I, II and Baguio-Manila route are shown in Figs. VIII-2-2-24 (b)-Fig. VIII-2-2-26. Fig. VIII-2-2-27 shows the frequency allocation at Baguio-Sto. Tomas section and Balungao-Binalonan section.
The polarization plane of the Binalonan-Sto. Tomas section and that of the Guinguinabang-Sto. Tomas section should not necessarily be orthogonal to each other. They may be on the same plane, since the angle formed by the paths in the directions to Guinguinabang and Binalonan is 160 degrees and the attenuation dut to antenna directivity is sufficient.

FORM-1

PATH PROFILE

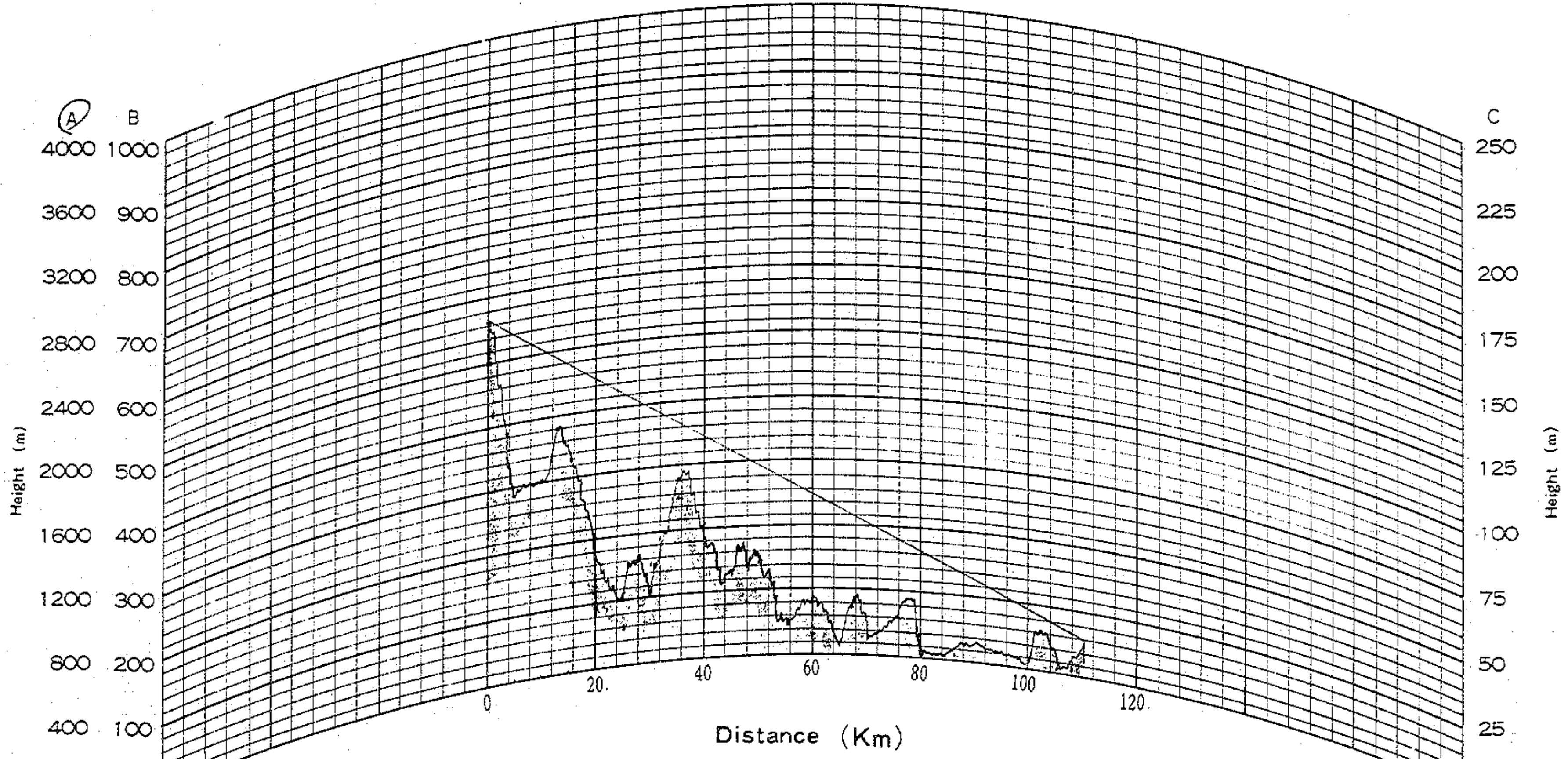
Name of Route :

No. : Fig Ⅷ－2－2－28

Drawer :

Date :

(K=4/3)



Frequency : ________ MHz

Power : ________ W

Full Scale Ⓐ=240Km
B=120Km
C= 60Km

Site : Sto. Tomas -------- Bigbiga

Height : 2,252 m 109 km 200 m

Antenna height : ________ m ________ m

Let us next, discuss interference due to overreach transmission. Since the microwave system will employ the 2-frequency plan, two frequencies will be used alternately as the operating frequencies for the respective sections. Accordingly, the frequency on the going way of the 1st section and that of the 2nd section will differ from each other. (In the case of the higher 6GHz band, these two frequencies will differ 340MHz from each other.) The 3rd section will use the frequency used by the 1st section. That is, the radio wave from the 1st section will interfere the receiver of the 3rd section. The distance between the transmitter of the 1st section and the receiver of the 3rd section will usually be equal to 3 sections or 100 to 150km. At such a long distance as this the receiving point of the 3rd section will not usually fall into the line-of-sight condition from the transmitting point of the 1st section. However, when the transmitting or receiving point is located at an extremely high position when compared with the neighboring mountains, the receiving point in the 3rd section will fall within the line-of-sight range from the transmitting point. In such occasions, overreach interference will be caused. Of course, when the amount of interference is small, there is no problem. In this project, it is in the case of the Sto. Tomas-Bigbiga section that the line-of-sight condition of the 3rd section will be achieved.
The path profile in the case of the Sot. Tomas-Bigbiga section is shown in Fig. VIII-2-2-29.

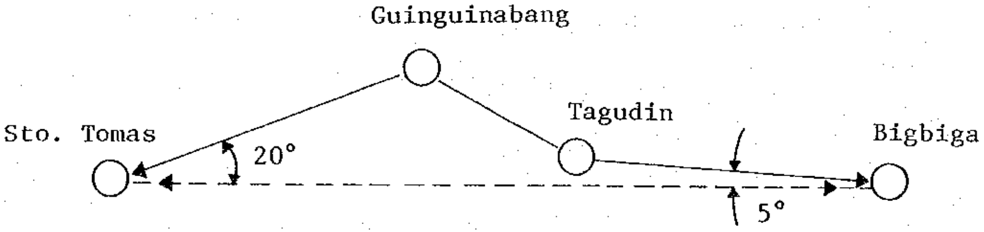


Fig. VIII-2-2-29 Interference Due to Overreach Transmission

In this case, it is necessary to discuss two courses of Interference: interference to the reciever at Bigbiga and interference to the reciever at Sto. Tomas.

As understood from Fig. VIII-2-2-29, an attenuation of abount 20° can be expected as the attenuation due to antenna directivity at Sto. Tomas and an attenuation of about 5° at Bigbiga. These attenuations can be as follows from the data of wide-angle dierctivity of

$$D_{20°} = 40\text{dB}$$

$$D_{5°} = 25\text{dB}$$

The radio wave transmission distance in the Sto. Tomas-Bigbiga section is 109 km. If the overreach distance is supposed to be equal to this value of distance, the ratios of the distances of the Sto. Tomas-Guinguinabang section and the Tagudin-Bigbiga to the overreach distance are respectively as follows.

$$\frac{46}{109} = 0.422 = -7.5\text{dB}$$

Sto. Tomas-Guinguinabang section

$$\frac{44.1}{109} = 0.405 = -7.9\text{dB}$$

Tagudin-Bigbiga section

From all these, interference to the receiver at Sto. Tomas is

$$\underset{\text{(to S.T)}}{S/I} = (D_{20} + D_5 + 7.5) + 16\text{dB}$$

Spectrum improvement factor

$$= 72.5 + 16 = 88.5\text{dB}$$

Likewise, interference to the receiver at Bigbiga is given by

$$\underset{\text{(To B.B)}}{S/I} = (D_{20} + D_5 + 7.9) + 16$$

$$= 88.9\text{dB}$$

These are as small as negligible, and there is no problem. Typical examples of antenna directivity which are used for the discussion of interference are shown in Fig. VIII-2-2-30.

(8) Instantaneous breakdown ratio

In radio transmission the signal is transmitted not only through equipment and cables manufactured by man but such media as free space given by nature. These media are beyond our control and

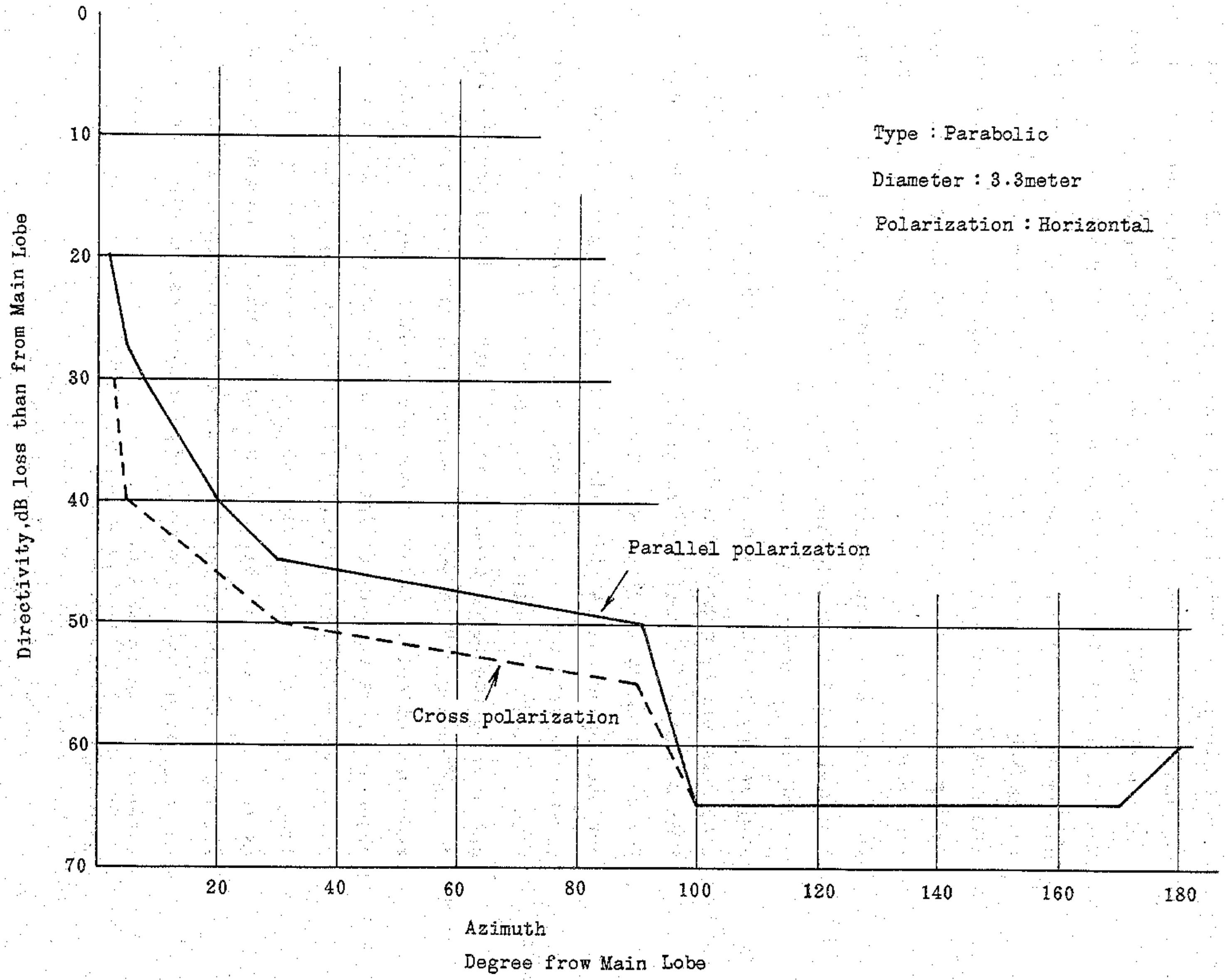


Fig VIII—2—2—27(d) Typical pattern of antenna directivity communication systems using these media cause various characteristics to very. A typical example thus caused is fading. As already mentioned, fading involves variation in receiving input field strength and then couses the signal-to-noise ratio (S/N) due to thermal noise to vary. Since fading occurs entirely on the basis of natural phenomena, the use of statistics for treating it is very helfful. The instantaneous breakdown of a radio system due to fading is such a phenomenon that the receiving field strength greatly drops due to fading, then the S/N degrades to a great extent, on the radio system become no more usable at all. In the case of shallow fading, noise increase is rather small and the radio system remains usable although the S/N has somehow degraded and freedom is reduced to some extent but to no excessive extent.

Now, let us discuss such cases where the radio system is no more usable at all by occourrence of deep dading. Such deep fading that disables the radio system from operting usually lasts only for an extremely short period of time although frequently occurs. For such phenomena as this, the concept of the time ratio of occurrence is very useful. CCIR sets out the following recommendation for abnormal noise, that is, the time ratio that the unweighted noise (measured with 5m sec integrated times) exceeds 10^6pW is less than 0.01% in any one month for a 2500km hypothetical reference circuit. CCITT recommends to make 0.001% the design objective from the standpoint of data transmission. For the microwave system of this project, 0.001% is divided according to length and design objectives are given to respective sections so as to allow check to determine whether actually calculated values for the respective sections fall within objectives. If the objectives are not met, the mean of space diversity, etc., should be taken into consideration.

As design objectives, we have

$$0.001\% \times \frac{L}{2500} = 4L \times 10^{-9}$$

for a section of L km in length.

Design objectives for respective sections are then as follows.

Laoag-Vigan section (74.6km):

$$4L \times 10^{-9} = 4 \times 74.6 \times 10^{-9} = 2.98 \times 10^{-7}$$

Vigan-Baguio section (155.3km):

$$4L \times 10^{-9} = 4 \times 155.3 \times 10^{-9} = 6.21 \times 10^{-7}$$

Tuguegarao-Ilagan (56.4km)

$$4L \times 10^{-9} = 4 \times 56.4 \times 10^{-9} = 2.26 \times 10^{-7}$$

Ilagan-Bayombong (107.3km)

$$4L \times 10^{-9} = 4 \times 107.3 \times 10^{-9} = 4.29 \times 10^{-7}$$

Bayombong-Binalonan (145,9km)

$$4L \times 10^{-9} = 4 \times 145.9 \times 10^{-9} = 5.84 \times 10^{-7}$$

Binalonan-Baguio (42km)

$$4L \times 10^{-9} = 4 \times 42 \times 10^{-9} = 1.68 \times 10^{-7}$$

Binalonan-Manila (103.2km)

$$4L \times 10^{-9} = 4 \times 103.2 \times 10^{-9} = 7.33 \times 10^{-7}$$

Now, let us consider the probability of the occurrence of fading in each radio section. According to experimental and empirical data, the probability of the occurrence in a radio section is given by

$$p = (\frac{f}{4})^{1.2} \times Q \times \ell^{3.5}$$

where

f: frequency [GHz]

Q: constant determined by the transmission path

- o Transmission over plains: $Q = 5.1 \times 10^{-9}$
- o Transmission over mountains: $Q = 2.1 \times 10^{-9}$
- o Transmission over seas: $Q = 3.7 \times 10^{-7} \frac{1}{h}$

$$h = \frac{h_1 + h_2}{2}$$

h_1 and h_2: heights of transmitting and receiving antennas above the sea [m]

Let us first calculate the probability of occurrence of fading in

each radio section so as to obtain P and then consider what type of pattern the receiving input field distribution will form. Numbers of measurements tell that the thermal noise power distribution due to receiving input field strength degradation in deep fading forms Peason 5 type distribution pattern.
The probability density function of Peason 5 type is the density function which is the reciprocal of distribution and is

$$f(N) = \frac{\gamma\lambda}{\Gamma(\lambda)} N^{-(\lambda + 1)} \exp(-\frac{\lambda}{N})$$

The mean value and distribution are given by

$$m = \frac{\gamma}{\lambda - 1}$$

$$\sigma^2 = \frac{\gamma^2}{(\lambda - 1)^2 (\lambda - 2)}$$

where λ is given by the extent of fading and $\lambda \geqq 1$. When $\lambda = 1$, the fading is the heaviest. Let us now find $\int_N^\infty f(N)dN$ by putting $\gamma = No$ and $\lambda = 1$, which corresponds to the probability of exceeding a ceratin noise power when the mean noise power is No, P(N), and which can easily be intergrated as follows.

$$\int_N^\infty f(N)dN \underset{\substack{\lambda = 1 \\ \gamma = No}}{=} P(N) = 1 - \exp(-\frac{No}{N})$$

When N is extremely large and No/N is considerable small,

$$P(N) = No/N$$

It is necessary to obtain P(N) for each section when $N = 10^6$pW. The product of p and P(N), that is, $p^{P(N)}$, is the time rate for forming 10^6pW per year. The probability that the noise exceeds as large noise as 10^6pW is usually extremely small and the probability that the total noise in multi-section repeatering exceeds 10^6pW can be made equal to the sum of the probabilities for respective section. Table VIII-2-2-9 gives calculated $p^{P(N)}$ values for the respective microwave section.
In calculating P(N), the noise 4dB lower than the noise in each section which has been obtained as per Table VIII-2-2-5 is made No. This is based on the idea that when as deep fading as caus-

ing 10^6pW in noise occurs, the mean noise also lowers about 4dB below normal.

For the instantaneous breakdown ratios for the respective sections which are given in Table VIII-2-2-9, a noise switching system is the case of a radio system configuration of finally 3+1, the ratio improved by the adoption of the noise switching method out of the instantaneous breakdown ratio due to fading is made 1/10.

Under the condition that the simultaneous probability density functions of the receiving input voltages of two radio waves respectively form Rayleigh distribution (reciprocal of Peason 5 type distribution), we generally have

$$p(R_1\ ,\ R_2) = \frac{4R_1R_2}{1-k^2}\exp\ (\frac{-R_1^2 + R_2^2}{1-k^2})\ \mathrm{Io}\ (\frac{2\ k^2R_1R_2}{1-k^2})$$

where k^2: Correlative coefficient between R_1^2 and R_2^2

$\mathrm{Io}(x)$: Oth-order modified Bessel function

$$k^2 = \exp(\frac{-4\ \ ^2\Delta p^2}{C^2})\Delta f^2$$

Δp^2: distribution of radio wave light path length variation

C : Light velocity (= 3×10^8 m/sec)

Δf : frequency difference between two frequencies

Δp^2 can roughly be given by

$$\Delta p^2\ \ [\mathrm{cm}] = 0.25 \times d\ [\mathrm{km}]$$

where d: transmission distance

The probability that the receiving input voltage of both working and protection channels become lower than voltage L, $P(R_1, R_2 < L)$, is given by

$$P(R_1, R_2 < L) = \int_0^L \int_0^L p(R_1, R_2)dR_1dR_2$$

Since, usually, $L/\sqrt{1-k^2} \ll 1$, we can approximate as follows.

$$\exp(x) \simeq 1$$

$$\mathrm{Io}(x) \simeq 1$$

Table VIII-2-2-8 S/N Estimation in TV Signal Transmission

o	Radio Section	S/N in dB	S/N in pW
Region I	Laoag - Sinait	78.0	15.8
	Sinait - Vigan	78.7	13.5
	Vigan - Bigbiga	80.5	8.9
	Bigbiga - Tagudin	77.1	19.5
	Tagudin - Guinguinabang	82.0	6.3
	Guinguinabang - Sto. Tomas	76.7	21.4
	Sto. Tomas - Baguio	89.4	1.1
	Total	70.6	86.5
Region II	Tuguegarao - Ilagan	74.9	32.4
	Ilagan - San Mateo	77.7	17.0
	San Mateo - Diadi	77.8	17.0
	Diadi - Bayombong	81.6	6.9
	Bayombong - Dalton pass	76.9	20.4
	Dalton pass - Kitakita	78.2	15.1
	Kitakita - Balungao	78.2	15.1
	Balungao - Binalonan	82.5	5.6
	Binalonan - Sto. Tomas	80.0	10.0
	Sto. Tomas - Baguio	89.4	1.1
	Total	68.5	140.2
To Manila	Binalonan - Balungao	82.5	5.6
	Balungao - Tarlac	77.3	18.6
	Tarlac - Dau	78.5	17.8
	Dau - Pandi	77.0	20.0
	Pandi - Manila	77.0	10.7
	Total	71.4	72.7

Table VIII-2-2-9 Probability Exceeding 10^6pW in Each Section

Microwave Section	p	P(N) (=No/N)	$pP(N)$
Laoag - Sinait	3.24×10^{-5}	7.08×10^{-5}	2.29×10^{-7}
Sinait - Vigan	2.80×10^{-3}	6.03×10^{-5}	1.69×10^{-7}
Vigan - Bigbiga	9.30×10^{-3}	2.97×10^{-5}	3.69×10^{-7}
Bigbiga - Tagudin	5.46×10^{-3}	7.81×10^{-5}	4.26×10^{-7}
Tagudin - Guinguinabang	7.49×10^{-4}	2.81×10^{-5}	2.10×10^{-8}
Guinguinabang - Sto. Tomas	2.60×10^{-3}	9.52×10^{-5}	2.48×10^{-7}
Sto. Tomas - Baguio	1.53×10^{-6}	0.53×10^{-5}	8.11×10^{-12}
Ilagan - Tuguegarao	1.29×10^{-2}	14.44×10^{-5}	1.86×10^{-6}
Ilagan - San Mateo	4.16×10^{-3}	7.59×10^{-5}	3.16×10^{-7}
San Mateo - Diadi	3.98×10^{-3}	7.41×10^{-5}	2.95×10^{-7}
Diadi - Bayombong	8.83×10^{-4}	3.09×10^{-5}	2.73×10^{-8}
Bayombong - Dalton Pass	2.36×10^{-3}	9.09×10^{-5}	2.15×10^{-7}
Dalton Pass - Kitakita	1.41×10^{-3}	6.73×10^{-5}	9.49×10^{-7}
Kitakita - Balungao	3.52×10^{-4}	6.73×10^{-5}	2.37×10^{-8}
Balungao - Binalonan	6.21×10^{-4}	2.51×10^{-5}	1.56×10^{-8}
Binalonan - Sto. Tomas	1.66×10^{-3}	4.47×10^{-5}	7.42×10^{-8}
Balungao - Tarlac	5.21×10^{-3}	8.51×10^{-5}	4.43×10^{-7}
Tarlac - Dau	3.24×10^{-3}	6.45×10^{-5}	2.09×10^{-7}
Dau - Pandi	5.86×10^{-3}	9.11×10^{-5}	5.34×10^{-7}
Pandi - Manila	1.98×10^{-3}	4.89×10^{-5}	9.68×10^{-8}

No: 4dB deterioration below normal

Then,

$$p(R1,\ R2 < L) \simeq \int_o^L \int_o^L \frac{4R_1R_2}{1-k^2}\, dR1\ dR2$$

$$= \frac{L^4}{1-k^2}$$

On the other hand, the probability that the receiving input voltage becomes lower than voltage L, $P(R_1 < L)$ is

$$P(R1 < L) = 1 - e^{-L^2}$$

$$\simeq L^2 \qquad (L \ll 1)$$

Accordingly, the probability that the receiving input levels of both working and protection channels become lower thatn switching level L simultaneously and that causes unavailability of switching, γ, is given by

$$\gamma = \frac{P(R_1,\ R_2 < L)}{P(R_1 < L)} \simeq \frac{L^2}{1-k^2}$$

When the switching level becomes 40dB lower than the normal input level,

$$L^2 = 10^{-4}$$

$$k = 0.9965$$

where $\Delta f = 80\text{MHz}$

$d = 50\text{km}$

Then, we obtain

$$\gamma = 0.02876$$

Hence, the ratio of improvement by adoption of the noise switching method is about 1/35.

In the ultimate system is of 3 + 1 configuration, we have, since the ratio of improvement is considered to degrade by about 1/2,

$$1/35 \times 2 \doteqdot 1/17$$

In consideration of a margine, we have 1/10 as the ration of improvement.

Table VIII-2-2-10 gives instantaneous breakdown ratio of the respective switching sections in consideration of improvement by the adoption of the noise switching effect. As understood from the table, the instantaneous breakdown ratios of all switching sections meet the CCITT's objective of 0.001%/2500km, which indicates that the route shown in Fig. VIII-2-2-1 is a suitable one select through route selection.

(7) Transmission of color TV signal

We have so far discussed the microwave system from the standpoint of transmitting super-multiplex telephone signal.
However, this project is expected, although in a form of preliminary operation, to transmit color TV signal as well. In this sense, discussion is necessary from the standpoint of color TV signal transmission. Recommendations are given for various characteristics in TV signal transmission by CCITT's CMTT and this project will be in conformity to these recommendations . When these CMTT recommendations are met and CCIR recommendations for 6GHz, 960-channel telephone systems are met, the recommendations for TV signal transmission are also met. In other words, all that is required is the examination of super multiplexed telephone signals. However, let us hereunder examine the microwave route to be established by this project from the standpoint of TV signal transmission for reference's sake.

(7)-1 Signal-to-random noise ratio

The signal-to-random noise ratio is a ratio of the TV video signal to thermal noise caused mainly in the first RF stage in a microwave receiver. In treating S/N of TV signal, noise is usually divided into various types. That is, these types of noise comprise random noise such as thermal noise, ham noise caused by ripples from power supply, and impulsive noise. CMTT gives recommendation to all these types of noise separately. Periodical and impulsive noises may occur from various equipments composing the transmission system, whereas random noise is greatly subject to the receiving input of the microwave receiver. Accordingly, random noise is discussed hereunder from the standpoint of transmission design. Other items should be thoroughly discussed upon preparing equipment specifications.

For calculation, we have

$$S/N = \log \frac{Pr}{KTF} \frac{3Sp^2}{fm^3}$$

where

Pr: receiving input power

Sp: Peak-to-peak frequency deviation of video signal (excluding frequency deviation of sync pulse portion)

fm: maximum modulation frequency

Other parameters: same as the equation of S/N in item (4)

Table VIII-2-2-8 gives S/N values for Pr of the respective radio sections under the condition that the specifications of the transmitter and receiver are the same as used for calculation in item (4) and CMTT Recommendation of 5.6MHzp-p is employed as Sp and fm = 4MHz. Table VIII-2-2-7 gives noises obtained by adding noise caused in demodulator, noise increased by the use of deemphasis circuit, and noise reduced by the use of weighting circuit for TV use to the noises given in Table VIII-2-2-9 for the Laoag-Baguio, Tuguegarao-Baguio and Binalonan-Manila sections. For the weighted values to be obtained by the use of deemphasis and weighting circuits, values given in CCIR Rep. 637 used.

For standard values in the respective sections, 52dB/2500km given in the CCIR Recommendation is allotted by section length. As is clear from Table VIII-2-2-8, S/N due to random noise in the transmission route is met from the standpoint of color TV signal transmission. Some other important characteristics which determine the availability/unavailability of color TV signal transmission are differential gain (DG), differential phase (DP), and other waveform transmission characteristics CMTT recommends differential gain and differential phase to be respectively 10% and 5° per 2500km.

Differntial gain depends mainly on the amplitude characteristic of the microwave repeater equipment and that of the low-frequency circuitry, whereas differential phase depends mainly on the phase characteristic of the microwave repeater equipment. For waveform transmission characteristics, CMTT recommends standard for various types of waveforms. Waveform transmission characteristics depends

Table VIII-2-2-9' Overall S/N in Each Video Section

(TV Signal Transmission)

Video Section of Microwave Link	S/N Due To Thermal Noise [pW]	Demodulator Noise [pW]	Summation of the Left Two Items [dB]	Deterioration Due To De-emphasis cct. [dB]	Improvement Due To Weighting cct. [dB]	Margin of Simultaneous Fading [dB]	Overall S/N in the Section [dB]	Stipulated Value [dB]
Laoag - Baguio	86.5	40	68.9	2.1	3.1	4	65.9	62.4
Tuguegarao - Baguio	140.2	80	66.6	2.1	3.1	4	63.6	60.5
Binalonan - Manila	72.7	20	70.3	2.1	3.1	4	67.3	63.4

mainly on the amplitude and phase characteristics of low-frequency amplifier.

To summarize, the differential gain, differential phase, and various waveform characteristics of the transmission system are mostly determined by the characteristics of the equipments in use, so that it is important to strictly prescribe specifications for various characteristics in slosely related with color TV signal transmission performance as in the case of the distortion and interface of multiplex telephone signals.

2-2-2 Spur Routes

(1) Route selection

The main transmission route brought about to primary centers by means of microwave should be connected to end offices furnished with local switches via toll switches. Transmission lined (spur routes) used to interconnect primary centers and end offices are available in two types, that is, by radio and by toll cable.

In consideration of installation cost, maintenance cost, the demanded number of telephone lines, etc., these spur routes have been determined as follows on the basis of the following basic principles.

That is, radio is to be used in any of the following cases.

a) When the section exceeds 15km in radio transmission distance

b) When the transmission route crosses a large river without bridge or a deep valley

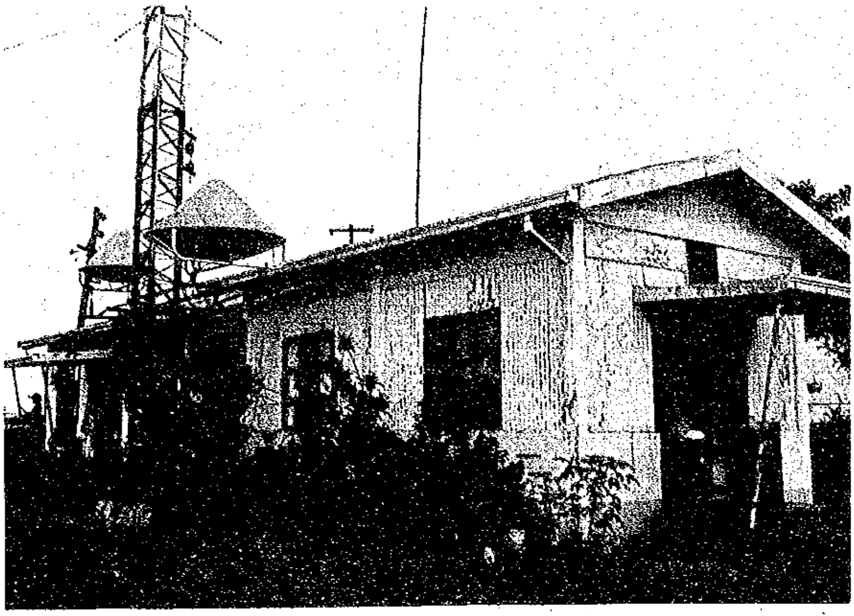
c) When the transmission route is apart from any adjacent road and maintenance will become difficult if cable line is adopted.

However, it is to be noted that the use of radio will not be achievable in case no spare is available in radio frequency.

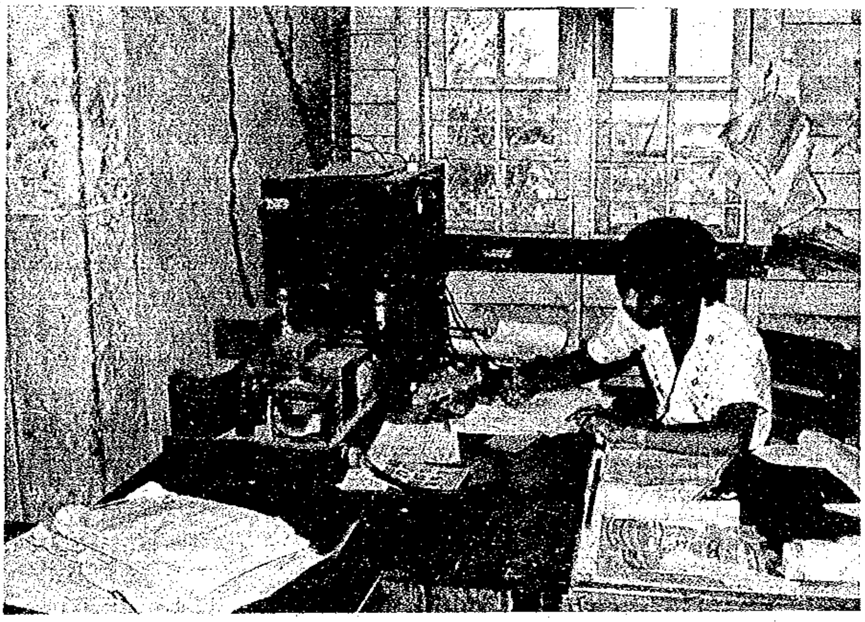
For this, see (5) "Frequency Allocation and Interference Noise."

The results of route selection for spur routes or radio transmission courses between offices ranking lower than primary centers by using radio are shown in Figs. VIII-2-2-31 and VIII-2-2-32.

The profiles of these spur routes are shown in Figs.VIII-2-2-33 - VIII-2-2-104. Since the number of profiles of these spur routes is considerably large, an index is provided for these profiles as table VIII-2-2-10(a) - Table VIII-2-2-10(c). The operating frequency bands of these routes are, in principle, as follows: 150MHz band for sections with a maximum channel capacity of 3 - 6 channels, 400MHz band for sections with a maximum channel capacity of 24 channel,



Dau Microwave Repeater Station near Manila



Lubuagan Radio Telegram Office Equipments
show HF transmitter and receiver

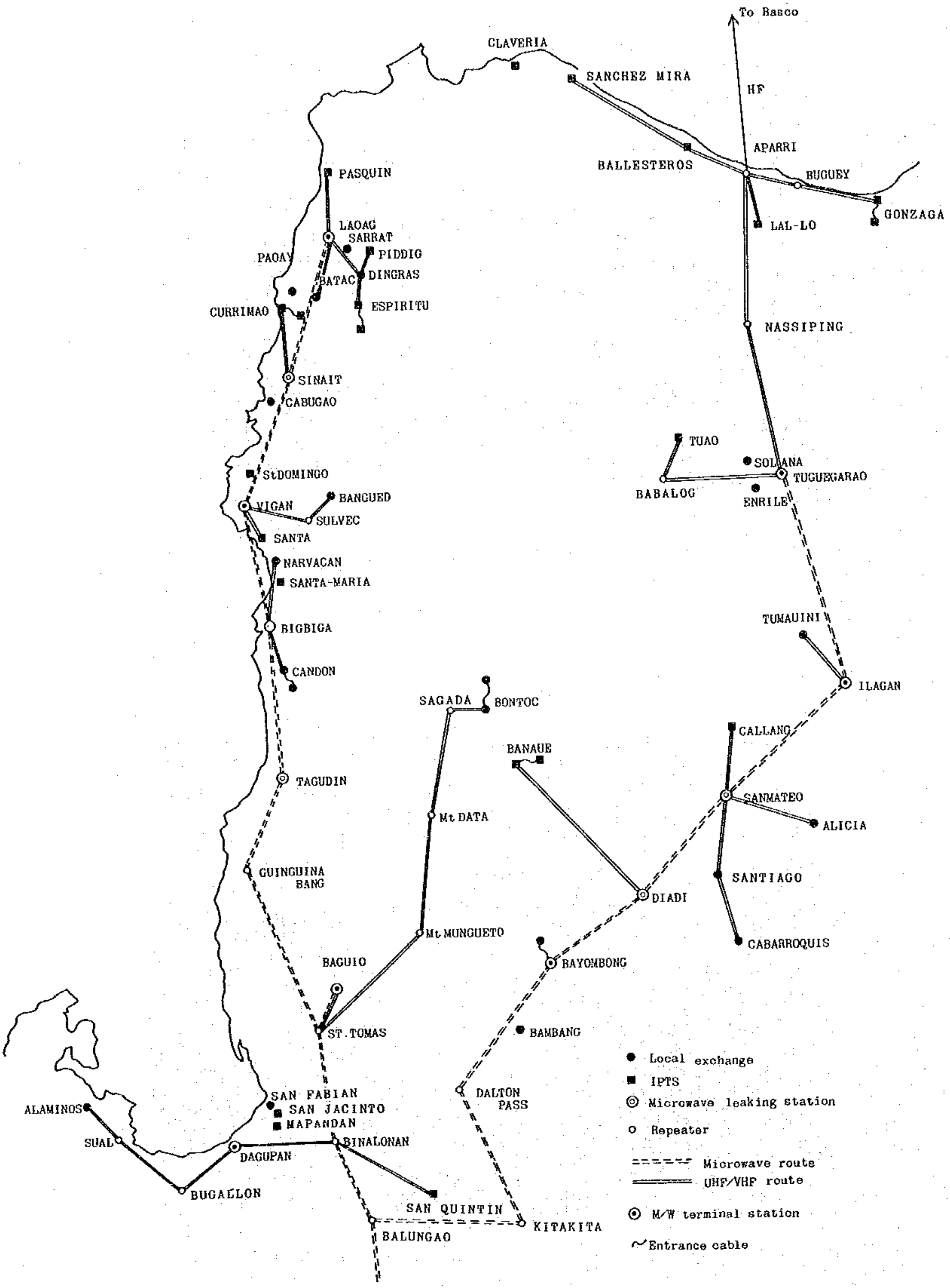


Fig. Ⅷ-2-2-31 Spur routes map in phase I

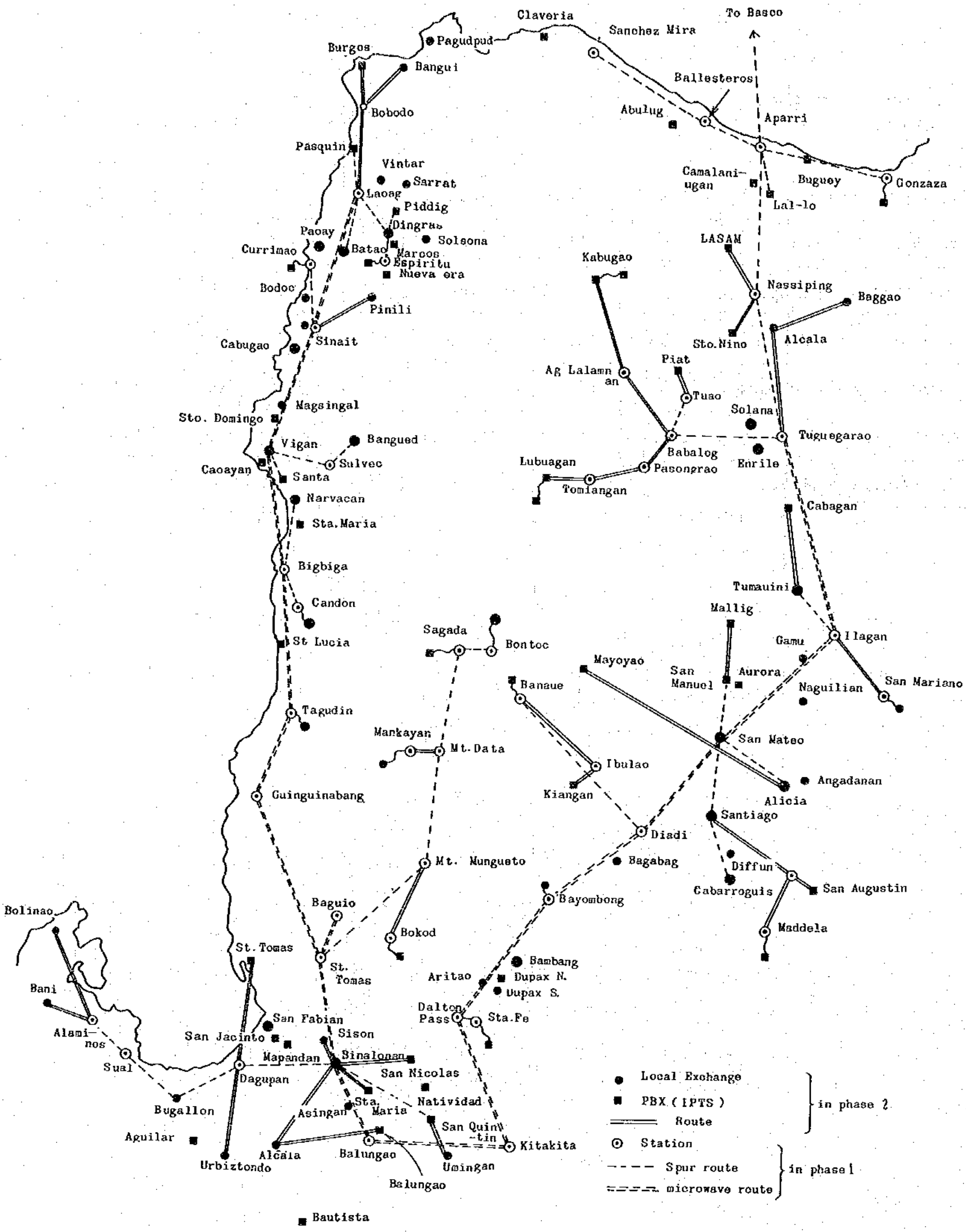


Fig. Ⅷ-2-2-32 Spur routes map in phase 1 and 2

Table VIII-2-2-10 Noise Burst Ratio Exceeding 10^6pW

Microwave Switching Section	No. of Radio Sections	Length [km]	Noise Burst Ratio Exceeding 10^6pW	Including Improvement of Noise Switching Effect	Stipulated Value
Laoag - Vigan	2	74.6	3.98×10^{-7}	3.98×10^{-8}	2.98×10^{-7}
Vigan - Baguio	5	155.3	1.06×10^{-6}	1.06×10^{-7}	6.21×10^{-7}
Tuguegarao - Ilagan	1	56.4	1.86×10^{-6}	1.86×10^{-7}	2.25×10^{-7}
Ilagan - Bayombong	3	107,3	6.38×10^{-7}	6.38×10^{-8}	4.29×10^{-7}
Bayombong - Binalonan	4	145.9	1.23×10^{-6}	1.23×10^{-7}	5.84×10^{-7}
Binalonan - Baguio	2	42.0	7.42×10^{-8}	7.42×10^{-9}	1.68×10^{-7}
Binalonan - Manila	5	183,2	1.30×10^{-6}	1.30×10^{-7}	7.33×10^{-7}

Table VIII-2-2-10(a) List of spur route sections

Radio sections	Fig. numbers
Pasgguin - Laoag	VIII-2-2-33
Dingras - Laoag	VIII-2-2-34
Piddig - Dingras	VIII-2-2-35
Espiritu - Dingras	VIII-2-2-36
Batac - Laoag	VIII-2-2-37
Currimao - Sinait	VIII-2-2-38
Pinili - Sinait	VIII-2-2-39
Bobodo - Laoag	VIII-2-2-40
Burgos - Bobodo	VIII-2-2-41
Bangui - Bobodo	VIII-2-2-42
Sulvec - Vigan	VIII-2-2-43
Bangued - Sulvec	VIII-2-2-44
Santa - Vigan	VIII-2-2-45
Candon - Bigbiga	VIII-2-2-46
Narvacan - Bigbiga	VIII-2-2-47
Mt. Mungueto - Sto. Tomas	VIII-2-2-48
Mt. Data - Mt. Mungueto	VIII-2-2-49
Sagada - Mt. Data	VIII-2-2-50
Bontoc - Sagada	VIII-2-2-51
Mankayan - Mt. Data	VIII-2-2-52
Mt. Mungueto - Bokod	VIII-2-2-53
Dagupan - Bugallon	VIII-2-2-54

Table 2-2-10(b)

Radio sections	Fig. numbers
Sual - Bugallon	VⅢ-2-2-55
Alaminos - Sual	VⅢ-2-2-56
Dagupan - Binalonan	VⅢ-2-2-57
San Quintin - Binalonan	VⅢ-2-2-58
Bolinao - Alaminos	VⅢ-2-2-59
Bani - Alaminos	VⅢ-2-2-60
Sto. Tomas - Dagupan	VⅢ-2-2-61
Urbiztondo - Dagupan	VⅢ-2-2-62
Umingan - San Quintin	VⅢ-2-2-63
San Nicolas - Binalonan	VⅢ-2-2-64
Sison - Binalonan	VⅢ-2-2-65
Sta. Maria - Binalonan	VⅢ-2-2-66
Alcala - Binalonan	VⅢ-2-2-67
Balungao - Alcala	VⅢ-2-2-68
Basco - Calayan	VⅢ-2-2-69
Calayan - Sanchez Mira	VⅢ-2-2-70
Sanchez Mira - Ballesteros	VⅢ-2-2-71
Ballesteros - Aparri	VⅢ-2-2-72
Buguey - Aparri	VⅢ-2-2-73
Gonzaga - Buguey	VⅢ-2-2-74
Lal-lo - Aparri	VⅢ-2-2-75
Aparri - Nassiping	VⅢ-2-2-76
Lazam - Nassiping	VⅢ-2-2-77
Sto. Nino - Nassiping	VⅢ-2-2-78
Nassiping - Tuguegarao	VⅢ-2-2-79
Baggao - Acala	VⅢ-2-2-80
Acala - Tuguegarao	VⅢ-2-2-81
Babalog - Tuguegarao	VⅢ-2-2-82
Tuao - Babalog	VⅢ-2-2-83

Table 2-2-10(c)

Radio sections	Fig. numbers
Piat - Tuao	VIII-2-2-84
Ag Lalamnan - Babalog	VIII-2-2-85
Kabugao - Ag Lalamnan	VIII-2-2-86
Pasonglao - Babalog	VIII-2-2-87
Tomiangan - Pasonglao	VIII-2-2-88
Lubuagan - Tominangan	VIII-2-2-89
Cabagan - Tumauini	VIII-2-2-90
Tumauini - Ilagan	VIII-2-2-91
San Mariano - Ilagan	VIII-2-2-92
Callang - San Mateo	VIII-2-2-93
Alicia - San Mateo	VIII-2-2-94
Mallig - Callang	VIII-2-2-95
Santiago - San Mateo	VIII-2-2-96
Jones - Santiago	VIII-2-2-97
San Augustin - Jones	VIII-2-2-98
Maddela - Jones	VIII-2-2-99
Cabarroguis - Santiago	VIII-2-2-100
Banaue - Diadi	VIII-2-2-101
Kiangan - Ibulao	VIII-2-2-102
Ibulao - Banaue	VIII-2-2-103
Mayoyao - Alicia	VIII-2-2-104
Sta. Fe - Dalton Pass	VIII-2-2-105

Table VIII-2-2-27 Site location of spur route stations

Spur route station	Longitude (E)	Latetude (N)	Eleva-tion (m)	Antenna height (m)	Course distance (km)
Pasquin	120°37'01"	18°20'08"	5	20	13.7 from LAG
Dingras	120°41'53"	18°06'24"	10	30,30,30	15.9 "
Batac	120°33'57"	18°03'35"	30	30	17.4 "
Currimao	120°28'56"	18°01'28"	30	15	14.6 from Sinait
Pinili	120°31'45"	17°57'23"	40	15	9.3 "
Bobodo	120°37'23"	18°25'40"	380	10,60,10	23.9 from Laoag
Burgos	120°38'34"	18°30'56"	60	60	9.9 "
Bangui	120°45'41"	18°32'31"	5	40	18.9 from Bobodo
Piddig	120°42'53"	18°10°05"	60	15	7.0 from Dingras
Espiritu	120°39'06"	17°58'59"	90	30	14.5 "
Sulvec	120°33'16"	17°32'22"	160	10, 20	17.8 from Vigan
Bangued	120°37'13"	17°35'43"	100	20	9.3 from Sulvec
Santa	120°26'02"	17°29'21"	5	15	10.4 From Vigan
Bigbiga	120°26'59"	17°18'51"	200	20,10,(15)	
Candon	120°26'32"	17°11'46"	5	70	13.2 from Bigbiga
Narvacan	120°28'36"	17°25'14"	5	20	12.0 from Bigbiga
Mt. Mungueto	120°47'06"	16°39'22"	2710	20,20,20	42.8 from Sto. Tomas
Mt. Data	120°51'06"	16°51'22"	2340	30,30,40	23.5 from Mt. Mungueto
Bokod	120°49'16"	16°29'34"	1400	20	18.9 "
Mankayan	120°46'51"	16°51'58"	1280	40	8.2 from Mt. Data
Sagada	120°53'57"	17°05'18"	1640	20, 50	26.1 "
Bontoc RS	120°58'04"	17°05'38"	1240	40	7.4 from Sagada
Dagupan	120°19'57"	16°02'44"	10	30,20,40, 45	27.1 from Binalonan

Table VIII-2-2-28 Site location of spur route stations

Spur route station	Longitude (E)	Latitude (N)	Elevation (m)	Antenna height (m)	Course distance (km)
Bugallon	120°13'07"	15°57'19"	5	30, 50	15.7 from Dagupan
Sual	120°04'57"	16°03'33"	260	20,20	18.8 from Bugallon
Alaminos	119°58'52"	16°09'43"	10	20,60,40	15.7 from Sual
Bolinao	119°53'50"	16°22'53"	30	35	25.9 from Alaminos
Bani	119°51'32"	16°11'15"	10	30	13.4 "
Sto. Tomas	120°22'41"	16°16'53"	5	20	26.6 from Dagupan
Urbiztondo	120°19'39"	15°49'31"	5	40	18.3 "
Binalonan	120°35'14"	16°03'15"	35	50,40,50 45,(20),45	
San Quintin	120°48'43"	15°59'08"	102	20	25.1 from Binalonan
Umingan	120°50'14"	15°55'47"	103	20	6.8 "
Sison	120°30'35"	16°10'28"	90	20	15.6 "
San Nicolas	120°45'37"	16°04'22"	75	20	18.6 "
Sta. Maria	120°42'03"	15°58'50"	43	20	29.4 "
Alcala	120°31'11"	15°50'51"	19	40,20	24.1 "
Balungao	120°40'15"	15°53'58"	40	20	17.1 from Alcala
Tuguegarao	121°42'29"	17°36'56"	20	30,20,60 (110)	
Nassiping	121°34'04"	17°59'05"	158	20,10,10 10	41.7 from Tuguegarao
Aparri	121°38'51"	18°20'43"	4	20,20,40	39.9 from Nassiping
Sto. Nino	121°34'04"	17°53'08"	20	20	12.6 "
Lazan	121°35'59"	18°04'00"	15	30	9.6 "
Lal-lo	121°39'46"	18°12'09"	5	30	15.9 from Aparri
Ballesteros	121°30'45"	18°24'35"	6	60,20	15.9 "
Gonzaga	121°59'38"	18°15'39"	5	20	17.7 from Buguey
Sanchez Mira	121°13'58"	18°33'37"	5	25,60	34.5 from Ballesteros
Basco	121°59'51"	20°27'08"	227	30	238.0 from Aparri
Alcala	121°39'25"	17°54'32"	59	20,20	32.8 from Tugaegarao
Baggao	121°46'01"	17°55'40"	70	20	11.9 from Alcara
Babalog	121°38'02"	17°28'55"	390	20,40,10 20	22.4 from Tuguegarao
Tuao	121°27'21"	17°44'19"	40	20,20	30.2 from Babalog
Piat	121°28'39"	17°44'19"	50	20	6.6 from Tuao
Kabugao	121°11'04"	18°01'31"	120	20	15.9 from Ag Lalamnan

Spur route station	Longitude (E)	Latitude (N)	Elevation (m)	Antenna height (m)	Course distance (km)
Lubuagan	121°10'23"	17°20'51"	900	20	10.2 from Tomiangan
Ag-Lalamnan	121°13'57"	17°50'28"	458	40,20	56.6 from Babalog
Tomiangan	121°14'36"	17°24'28"	400	20,20	18.2 from Pasonglao
Pasonglao	121°24'56"	17°23'47"	300	10,20	17.0 from Babalog
Ilagan	121°52'29"	17°08'oo"	80	30,50 (70),55	
Tumauini	121°48'19"	17°16'41"	32 32	20,20	17.6 from Ilagan
Cabagan	121°45'49"	17°25'39"	20	20	17.0 from Tumauini
San Mateo	121°35'32"	16°52'47"	77	35,30,45 25,(30)	
San Manuel	121°38'05"	17°01'35"	62	30,20	16.9 from San Mateo
Mallig	121°36'12"	17°18'58"	109	20	32.2 from San Manuel
Alcia	121°41'52"	16°46'38"	65	30,20	15.6 from San Mateo
Santiago	121°32'56"	16°41'26"	80	35,20,50	21.3 from San Mateo
Jones	121°42'02"	16°33'34"	90	50,40,20	21.8 from Santiago
San Augustin	121°44'41"	16°30'52"	100	20	6.9 from Jones
Maddela	121°41'07"	16°20'28"	150	70	24.0 from Jones
Cabarroguis			110	50	19.3 from Santiago
San Mariano			100	20	22.0 from Ilagan
Banaue	121°02'51"	16°54'32"	1500	20,20	42.6 from Diadi
Sta.Fe	120°56'07"	16°09'37"	580	20	3.3 from Dalton P.
Kiangan	121°05'01"	16°46'42"	780	20	3.8 from Ibulao
Mayoyao	121°12'48"	16°58'25"	1120	20	55.8 from Alicia
Ibulao	121°07'21"	16°54'28"	600	30,25	15.9 from Banaue
Buguey	121°49'28"	18°16'58"	5	20	
Laoag	120°35'51"	18°12'48"	50	(95),55,90 30,15	
Sinait (M/W)	120°28'17"	17°53'34"	65	(50),20,45	
Vigan	120°23'18"	17°24'25"	8	(60),60,20	
Baguio	120°36'33"	16°25'05"	1460	(20),20	
Sto. Tomas	120°33'35"	16°25'07"	2250	(15),15,20	
Bayombong	Refer to Table VIII-2-2-1 due to microwave stations				
Guinguinabang					
Balungao (M/W)					
Kitakita					
Tagudin					

800MHz band for sections with a maximum channel capacity of 60 - 120 channels and 2GHz band for sections with a maximum channel capacity of 24 channel, 800MHz band for sections with a maximum channel capacity of 60 - 120 channels and 2GHz band for sections with a maximum channel capacity of 300 channels.

It is necessary to describe the method of the communication to Basco (in Batanes Province) as the only one exceptional case.
At first, communication to Basco by VHF (150MHz band) was considered but it has been determined that the construction of the initially proposed Basco repeater station for VHF use is extremely difficult because of geographical restriction. Accordingly, it recommended to employ HF by 3 channels for communication to Basco. (Detailed frequency assignment will be determined at the time of the time of the detailed design.)
Details of the frequency allocation are described in (5) "Frequency Allocation and Interference Noise." Data on sited locations of the respective repeater stations are given in Tables VIII-2-2-27 - VIII-2-2-30. The distribution of the distances of these sections (course distance distrubution) is shown in Fig. VIII-2-2-105.
The number of radio sections of spur routes (including microwave spur routes) is 82 and their average distance is 23.8km.
Their frequency distribution of course distance is shown in Table VIII-2-2-11. Although spur routes are intended for interconnection primary centers and end offices as already mentioned, the distribution of the number of radio sections is obtained as shown in Table VIII-2-12.
The number of radio repeatering sections is 6 maximum and 2.4 in average.

Table Ⅷ-2-2-11 Distribution of course distance in spur routes

Course distance in [km]	Number of courses	%
2		
4	2	2.7
6		
8	5	6.9
10	5	6.9
12	5	6.9
14	7	9.7
16	10	13.9
8	9	12.5
20	5	6,9
22	3	4,2
24	5	6.9
26	4	5.6
28	2	2.7
30	0	0
32	1	1.4
34	2	2.7
36	1	1.4
38	0	0
40	1	1.4
42	2	2.7
44	1	4.4
46	0	0
48	0	0
50	0	0
52	0	0
54	0	0
56	1	1.4
58	1	1.4
		0
238.0	1	1.4

Total 73 courses

nean 23.0km

Including branched microwave sections

Table VIII-2-2-12 Distribution: Number of spur radio section

Number of radio sections	Number of routes	%
1	14	24.1
2	23	39.7
3	9	15.5
4	10	17.3
5	2	3.4
6	0	0
Total	58	100

Mean : 2-4 radio sections

5 radio section means Baguio - Bontoc

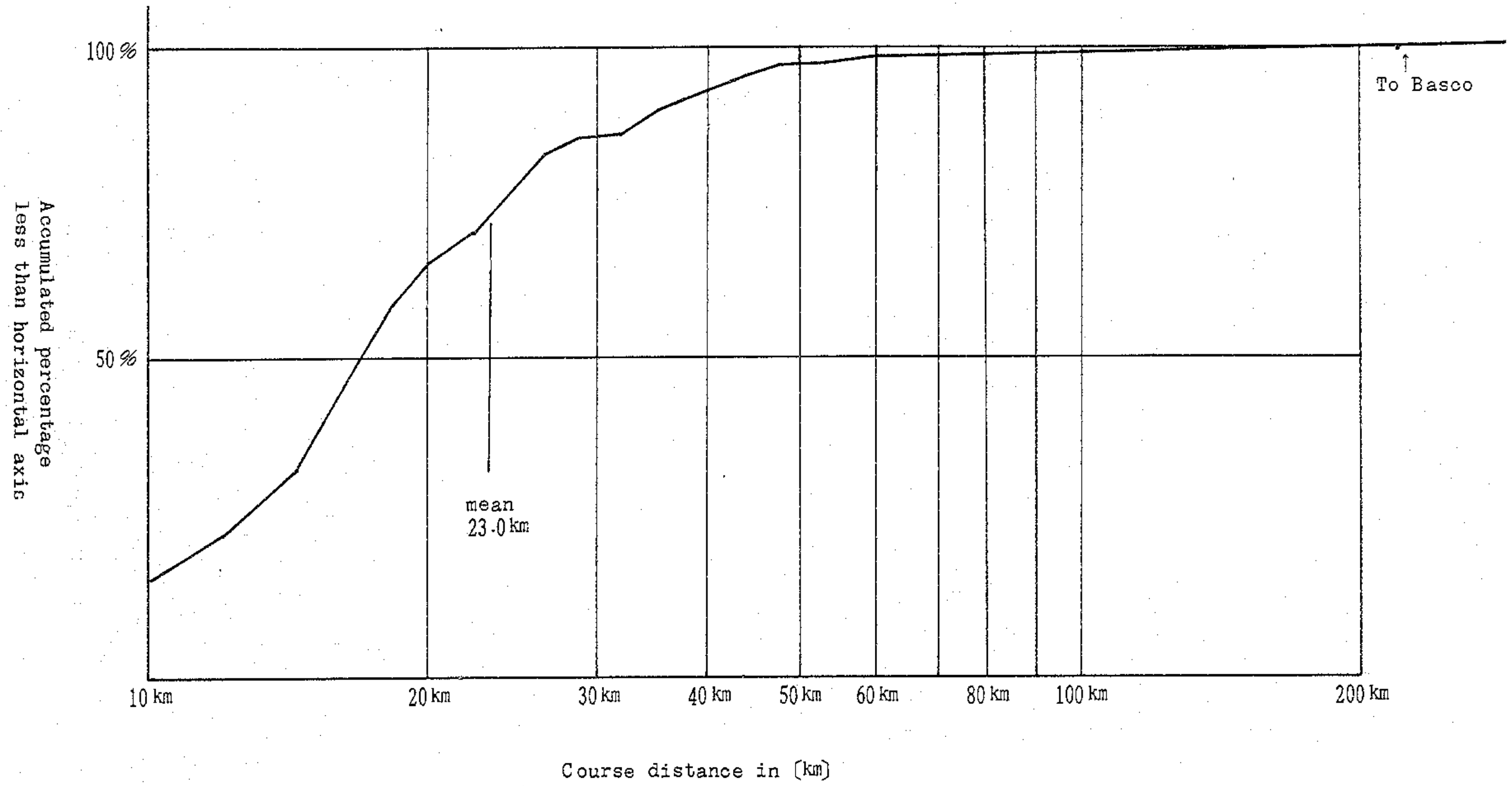


Fig.Ⅷ—2—2—105 Accumulated distribution of course distance in spur routes

(2) System configuration

As already discussed, a 90% value in the course distance distribution of radio sections of spur routes connecting offices ranking lower than primary centers corresponds to about 40km. Four repeatering sections correspond to 97% in course distance distribution. By allotting a noise of 2000pW (weighted) in conformity with the CCITT recommendation for international circuits, we assume such a hypothetical reference circuit as shown in Fig. VIII-2-2-106 (6).

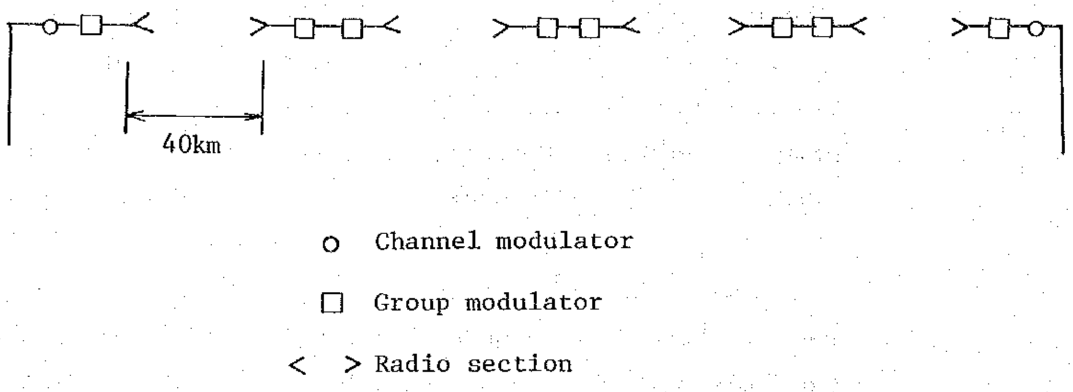


Fig.VIII-2-2-106(b) Hypothetical Reference Circuit for Spur Routes

The ratio of distribution to carrier terminals and radio sections is as follows.

Carrier terminals
850pW

2000pW - 3560pW ── Radio sections ── Each radio section
(Weighted)(Unweighted) 2710pW 677pW
(61.7dB)

For details of noise allotment, see the paragraph on average circuit noise.

It is recommended, as mentioned, to employ frequency bands of 150MHz - 2GHz for spur routes. It is also recommended to employ baseband repeating type transmitter-receiver equipment for the 150MHz, 400MHz, and 800MHz systems and heterodyne repeating type transmitter-receiver equipment for the 2GHz system. The 2GHz system will form a route stand-by system, whereas equipment to be used in the 150MHz - 800MHz bands will employ the preset system. Requirements for antennas and other equipment are described in the paragraph of average circuit noise.

(3) Required number of channels and maximum channel capacity

It is necessary to determine, first of all the maximum channel capacity of the transmission routes interconnecting primary centers (8 in number), secondary centers, local telephone offices surrounding the primary centers or secondary centers, and IPTS (Inter-Provincial Telephone Subscribers). The maximum channel capacity is calculated on the basis of the demand of telephone channels which is obtained from the telephone demand forecast and estimation of required telephone channels in this report. The required numbers of telephone channels between the respective offices and primary centers are obtained from the demand of telephone channels and are shown in Figs.VIII-2-2-106 ~ VIII-2-2-114. These tables give, for Phase 1, estimated demands in the peruid ranging to 1987, estimated demand in the period to 1990, and estimated demand in the period to 1997. For Phase 2, these tables give estimated demand in the period to 1990 and estimated demand to 1997.

The trends of the numbers of required telephone channels for the

Fig. Ⅷ-2-2-106 Legend of figures of required telephone channel numbers between P.C and local exchanges.

(1) ○ Local exchange in Phase I

(2) □ I.P.T.S. in Phase I

(3) ● Local exchange in Phase Ⅱ

■ I.P.T.S. in Phase Ⅱ

(4) ——— V/UHF route

═══ Microwave route

------ Metalic cable

(5) 15 16 17 18

18 ↑ Final numbers of lines 15 years after in Phase I
12 years after in Phase Ⅱ

17 ↑ Number of lines up to 1990 of Phase I project.

16 ↑ Number of lines up to 1990 of Phase Ⅱ project.

15 ↑ Number of lines up to 1987 of Phase I project.

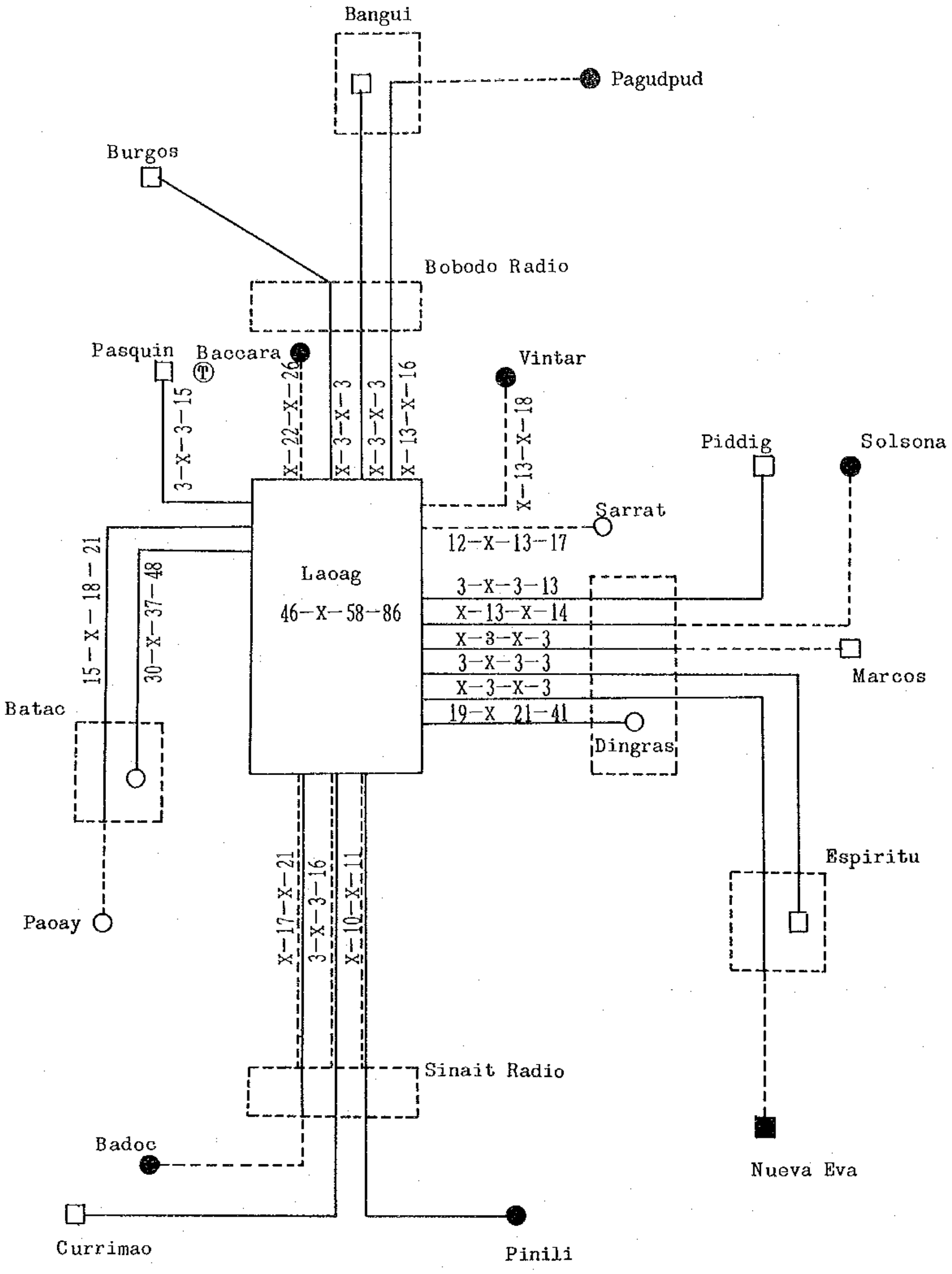


Fig. VIII−2−2−107 Required telephone channel numbers in Laoag PC area

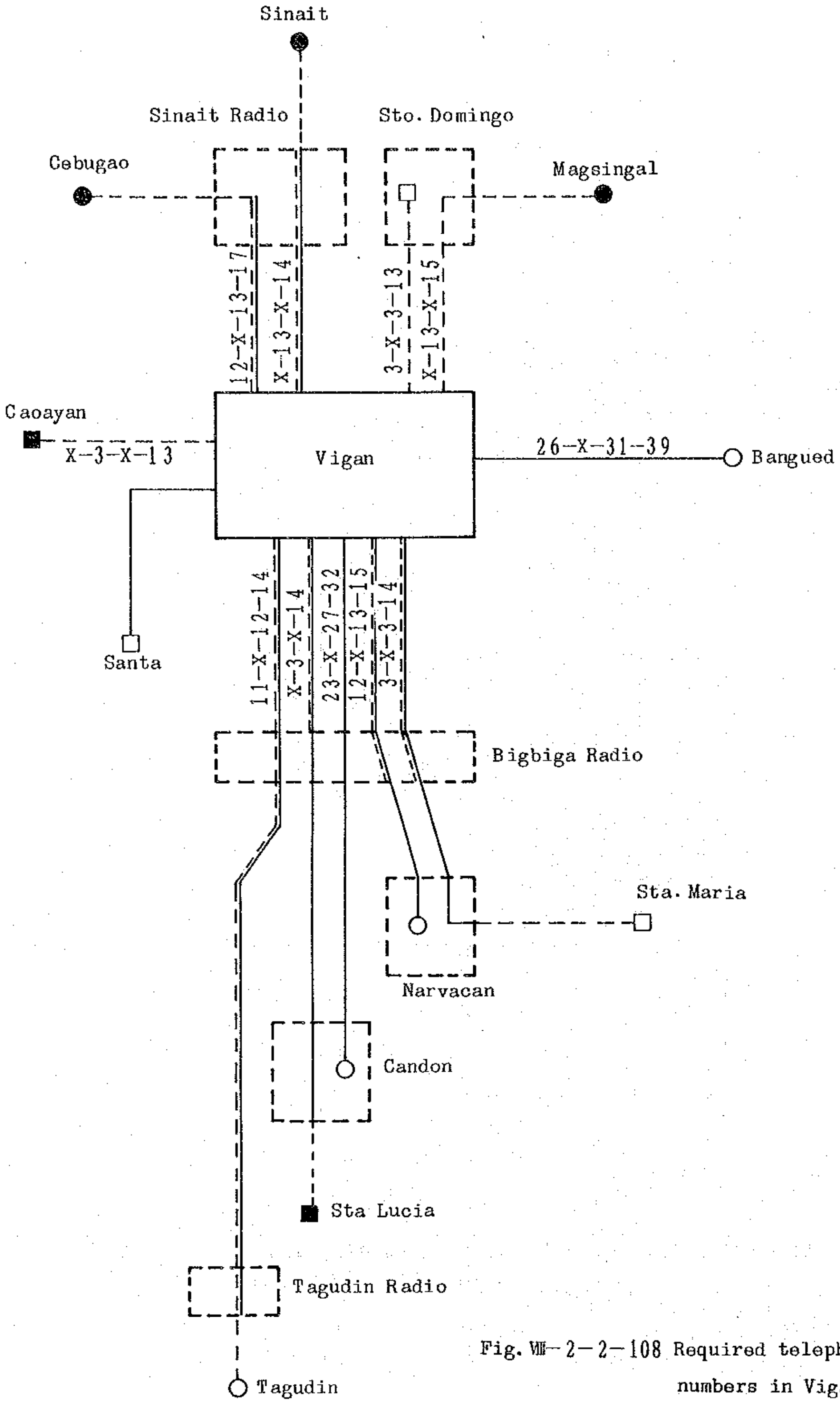


Fig. Ⅷ-2-2-108 Required telephone channel numbers in Vigan PC area

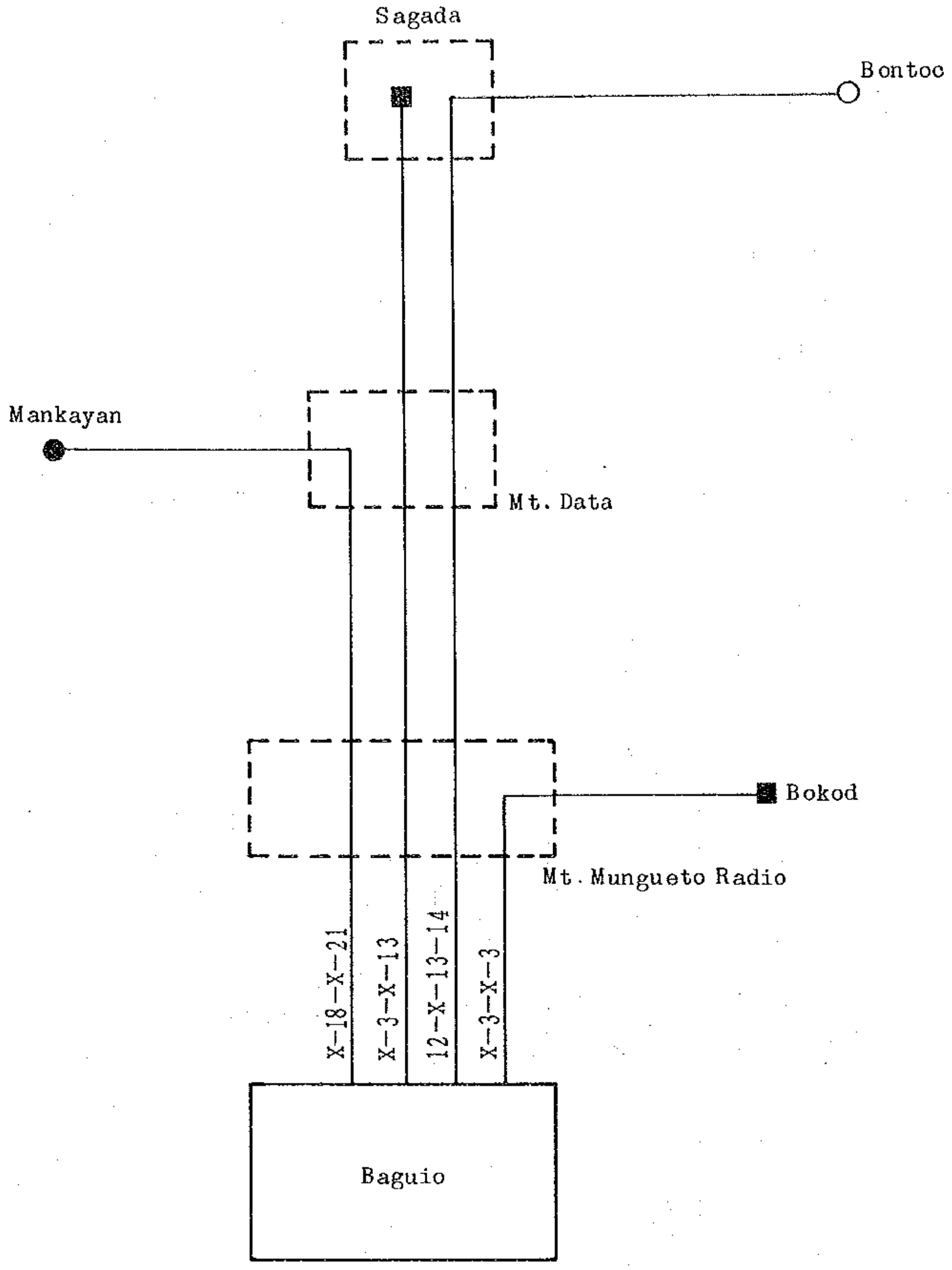


Fig.Ⅷ−2−2−109 Required telephone channel numbers in Baguio SC area

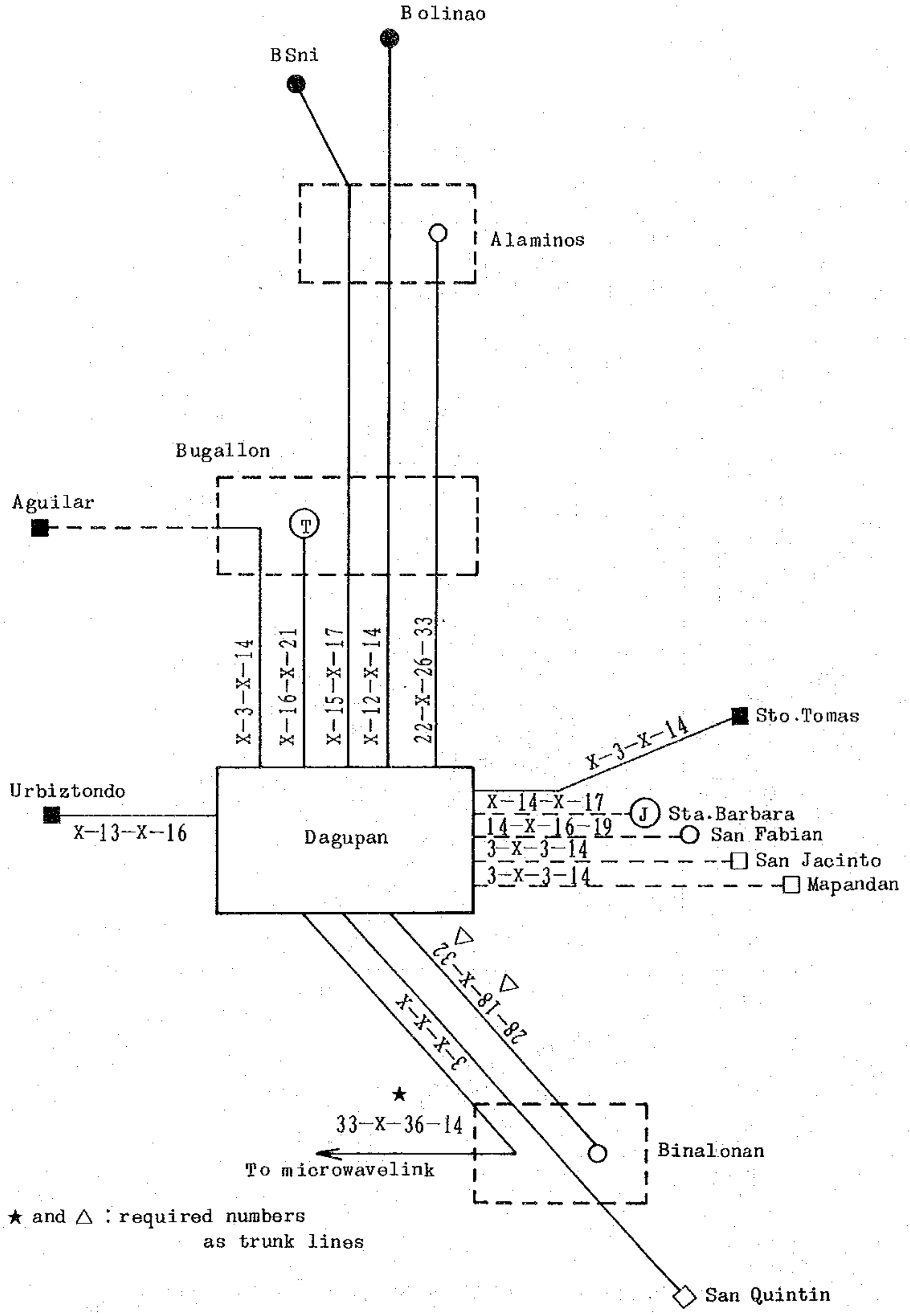


Fig.Ⅷ-2-2-110 Required telephone channel numbers in Dagupan PC area

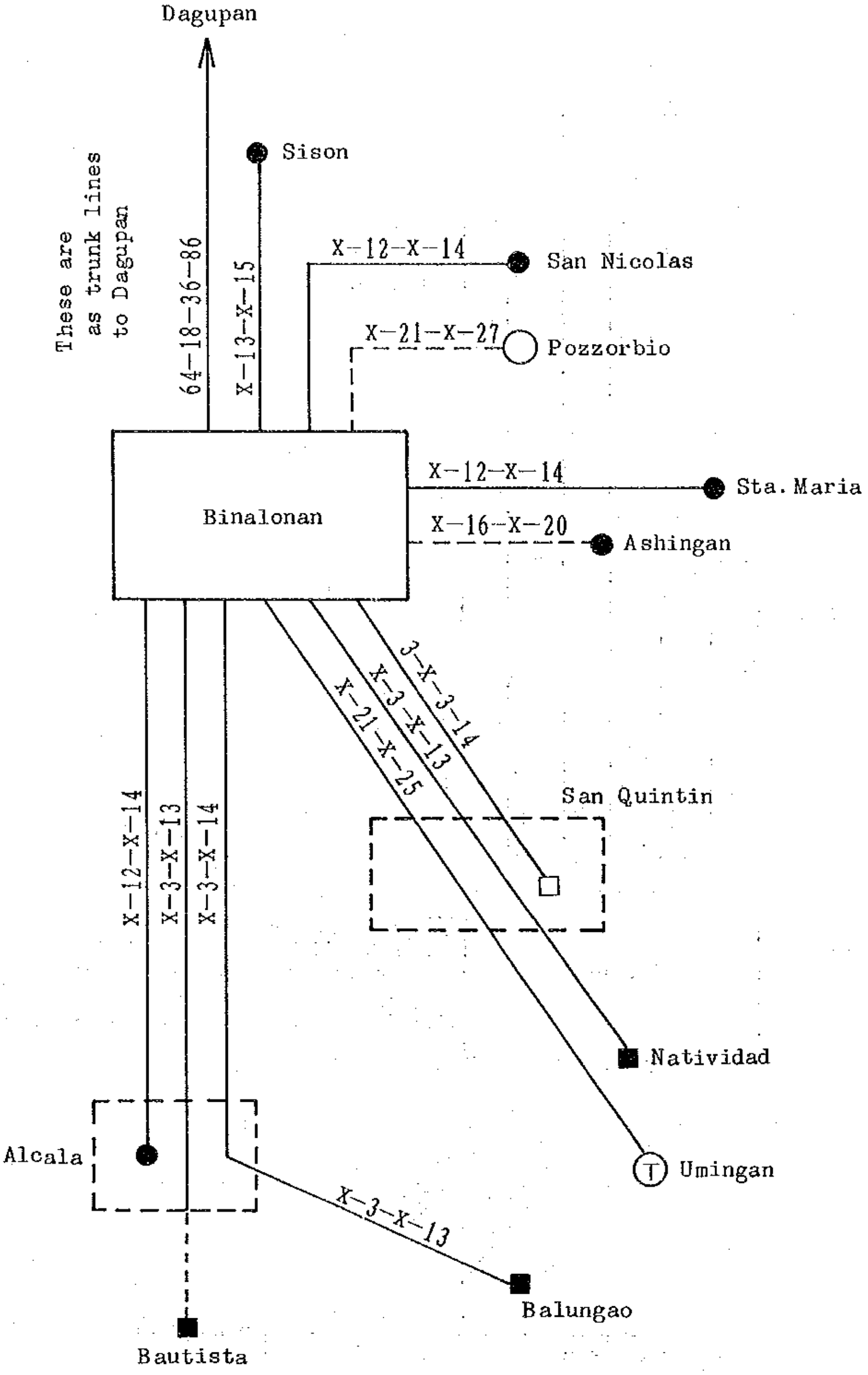


Fig.Ⅷ-2-2-111 Required telephone channel numbers in Binalonan PC area

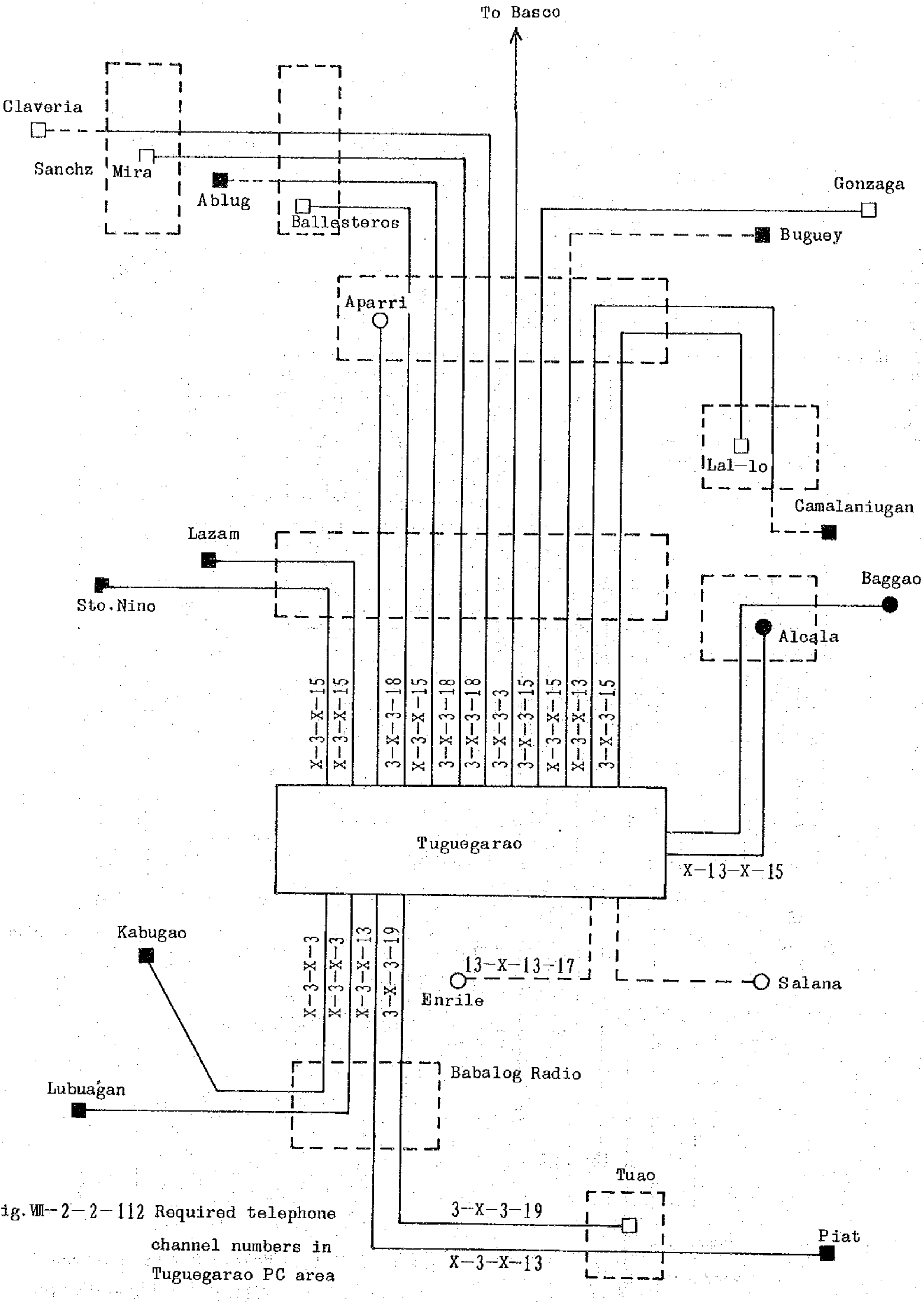


Fig.Ⅷ-2-2-112 Required telephone channel numbers in Tuguegarao PC area

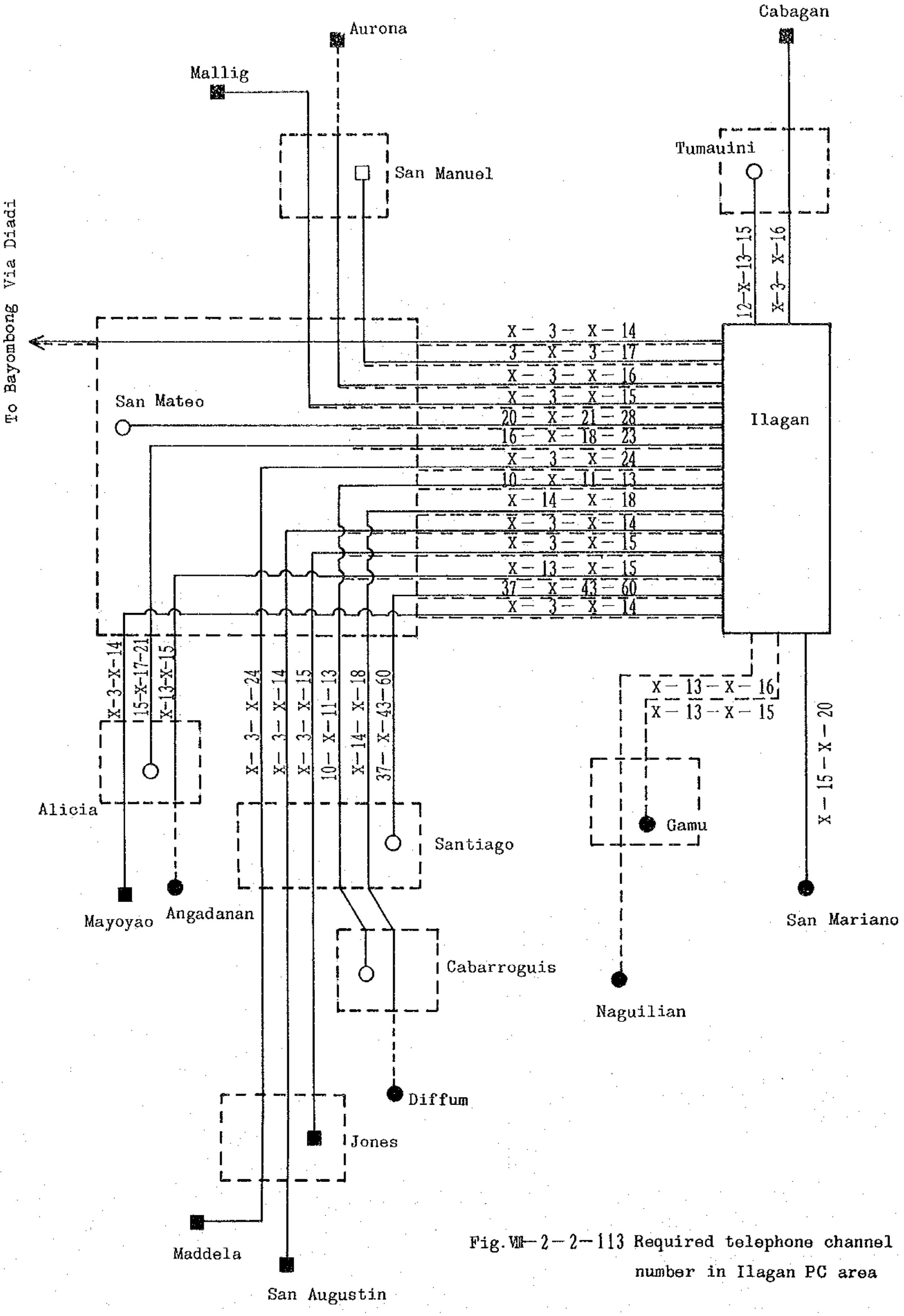


Fig.Ⅶ-2-2-113 Required telephone channel number in Ilagan PC area

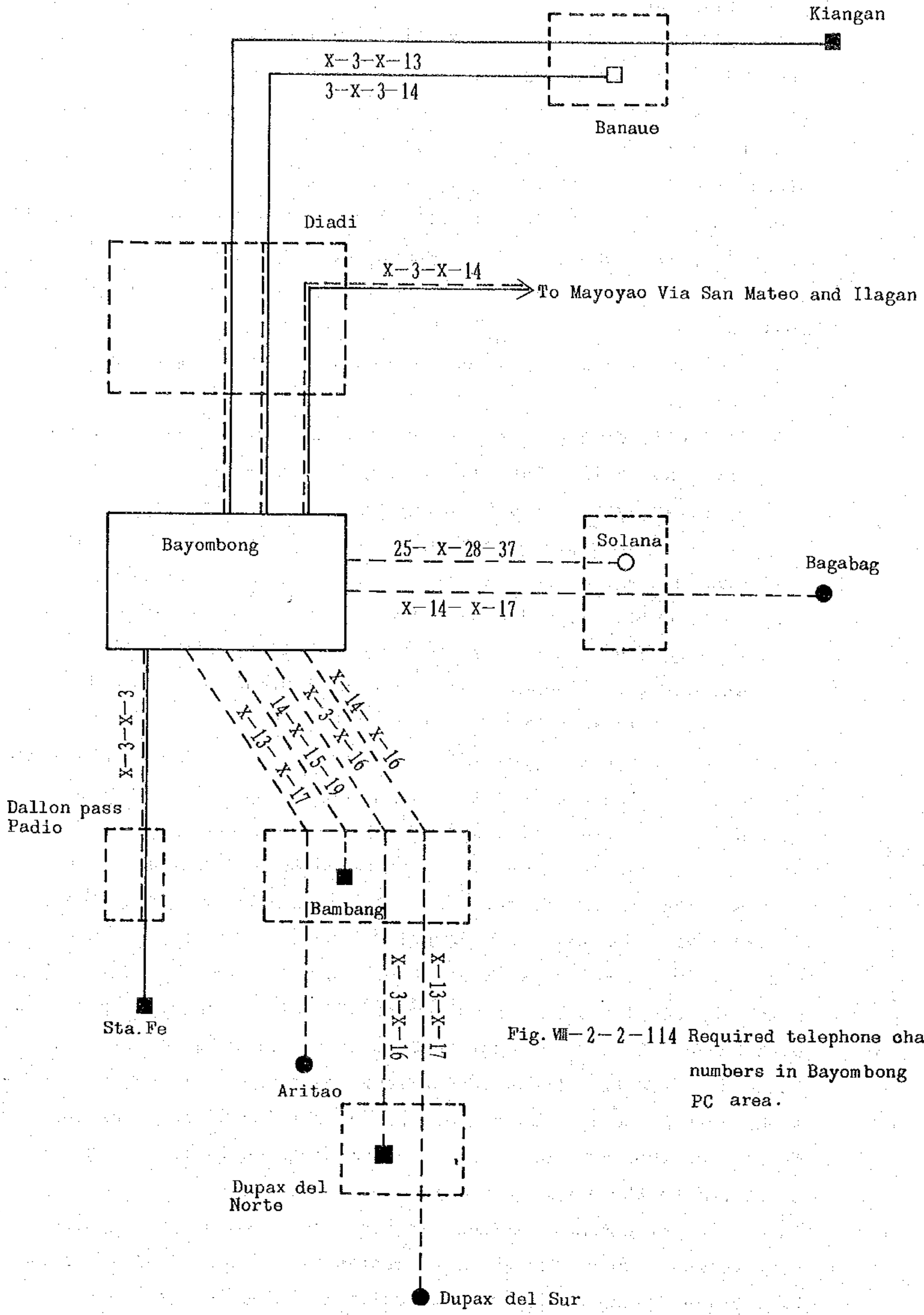


Fig. Ⅷ-2-2-114 Required telephone channel numbers in Bayombong PC area.

respective radio transmission sections are obtained from these data and shown in Figs.VIII-2-2-115 - VIII-2-2-122.

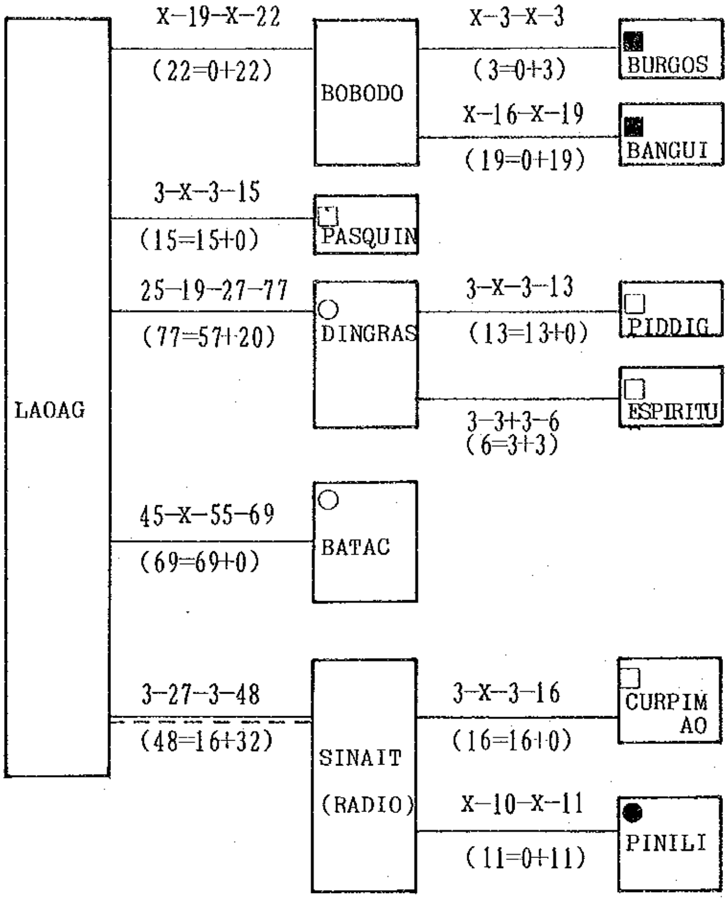
Now, let us plan the maximum channel capacities of the respective sections considering, from the above data, the demand ranging from the commencement of the service by Phase 1 to 15 years ahead, that is, to 1997. For radio systems to be adopted, 3-channel, 6-channel, 24-channel, 60-channel, 120-channel, and 300-channel systems are provided. Which radio systems should be adopted to the respective radio sections should be determined as follows.

a) To IPTS, 3-channel system should always be assigned exceptionally.
b) To sections where 2 routes of IPTS call will be transmitted (such as Babalog-Tuao and Mallig-Callang sections) 6-channel system should always be assigned.
c) To sections where more than 3 routes of IPTS call will be transmitted 24-channel system should always be assigned.
d) In other cases, radio system will be determined by using as many channels as nearest to the channel demand to 1997 not exceeding 24 channels, 60 channels, 120 channels and 300 channels in respective cases.

The maximum channel capacities of the respective radio sections are determined on these principles and shown in Figs.VIII-2-2-123 ~ VIII-2-2-131. Tables VIII-2-2-14 ~ VIII-2-2-20 show the types of radio systems to be installed at repeater stations of the spur routes. The numbers of the respective radio systems are given in Table VIII-2-2-21. As understood from the table, major spur routes with channel capacities of 60 channels - 300 channels will mostly be completed in Phase 1, whereas small-capacity spur routes with capacities of 3 channels - 24 channels will be completed in Phase 2. From the standpoint of spur route plans, it can be understood that Phase 1 gives an emphasis on the installation of basic facilities whereas Phase 2 gives an emphasis on facilities to be connected to the basic facilities.

The trends of channel demands for baseband sections in the respective spur routes are given in Tables VIII-2-2-21 - VIII-2-2-26. Fig. VIII-2-2-132 shows the cumulative distribution of channel demands to 1997. It can be said that nearly 90% of all demands can be met by the channel capacity of 60 channels in the ultimate state as well.

June 13
June 26 1st Revised
June 28 2nd Revised
June 24 3nd



Legend

3−27−3−48

Required number of telephone channeles up to 1997

Reguired number of telephone channels of phase I up t.1990

Reguired number of telephone channels of phase Ⅱ up to 1970

Reguired number of telephone channels of phase I up to.1987

(48=16+32)

Reguired number of telephone channels of phase Ⅱ up to 1997

Reguired number of telephone channels of phaseI up to 1997

Fig.Ⅷ−2−2−115 Required teleplrone channel numbers for spur routes radio sections in Lavag PC area

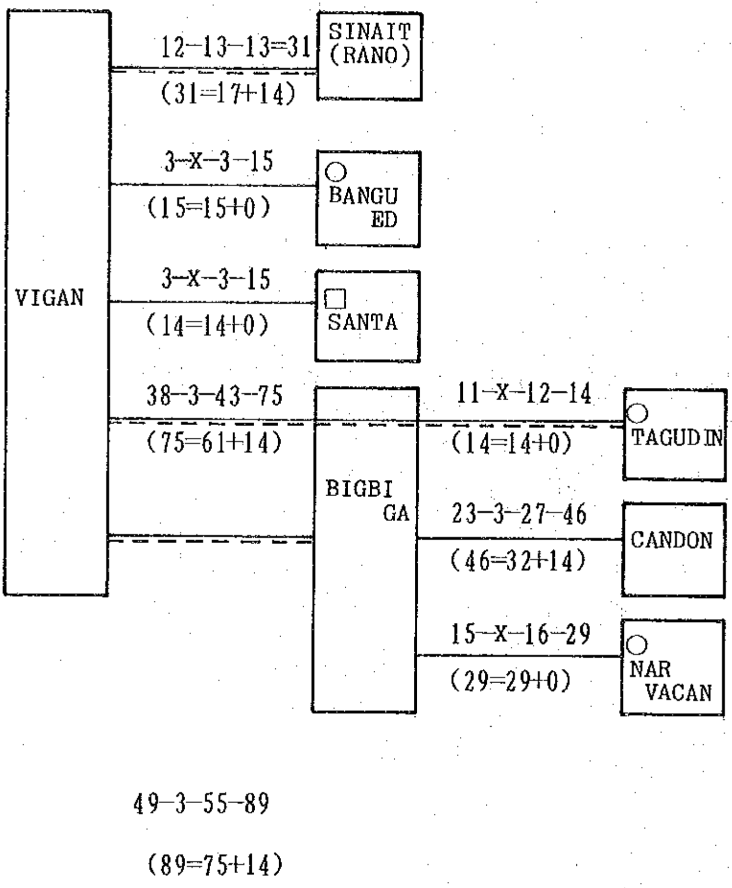


Fig.Ⅷ-2-2-116 Required telephone channel numbers for spur route radio sections in Vigan PC area

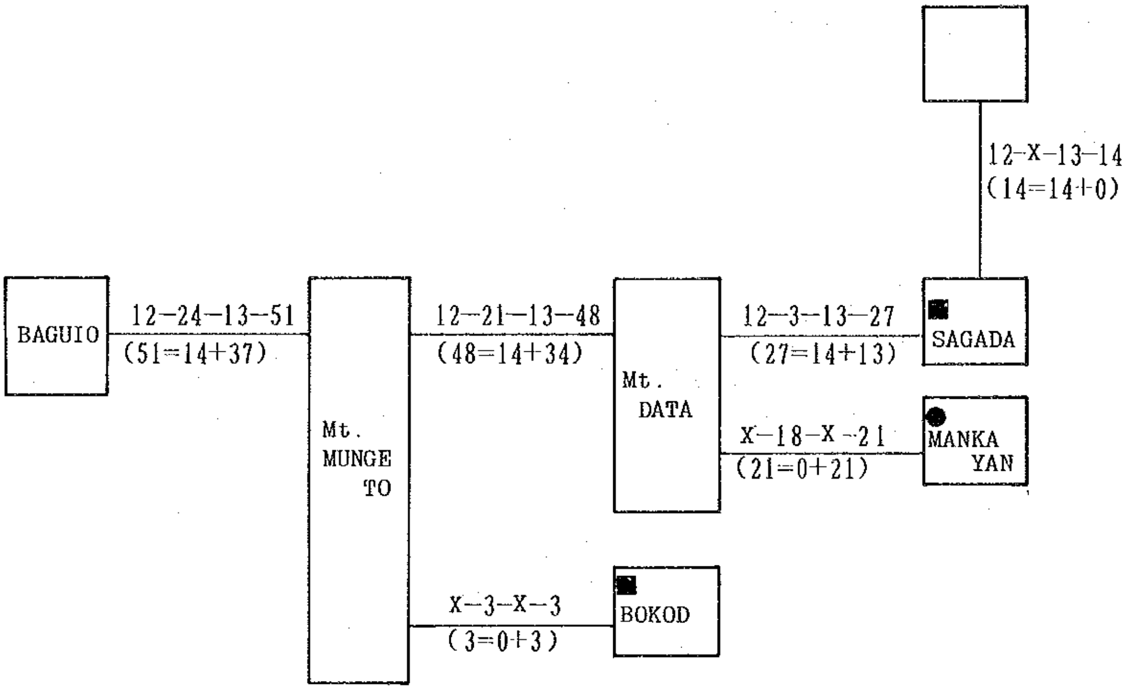
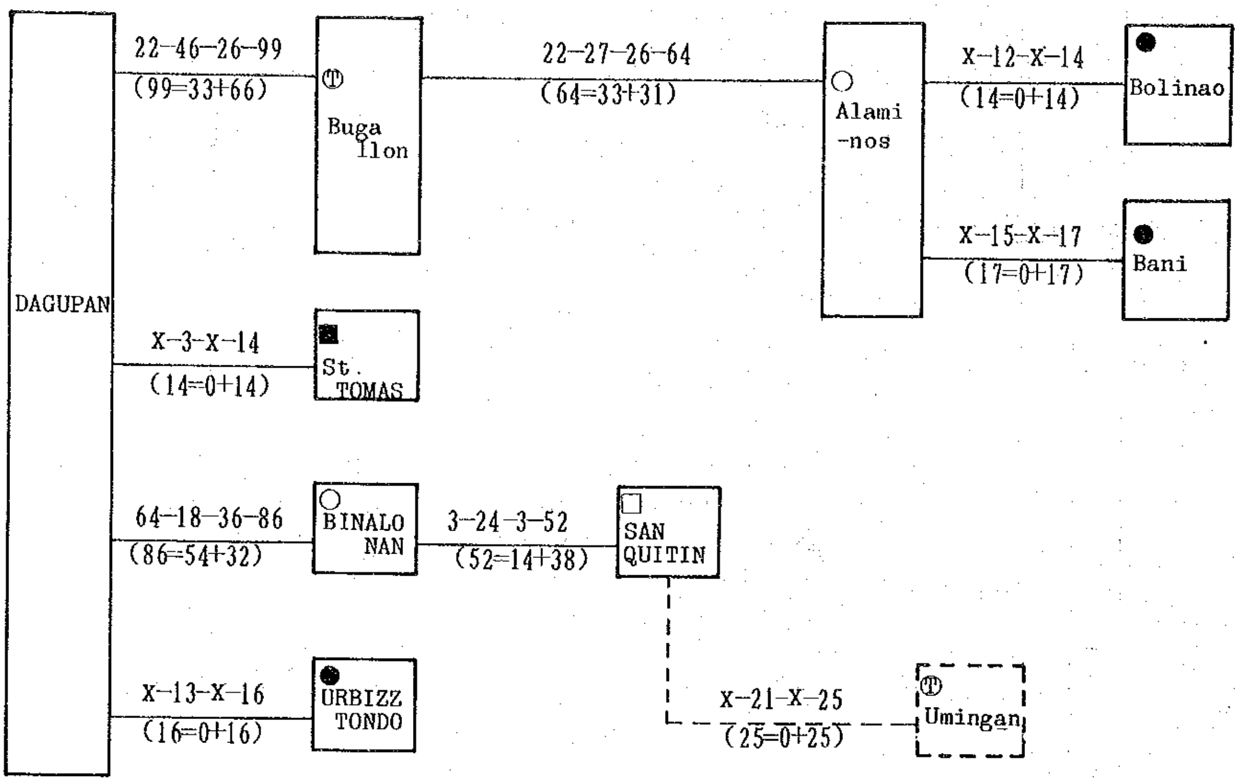


Fig.Ⅷ-2-2-117 Required telephone channel numbers for spur route radio sections in Baguio SC area



Remarks : San Quintin ~Natividad will be planned by cable system

Fig. Ⅷ-2-2-118 Required telephone channel numbers for spur route radio sections in Dagupan PC area

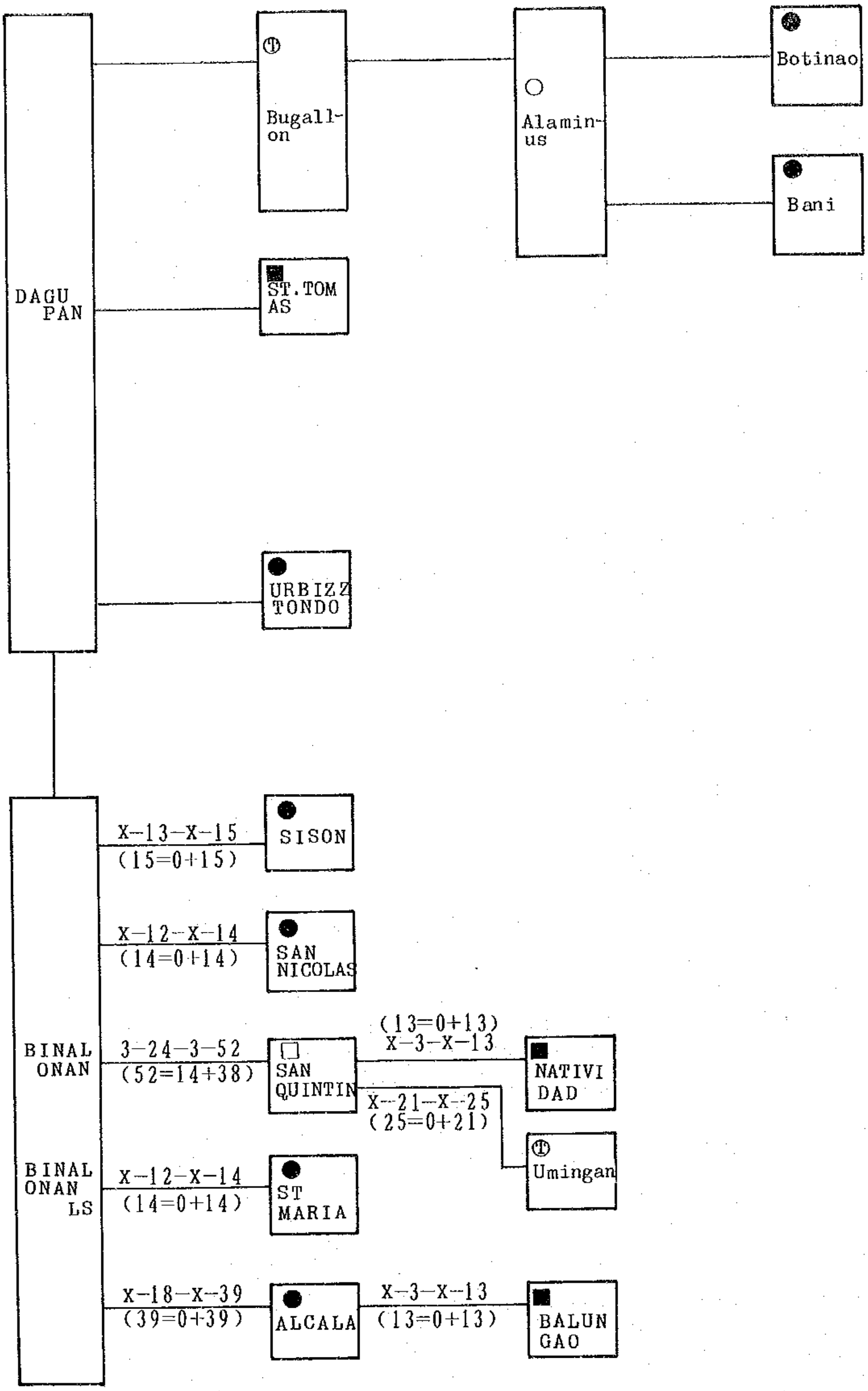


Fig.Ⅷ-2-2-119 Required telephone channel numbers for spur route radio sections in Binalonan PC area