REPORT

ON

THE ESTABLISHMENT OF ELECTRONIC AND OTHER NAVIGATION AID SYSTEMS PROJECT

MALACCA/SINGAPORE STRAITS

1976

JAPAN INTERNATIONAL COOPERATION AGENCY

[redacted]

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PREFACE

In response to the request of the Republic of Indonesia, and with the consent of the Government of the Federation of Malaysia and the Republic of Singapore as to study in the straits of Malacca and Singapore, the government of Japan decided to make a feasibility study of the Establishment of electronic and other navigation aid system project for the Malacca & Singapore straits and Lombok & Makassar straits as a part of Japan's overseas technical cooperation programmes, and this study was conducted by the Japan International Cooperation Agency (JICA).

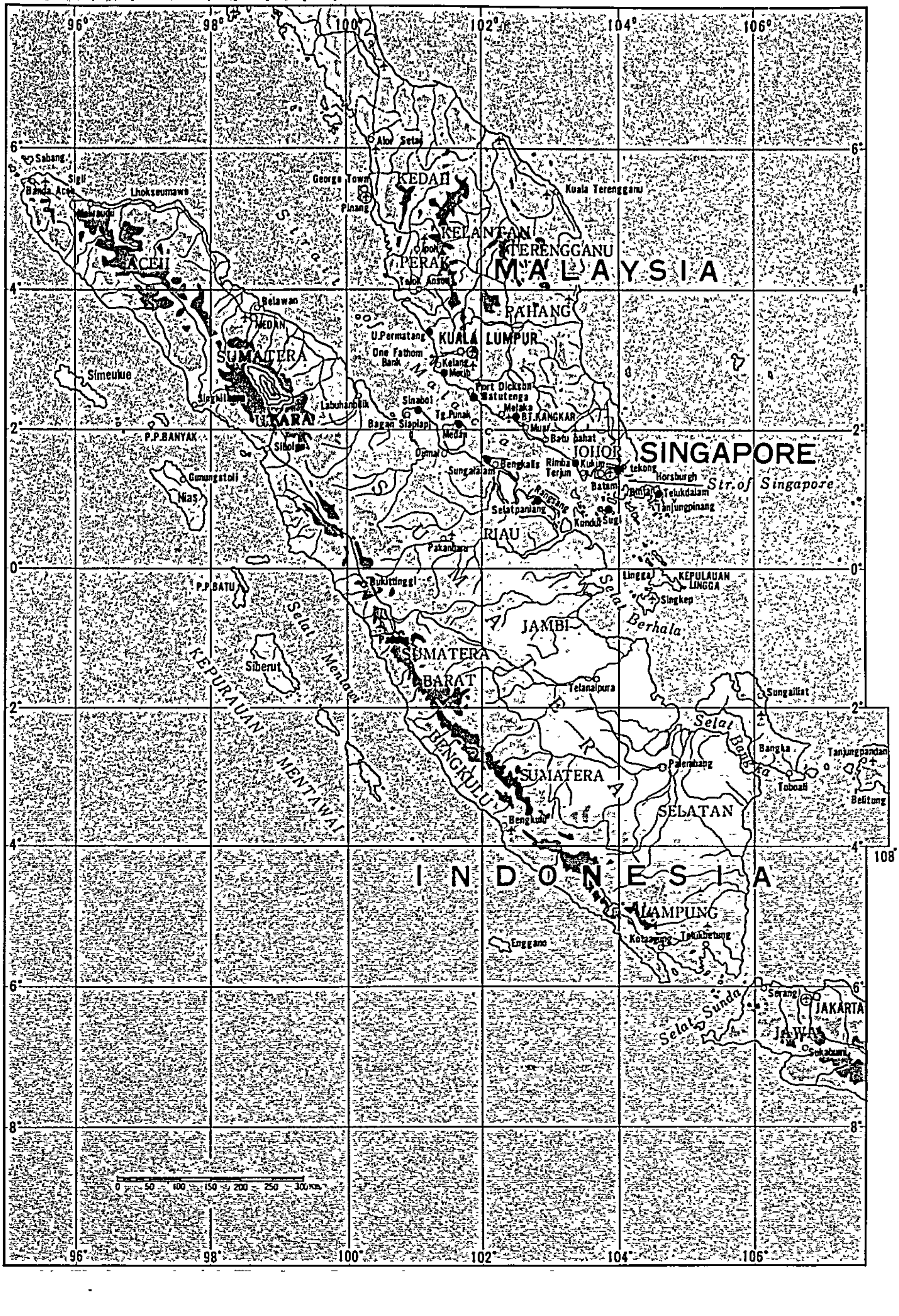
JICA dispatched a survey team consisting of 14 experts, headed by Mr. Shigeyoshi TOYOFUKU, Director, Electronic Navigation Aids Division, Navigation Aids Department, Maritime Safety Agency, to Indonesia, Malaysia and Singapore from Oct. 1976 to Feb. 1977 to carry out the field investigation for its technical and economic feasibility. The results of the survey have been carefully examined, and then compiled into the report presented herewith.

It is my great pleasure that the report would make a contribution to the development of maritime transport in these countries and to the safety of navigation in those straits, at the same time contribute towards the enhancement of friendly relations now existing between these countries and Japan.

I wish to express my heartful appreciation to the competent authorities of the Republic of Indonesia, the Federation of Malaysia and the Republic of Singapore and other parties concerned for the cooperation and hospitality extended to the team during the study period.

1978

Shinsaku HOGEN
President
Japan International Cooperation Agency



MALAYSIA
SINGAPORE
INDONESIA
Str. of Singapore
KEDAH
KELANTAN
TERENGGANU
PERAK
PAHANG
KUALA LUMPUR
JOHOR
ACEH
SUMATERA UTARA
SUMATERA BARAT
RIAU
JAMBI
BENGKULU
SUMATERA SELATAN
LAMPUNG
JAWA
JAKARTA
Selat Mentawai
KEPURAUAN MENTAWAI
Selat Berhala
Selat Bangka
Selat Sunda
KEPULAUAN LINGGA
Lingga
Singkep
Siberut
Nias
Gunungstoli
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P.P.BANYAK
P.P.BATU
Enggano
Bangka
Belitung
Tanjungpandan
Toboali
Sungailiat
Palembang
Telanaipura
Bengkulu
Bukittinggi
Pakanbaru
MEDAN
Belawan
Sibolga
Labuhanbilik
Bagan Siapiapi
Sabang
Banda Aceh
Sigli
Lhokseumawe
Alor Setar
George Town
Pinang
Kuala Terengganu
Port Dickson
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Chapter 1

Summary

Chapter 1 Summary

This report is a compilation of the result of a technical study on the navigation systems suitable for the water areas of Indonesia, Malaysia and Singapore, particularly Lombok-Makassar straits and Malacca-Singapore straits,and on the way that such systems should be, and also a study on the appropriateness of such systems from the economical point of view.

This report describes the desirableness of newly establishing 3 Decca chains to chiefly cover Malacca-Singapore straits with high degree of accuracy, and for newly establishing 1 medium wave radio beacon station, 5 Ramark stations, 1 radarbeacon station, 3 lighthouses, 5 light beacons. The report also mentions that such new establishment is technically feasible.

The total cost of construction of this project is approximately 7,300 million yen or almost 26 million U.S. dollars, which is broken down as follows:

Classification	Number of stations (or chains)	Amount (in million yen)	Amount (in ten thousand U.S.$)	Remarks
Decca	3 chains	6,486	2,316	
Medium wave radio beacon	1 station	42	15	
Ramark	5 stations	261	93	
Radarbeacon	1 station	42	15	
Lighthouse, etc.	8 lights	468	167	
Total		7,299	2,607	

The role of an aid to navigation is to contribute to the prevention of marine accidents and the promotion of operational efficiency of vessels, and, in addition, provide vessels with information on their exact positions at sea which is very useful to the development of fishing industry and promotion of ocean development.

It is extremely difficult, however, to attempt to evaluate or assess the benefit provided by aids to navigation, in terms of monetary value. The prevention of marine accidents means not just the protection of hulls and cargoes, but also the protection of invaluable human life at sea and the prevention of environmental destruction by secondary disaster from oil spillage or other accidents.

The shortage or inadequateness of aids to navigation is not a direct cause of marine accident. Or, however perfectly aids to navigation may be furnished, marine accidents cannot possibly be eliminated completely.

A marine accident occurs when various unfavourable conditions are piled up, such as narrow channels, poor visibility, traffic congestion, lack of navigational information and artificial mistakes. The means to remove these unfavourable conditions should be considered from an overall point of view. The establishment of an electronic navigation system is considered an extremely effective measure to cope with these situations.

It is true that navigation systems, electronic navigation systems in particular, have many important advantages, but it is also true that they require a great amount of investment. It is advisable therefore to install such systems gradually according to the order of priority.

What requires special attention on the assumption of the above is that these systems should be operated in good condition, and an active study should be made as to the promotion of standard of electronic technology, ensuring of proper operation of the systems and appropriate measures for securing the safety of navigation.

Chapter 2

Recommendations

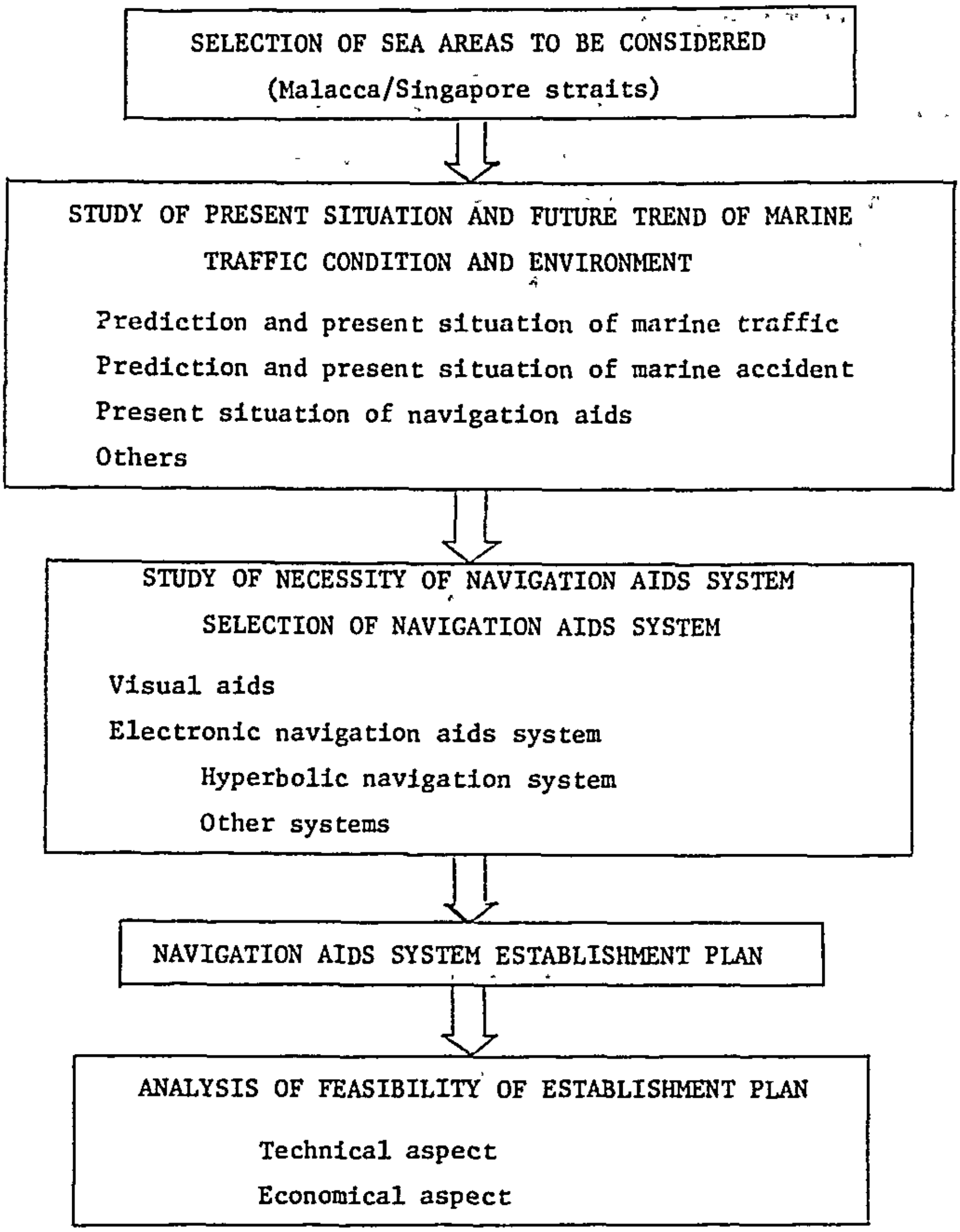
Chapter 2 Recommendations

In promoting the economic growth and building up the national power of a country, the development of foreign trade is certainly indispensable. In order to achieve this objective, it is essential to consolidate port and harbour facilities as well as to furnish a sufficient number of aids to navigation to ensure the safety of shipping traffic in or around the waters of that country.

Indonesia is one of the leading maritime nations in South-East Asian region and promotion of shipping will contribute greatly to the national economic development also in Malaysia and Singapore. Of the waters of the three countries concerned, Malacca/Singapore straits are recognized especially as an important place of marine traffic. In other words, Malacca/Singapore straits are complicated in sea bottom configuration and a place hard to pass where many kinds of over 50,000 vessels a year are navigating. The marine traffic in the area concerned has a tendency to congest increasingly and there will be in danger of occuring a marine accident. The required position fixing accuracy level in these sea areas is considered approximately 50 metres in the most adverse area of Malacca/Singapore straits.

In the present situation of the navigation aids system, the considerable visual aids to navigation have been established in the straits but insufficient. In order to improve the safe of navigation, it is required that additional visual aids to navigation and high accurate electronic navigation aids systems be established.

A long-range plan should be prepared taking into consideration the existing marine traffic situation, economical development and future marine traffic trend. Each system should be selected on the basis of careful study as to its functional application, reliability, economical character, future posibility and worldwide commonness, etc.



After this careful study, the team has prepared the navigational aids system establishment plan on the basis of the results of the site survey. Of the electronic navigation aids systems, the team has selected the Decca Navigator system as the suitable hyperbolic navigation system and the medium wave radio beacon, Ramark and radarbeacon as appropriate electronic navigation systems.

A plan to furnish these systems and a plan to provide visual aids to navigation have been put together to produce an overall programme. In the field of hyperbolic navigation systems, two systems, Decca and Loran-C, are functionally competitive, so the proposed site survey was carried out for both systems and a detailed comparative study has been made in various aspects.

The Decca Navigator system is suitable to coastal and narrow channel waters. On the other hand, however, it is thought that Loran-C suitable for long range can provide accuracy required for the straits if special consideration is taken into the transmitting station configuration, etc. Generally speaking, both systems have merits and demerits and have no absolute superiority recognized. When concentrated on Malacca/Singapore straits, the Decca Navigator system is more suitable on the complehensive judgement. The detailed comparative study between both systems is described in 5-1-3.

2-1 Overall programme

2-1-1 Decca chains

The configuration plans for Decca chains have been prepared, laying special emphasis on the Lombok/Makassar straits and Malacca/Singapore straits. The reason for this is that these straits are particularly important as viewed from the amount of shipping traffic in all areas of the three littoral countries; Indonesia, Malaysia and Singapore. Depending upon the progress of the overall development plan of Indonesia, the establishment of an additional chain would become necessary to be planned to cover the area from Sunda Strait through to the Java Sea.

Malacca/Singapore straits

This is an area situated in the very critical point of navigation with its complicated sea bottom topography, narrow fairways, many intersecting waterways where many kinds of vessels are navigating. The Decca chains for this area, therefore, have been configured, placing more importance on the accuracy in position-fixing and considering so as to enable vessels to navigate as far as possible on a single line of position. Consideration has also been given so that in the event of accidental off-air at a slave station of a chain, other pattern or chain is utilised to provide continuous service.

In order to cover the area from the east of Horsburg Lighthouse to the west of One Fathom Bank with Decca with required accuracy, at least three Decca chains should be installed which will tentatively be called Singapore Strait Chain, Malacca Strait South Chain and Malacca Strait North Chain.

2-1-2 Medium wave radio beacons

Medium wave radio beacons for marine use cannot provide expected accuracy. However, all vessels of 1,600 gross tons and upwards are required, when engaged on international voyages, to be fitted with radio direction-finding apparatus under the International Convention on the Safety of Life at Sea, and for these vessels medium wave radio beacons are an effective system for coastal navigation because the system can be utilised with simple receivers.

A considerable number of medium wave radio beacons for aircraft use (which are referred to as NDB's) are already in operation. These stations are using the frequency band adjacent to that of marine medium wave radio beacons and therefore vessels can also use NDB's. Many existing NDB stations are situated in the positions which are available also for marine use. It would therefore be more economical and effective to use these NDB's as they are, and establish new radio beacon stations for marine use in other critical places. There are many NDB's which are in operation during the limited time. It would be all the more efficient if all these stations could provide a 24-hour service.

Incidentally, it is generally known that the International Hydrographic Bureau has decided in its resolutions to chart the position of the radio beacons for aircraft which can also be used by vessels.

In establishing a medium wave radio beacon station, it is adequate from the viewpoint of maintenance and administration to select a station site close to an esisting lighthouse.

Under these points of view the medium wave radio beacon stations have been configured as shown in Fig. 5-1-29. The scale of the stations is rather small and no actual survey was conducted during the recent survey, but before making final decision on the site, preliminary survey must be made to find the suitability.

2-1-3 Ramark and radarbeacon

Plans have been made to establish ramark beacons and radarbeacons as landfall beacons or obstruction beacons. The working frequencies of marine radar are mostly in the band of 9GHz. It would be sufficient therefore if the frequencies of these micro-wave beacons could be made in the band of 9GHz. A tentative plan of installation of these radio beacons is as shown in Fig. 5-1-29.

2-1-4 Visual aids to navigation

Visual aids to navigation can be utilised by all vessels ranging from huge vessels to small sailing craft. No special instruments are required to measure such aids. They are most basic aids to navigation, requiring no great amount of expenses to install, operate and maintain.

The number of visual aids for every navigable coastal line in the area concerned is extremely small except for Singapore Strait. There are places where two-point bearings cannot be taken or where even one-point bearing is unavailable because of the dead angle produced between the two aids. A table appended hereto shows a tentative plan for establishing visual aids to navigation, taking into consideration the amount of shipping traffic, important turning points, fishing vessels operation area and area of many occurrences of marine accidents.

2-2 Survey for execution plan

During the recent feasibility study, survey was conducted to find the technical and economical appropriateness of various systems, and, through the good offices of the Governments concerned, much fruitful result could be obtained for a relatively short period.

Before implementing the plan, however, a detailed execution design survey should be conducted, such as precise position measurement of the possible sites, radio wave propagation survey at some representative places, including execution design of buildings and aerial tower, etc common to each chain.

2-3 Frequency plan

The electronic navigation systems proposed in the present report are Decca, medium wave radio beacons, ramark and radarbeacons. The frequency bands and frequency allocations by the Radio Regulations annexed to the International Telecommunication Convention are as shown in the table below. The frequencies are internationally allocated and protected.

Frequency Band

System	Frequency band	Remarks
Decca	70～90 kHz 110～130 kHz	
Medium Wave Radio Beacon	285～325 kHz	
Ramark	9 GHz band	
Radarbeacon	9 GHz band	

The Loran-C system which has been studied in this report in parallel with Decca and other systems is indicating the trend of being used for coastal navigation in recent years, but this system was originally developed as a long range navigation system and is using the frequency band secured for that purpose.

Table of frequency allocations

Region	Frequency band (kHz)	By type of business
3	70 - 90	Maritime mobile Radionavigation 162
	90 - 110	*Fixed* Maritime mobile Radionavigation 166, 167
	110 - 130	Fixed Maritime mobile Radionavigation 162, 167, *168 and 170*
	160 - 200	*Fixed* Aeronautical radionavigation
	200 - 285	Aeronautical radionavigation Aeronautical mobile
	285 - 315	Maritime radionavigation (radiobeacons) Aeronautical radionavigation
	315 - 325	Maritime radionavigation (radiobeacons) Aeronautical radionavigation
	325 - 405	Aeronautical radionavigation Aeronautical mobile
	405 - 415	Radionavigation Aeronautical mobile

Remarks:

162 Limited to continuous wave systems.

166 The development and operation of long distance radionavigation systems are authorized in this band, which will become exclusively allocated, wholly or in part, to the radionavigation service for the use of any one such system as soon as it is internationally adopted. Other considerations being equal, preference should be given to the system requiring the minimum bandwidth for world-wide service and causing the least harmful interference to other services. If a pulse radionavigation system is

employed, the pulse emissions shall nevertheless be confined within the bank 90-110 kHz and shall not cause harmful interference outside the band, to stations operating in accordance with the Regulations. In Regions 1 and 3, during the period prior to the international adoption of any long distance radionavigation system, the operation of specific radionavigation stations shall be subject to agreements between administrations whose services, operating in accordance with the Table, may be affected. Once established under such agreements, radionavigation stations shall be protected from harmful interference.

167 Only calsses A1 or F1, A4 or F4 emissions are authorized in the band 90-160 kHz for stations of the fixed service and in the bank 110-160 kHz for stations of the maritime mobile service. Exceptionally, class A7J emissions are also autorized in the band 110-160 kHz for stations of the maritime mobile service.

168 Aeronautical stations may use frequencies in the bands 110-112 kHz, 115-126 kHz and 129-130 kHz on a permitted basis for high-speed communications to aircraft.

170 In the bands 112-117.6 kHz and 126-129 kHz, the radionavigation service is the primary service and the fixed and maritime mobile services are secondary services, except in Japan and Pakistan.

2-4 Execution plan

In implementing this plan, consideration should be given to a gradual furnishing of the system according to the degree of urgency and consulting with the budgetary limitations. It is advisable to follow the tentative plan indicated in the attached Table 5-6-2. It is also suggested that contracts with the suppliers of equipment be made in bulk by the turn-key system, thereby expediting the work of construction and clarifying where the responsibility for the work lies.

2-5 Administration plan

In order to enable the systems to give full play to their functions, it is essential to have good administration of them. In the case of the Decca Navigator system for Malacca/Singapore straits in particular, the system is spread over the three littoral countries, and it would be desirable to have a technical agreement of mutual operation and maintenance concluded among the countries concerned. It would be very useful in promoting smooth operation and mutual understanding among the stations to make direct communications possible among these stations.

It would be also important to establish an administrative organisation within each country and for each system it would be required to carry out in good order the preparation of operation and maintenance, rule making of technical regulations, logistic support system, establishment of back-up organisation, personnel training programme, system evaluation plan and guidance of users.

It is also important to notify each vessel of such information as the system mulfunction, but the method should be discussed with the international navigational warning system.

2-6 Charts

The three coastal states; Indonesia, Malaysia and Singapore have, in co-operation with Japan, initiated a project to prepare common Datum charts. Decca charts should also be prepared on the basis of the common Datum charts.

Chapter 3

Introduction

Chapter 3 Introduction

3-1 Purpose of the survey

The purpose of the present survey is to select the integrated navigation system most suitable for the waters of Indonesia, Malaysia and Singapore particularly of Lombok/Makassar straits and Malacca/Singapore straits, and to study the appropriateness of such systems from the technical and economical point of view, and to prepare an overall improvement programme on the basis of such study.

3-2 Progress of the survey

In compliance with a request from the Republic of Indonesia to conduct a feasibility study related to the improvement of electronic navigation systems in Indonesian waters, the Government of Japan organised a survey team with the Japan International Co-operation Agency (JICA) as the executive organ conducted a preliminary survey for 27 days from February 1976 and a regular survey for 117 days from October, 1976.

The envisaged navigation systems in the Malacca/Singapore straits area involve the three littoral countries - the Republic of Indonesia, Malaysia and the Republic of Singapore, and it therefore became necessary to conduct syrvey in these three countries under their agreement.

3-3 Policy of the survey

This survey was carried out in line with the Scope of Work agreed upon at the time of the preliminary survey. This survey consisted of the field survey and the work in Japan. In the field survey, survey was conducted on the present state of shipping traffic and navigation systems, the selection of possible sites for systems, the measurement of radio noise and other matters necessary for the construction of the systems and for the operation and maintenence programme.

In the work in Japan the requirements for the navigation systems applicalbe in the various sea areas concerned were on the basis of results of the field survey; the most suitable systems were selected, the configuration plan, construction plan and administration plan were prepared, and estimated costs were calculated. A study was also made on the economic feasibility of the present project. The actual survey was conducted chiefly in the Lombok/Makassar and Malacca/Singapore straits area.

3-4 Formation of the survey team and the work in the team's charge

In order to conduct the survey effectively, the survey team was divided into four groups of A,B,C and D, and to each group was assigned work to perform.

Group A	4 members	Hyperbolic navigation systems	Lombok/ Makassar straits
Group B	4 members	Hyperbolic navigation systems	Malacca/ Singapore straits
Group C	3 members	Visual aids and electronic navigation systems	
Group D	2 members	Transport and economy	

The members of the survey team are as follows:

Group:	Name:	Organisation to which the member belongs
Head of the Team	Shigeyoshi Toyofuku	Maritime Safety Agency Headquarters, Tokyo
B	Yoshio Nawa	Maritime Safety Agency Hqs, Tokyo
C	Shyoji Kaneko	Maritime Safety Agency Hqs, Tokyo
C	Akiyoshi Arai	Maritime Safety Agency Hqs, Tokyo

A	Yoshio Tanimoto	7th Regional Maritime Safety Hqs.
C	Masamitsu Kobayashi	4th Regional Maritime Safety Hqs.
D	Makoto Washizu	Ministry of Transport
A	Terutaka Terakado	Ministry of Posts & Telecommunications
B	Hidenobu Morohashi	Ministry of Posts & Telecommunications
B	Yoshio Horie	Cona Co., Ltd.
A	Makoto Nikaido	Cona Co., Ltd.
A	Eiichi Sato	Oki Electronic Ind. Co., Ltd.
B	Wataru Ohashi	Fujitsu Limited.
D	Nobuwaka Yamakawa	Pacific Consultant International Ltd.
J	Hiroshi Tsukada	Japan International Co-operation Agency

3-5 Itinerary of the survey

An outline of the itinerary of the survey of each group was as follows:

Group	Oct 76	Nov	Dec	Jan 77	Feb 77	Number of days
A						96 days
B						117 days
C						66 days
D						30 days

3-6 Co-operation of the Government concerned

The Governments of the Republic of Indonesia, Malaysia and the Republic of Singapore kindly extended to the Japanese survey team very efficient and friendly co-operation throughout the term's survey and contributed to the success of the survey, under the sympathetic and zealous understanding of the mission of the team.

Chapter 4

Navigation Aid Systems

Chapter 4 Navigation aids systems

It is one of the basic requirements for vessels in general, while navigating, to find their positions at sea, in order to ensure safe and efficient navigation. Shapes and lights have long been used as aids to navigation of vessels and will no doubt continue to be very useful in the future. It is, however, true that there are certain functional limitations to these visual aids. The range normally covered by light is no better than 30 nautical miles, and in time of poor visibility the light cannot be sighted even from a short distance. It is for this reason that from olden times a great number of vessels have lost their courses and met with accidents and disasters.

It is only 50 odd years since radio waves were utilised to cope with the situation as aids to marine navigation, during which period electronic technology has made quite a remarkable advance, introducing and putting into practical use various new systems one after another. The hyperbolic navigation systems that were developed in the 1940's made it possible for vessels to find their positions with high accuracy. It was indeed great strides from the system by means of direction finding with relatively big errors.

The greatest advantage of the navigation systems using radio waves is that they can be utilised at all times even at a long distance without sight of land or in poor visibility. With a rapid increase in the amount of shipping traffic incidental to the worldwide economic development in recent years, various types of new systems are developed as occasion demands and put into practical use. At the International Meeting on Marine Radio Aids to Navigation 1946 London, a tentative criteria was indicated, with international agreement classifying such systems into the following three groups; those to be used for ocean, those for coastal waters and those for port and harbour areas.

Function	General order of depth of Water	Distance from near-est danger	Order of accuracy required	Order of time available to obtain position
Aid to ocean navigation	Over 100 fathoms	Over 50 miles	± 1 percent of distance from danger	15 minutes
Aid to approaching coastal navigation and port approach	20-100 fathoms	Between 50 miles and 3 miles	± 1/2 mile to ± 200 yards	5 minutes to 1/2 minute
Aid to harbor entrance	Up to 20 fathoms	Less than 3 miles	± 50 yards	Instantaneous position and track required

The ocean area lies far distant from shore and is therefore almost free from hidden reefs and other obstacles. However, such area, of course, needs navigation systems to ensure safe navigation of vessel, which systems are in fact contributing greatly to the improvement and promotion of operational efficiency of the vessels, by informing them of the most economical course to follow. In normal cases errors of 2 to 3 nautical miles in position-fixing are no serious problems in the navigation in the ocean. There is no need for continuous position fixing either.

As electronic navigation systems that have hitherto been used in the ocean, Loran A and Loran C have been playing a major role, but in recent years the Omega Navigation system has been developed and put into practical use as a worldwide system. For some time to come, the Omega system will play a major role as system to be used in the open sea. There has already been a tendency that users are shifting from Loran to Omega.

There is a system comparable to Omega, which utilises artificial satellites system. At the present time NNSS of the United States Navy is the only system of this type in practical use. However, NNSS would rather be used to reinforce other systems because the time interval between measurements is too long for ordinary navigational purposes, especially in low latitude area. It will take some years before satellite navigation system which will have shorter time interval between measurements, is put to practical use.

Coastal waters are areas which include water routes from the ocean to ports, from ports to the ocean, or from ports to ports along the coast line and are usually congested with vessels, large and small. The accuracy in position-fixing, which is required for these waters is less than half nautical mile or even a few hundreds of metres depending upon the circumstances, and in addition, position-fixing should be carried out as frequently as possible.

Navigation systems for use in coastal waters include medium wave radio beacon, Decca Navigator and a few other systems. In the United States, it has recently been announced that the Loran C system which used to be for the ocean and chiefly for military use would now be used to cover coastal waters of the United States while the ocean would be covered by the Omega system. In order to make Loran C available for general users, efforts have been made to reduce the prices of the receivers. Studies are being made in the United States also on a possible use of this system in ports and harbours and narrow channels.

The Decca Navigator system, on the other hand, has been originally utilised for coastal waters and has proved its utility in ports, harbours and narrow channels. This system is used in almost all area of Europe and gradually spreading to many other areas of the world. It is of course desirable from the users'point of view to have a unified system for coastal water use all over the world, but unfortunately it will not be possible to have such system for sometime to come.

With respect to medium wave radio beacons for marine use, the International Convention for the Safety of Life at Sea, 1948 stipulates that all vessels of 1,600 gross tons and upwards, when engaged on international voyages, are required to be fitted with radio direction-finding apparatus. The Convention also requires each Contracting Government to arrange for the establishment and maintenance of aids to navigation including radio beacons and electronic aids as the volume of traffic is considered to justify. Partly because these beacons can be utilised even with relatively simple equipment, there are more than 700 beacon stations currently in operation around the world.

Ports and harbours and narrow-channels are areas where conditions of navigation are most stringent, with the hidden reefs, shoals, bends and a great number of large and small vessels. Most of the marine accidents occur in these water areas. There is also a danger of secondary desaster by oil spillage. The accuracy of position-fixing in these waters should be within several tens of metres and position-fixing should be made continously.

Systems in practical use under these conditions include the foregoing Decca Navigator system and the harbour radar system which provides vessels with information on the movements of vessels, from ashore.
There are also ramark and radar beacon systems; the former being a system to indicate the bearing of a prominent place on the shipborne radar screen and the latter to display the positions of obstacles to shipping traffic.

What is usually required of a modern port is the consolidation and furnishing of wharfs, loading and unloading facilities, warehouses and transportation facilities, but it is the furnishing of navigation systems that counts most, to ensure safe passage of vessels to and from such port.

A typical example of this can be seen in the No.1 port of the world, Europoort, the Nethlands. This port adopts a unique configuration of the Decca Navigator system to cope with the approaches restricted and bended fairways to the port, and vessels equip themselves with Decca receivers with simple Brown Box attached, to detect deviation from their course. In addition. there are radar stations to watch the movements of vessels at all times. Pilots on board keep contact with these radar stations to ensure safe navigation of the vessels they pilot. There are of course well furnished lighthouses and also leading lights at critical points to show fairways to the port. The adept combination of these various types of aids to navigation has contributed immensely to making the port a safest and greatest port of the world.

Thus, there is a big difference in the accuracy required by vessels in position-fixing according to the object of navigation and environmental conditions, and in selecting a suitable navigation system, careful study should be made of any systems needed by vessels on the functions, universality, future possibility, reliability and overall economical character of such system. In addition, the establishment of a system should be planned on the basis of a long term view as a part of the national policy.

Chapter 5

Establishment of Electronic Navigation Systems

Chapter 5 Establishment of electronic navigation systems

5-1 System design

5-1-1 Criteria for selecting electronic navigation aid system

(1) Matters to be considered in the selection of a system

Major requirements to be considered in selecting optimum electronic navigation systems are generally as follows:

1) The system should be of universelity

The users of such system are vessels navigating in waters of the world. The safety and effectiveness of navigation, using such system, have been appreciated and selected historically by the users across the world. A comparative study should also be made on the situation in which such system in being used, i.e. in what country is such system being used? . Who is operating and maintaining such system? What about servicing for the system and who are the users of the system? Besides, it would be necessary to foresee the future trend.

2) The system should have superior performance

Under the due consideration of the waters in question, the required performance of the system should be defined by the type, tonnage and size of the vessels using it and the navigable width of the channels they are using, and then the optimum system for the waters should be selected to meet the requirements.

a) Capability of obtaining the required accuracy in position fixing

The accuracy required in the sea area in question should be established in the first place. Then the accuracy of each system should be calculated theoretically and compared with that of other systems. The factors to influence the accuracy are roughly divided into the following three groups:

i) Those by the performance of transmitting equipment

ii) Those by propagation paths of radio wave

iii) Those by the performance of receiver

These factors should be considered collectively to find out a system which could provide the required absolute accuracy and repeatability.

b) Capability of obtaining required and sufficient service area

There is naturally a limitation in the effective area of propagation of radio wave. The service area changes with the way of propagation of the radio wave which the system in question is utilising, with frequencies, transmission output and type of transmission.

It is of course desirable that the system can cover wide service area, providing users with high degree of accuracy in position-fixing, but the general objective is to obtain required accuracy in the required sea area.

c) High reliability and easy maintenance

However high the accuracy a system could provide theoretically may be, such system would be insignificant in practical use if it cannot provide stable service at all times. Most of the factors that would affect the stability of a system are environmental conditions of the equipment and fluctuations in the state of radio wave propagation. The fluctuations are particularly severe in the tropical zone and this must be carefully studied in considering the reliability of a system. It is also necessary to make a comparative study of the effect on the system by a trouble in the equipment and the easiness or difficulty in taking counter-measures therefor.

3) The facility should be economical

In considering the relative difficulty of the effect and method of investment, comparison should be made on the capital cost and operation/maintenance (O/M) cost of the transmission side (shore facilities) and the capital cost and O/M cost of the receiving side (shipborne equipment). In a system widely spread in the world, users are already equipped with receivers for such system, and therefore once the equipment on the transmitting side is completed, the system will be used by many vessels.

(2) Required accuracy for position-fixing

In (1) 2) a) above reference was made to the required accuracy in position fixing of vessels, but what would the actual value be?

The required accuracy in position-fixing varies with the area; Whether it is a narrow channel, coastal waters or wide sea area.

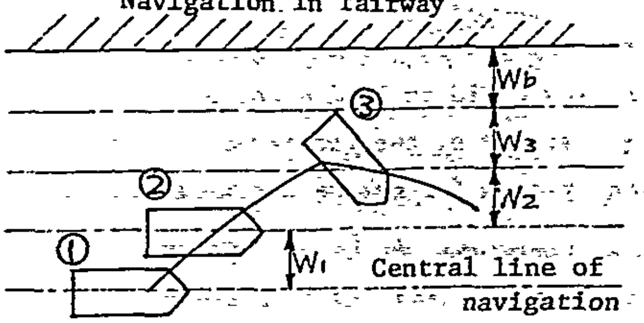
In 1946 the International Meeting on Radio Aids to Marine Navigation was held in London and at this meeting the following criteria of the requirements for electronic navigation systems for marine use were indicated:

Requirements for electronic aids to navigation

Distance	Functions	Shortest distance to obstacle	Required accuracy	Time required for position-fix
Long distance	Aids to navigation in outer sea	50 nautical miles or over	± 1%	Within 15 minutes
Medium distance	Aids to navigation in the approach to land or port	50 3 n.m.	± 1 n.m or 200 metres	5 min. to 1/2 min
Short distance	Aids to navigation in port and harbour or at the time of entering port	Within 3 n.m	± 50 metres	Instantly

For the first time the criteria were clearly established for classifying electronic navigation systems by their different usages. In the following paragraphs a few remarks will be made about the required accuracy in a narrow channel where requirements are most strict.

1) The sketch below illustrates the case where a vessel navigating in Waterway (1) is driven out by wind and current to Position (2) and there the vessel takes notice of the deviation in the course and tries to shift the helm. The helm, however, does not work immediately, and after certain seconds, the helm now works and the vessel starts to manoeuvre at Position (3), resuming its original course.



The required width of the waterway in this case is expressed by the following formula:

$$W = 2(W_1 + W_2 + W_3) + W_b + 2(W_1' + W_2' + W_3') + W_b' + W_s \quad \ldots\ldots\ldots (1)$$

Where W = Width of waterway

W_1, W_1' = Required accuracy indicated by probability of 95% value

(' indicates cases of huge vessels)

W_2, W_2' = Ranges of delay according to the manoeuvrability of a vessel

W_3, W_3' = Amount of kick at the vessel's turning

W_b, W_b' = Bank clearance

W_s = Ship clearance

In a narrow channel, when wind velocity (V_a), tidal current (V_c), manoeuvrability (T), breadth of the vessel (B) and wind pressure co-efficient (C) are taken into consideration in the above formula, the formula in the case of one way traffic will be:

$$W = 2\left\{W_1 + (CV_a + V_c)T + 0.9B\right\} + 1.8B \quad \ldots\ldots\ldots\ldots (2)$$

Suppose a tanker of 200,000 tons transits a narrow channel, and V_a = 20 m/s, V_c = 0.5 m/s, T = 200 S, B = 50 m, W = 1,000 m and C = 0.06, and then the required accuracy should be

$$W_1 = 70 \text{ metres}$$

This appears to be quite logical, but is nothing but a tentative plan.

2) There are several elements for determining the reduced scales of a chart, and vessel position-fix entry error is one of them. The scale of the Japanese chart of Singapore Strait was decided to be 1/50,000 after consultation with old-timer shipmasters of the Japan Captains'

Association. A position-fix error of 1mm on the chart would be 50 metres in actual error. This value is considered to be the minimum value of the required accuracy.

Apart from the foregoing, Japanese captains were once asked about the accuracy they considered necessary in transiting the Strait of Singapore, and they answered the accuracy should be something similar to the breadth of the vessel. The breadth of a 200,000 ton-class vessel is approximately 50 m. This appears to be an unscientific value, relying just upon the "hunch" of the old-timer shipmasters, but the hunch of the well experienced captains is considered to be considerably reliable in most cases.

The report (1974 No.12) prepared by the International Oil Tanker Committee (IOTC) cites an example of navigation in Rotterdam traffic route, in which the maximum divergence in the ship's position against the route axis proved to be almost equal to the breadth of the vessel, i.e. approximately 50 metres in the case of a 200,000 ton vessel.

3) Here is another way of expressing the hunch of the experienced captains. When they were asked a question about the required accuracy for position-fixing in the event of the separation scheme being established, they answered that when they would be alone in the route, the accuracy should be 1/4 of the width of the route and when more than one vessel would be present in the route, then the accuracy should be 1/10 of the route width. The abovementioned international organisation IOTC expresses the required accuracy the other way around; the minimum width of the separation route should be four times the breadth of the vessel.

From all the above ideas, it can be considered that the accuracy in fixing vessels positions in a narrow channel should be something around 50 m.

Incidentally, the repeatable accuracy required by a fishing vessel dragging a fishing net is said to be 50 m to 100 m, although this accuracy is slightly different in meaning from the accuracy discussed above.

Accoding to the captains, a quarter of a nautical mile would be quite enough for the accuracy in position-fixing in a relatively wide sea area such as in Lombok and Makassar straits.

5-1-2 Selection of hyperbolic electronic navigation systems

(1) Introduction

The hyperbokic electronic navigation systems which are considered applicable in the area in question are the Decca Navigator system and the Loran C system. In this section is made a comparative study of these two systems.

(2) Principles of hyperbolic navigation and comparison of systems

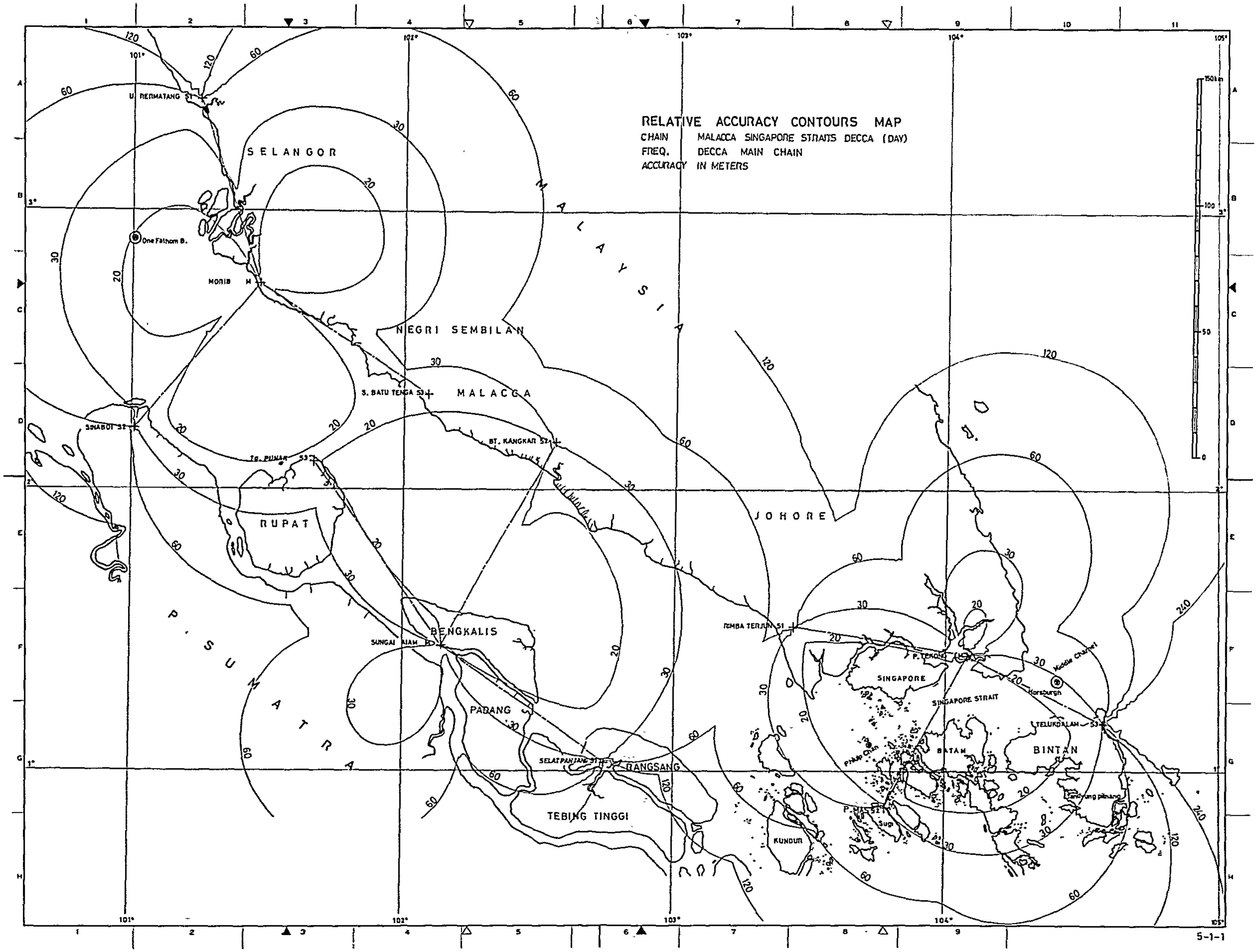
The principles of hyperbolic navigation and the two representative systems of hyperbolic navigation, Decca and Loran C and comparison between these two systems are described in detail in 5-1-3.

(3) Errors

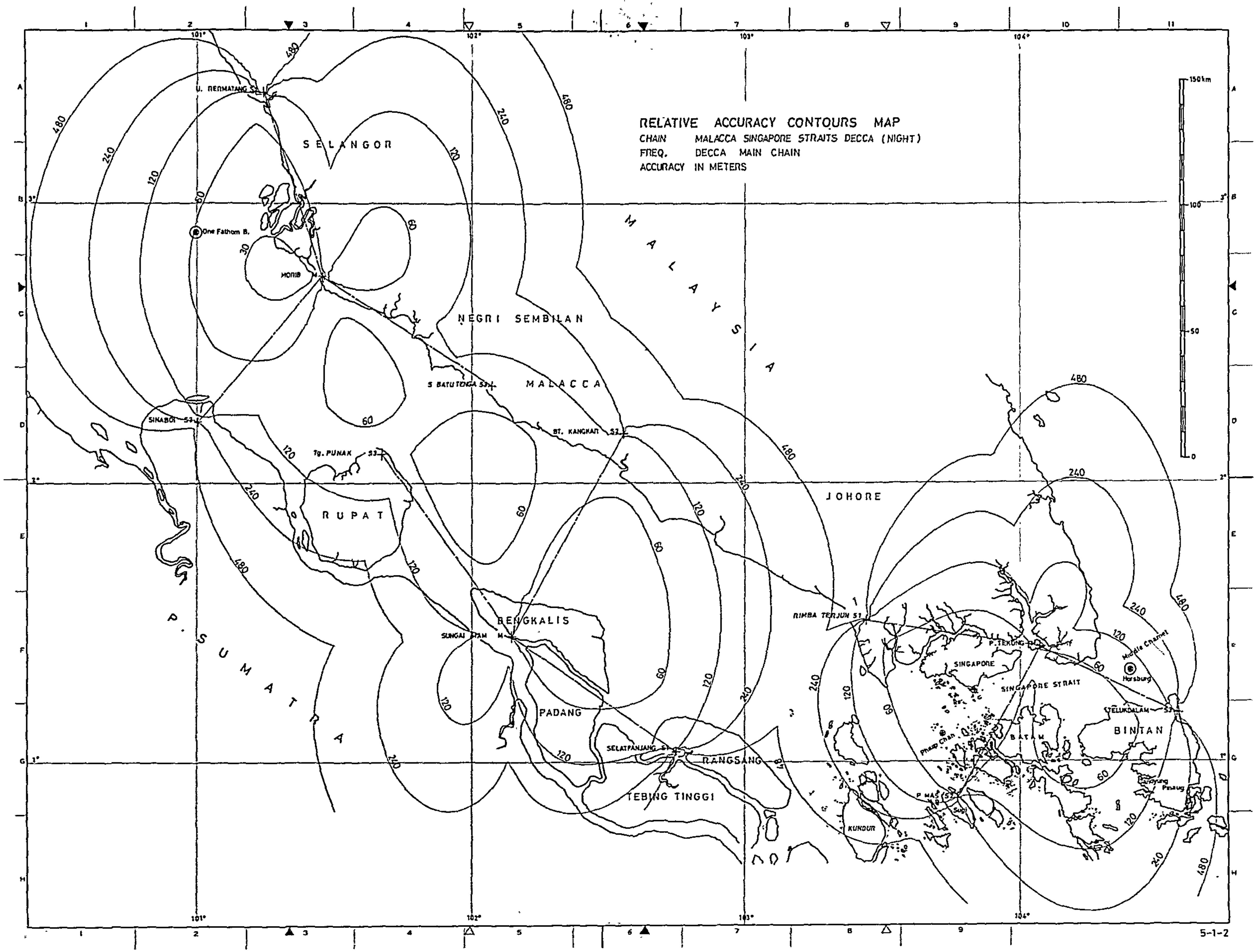
It is a usual practice to evaluate errors of these systems in the form of circular errors just for the sake of convenience. In this section an analysis has been made on errors of both Decca and Loran C, using computer in accordance with the method of analysis described in Chapter 2 of Appendix A. The result of the analysis is as shown in Fig. 5-1-1 and Fig. 5-1-2 for the Decca system and Fig. 5-1-6 for the Loran C system.

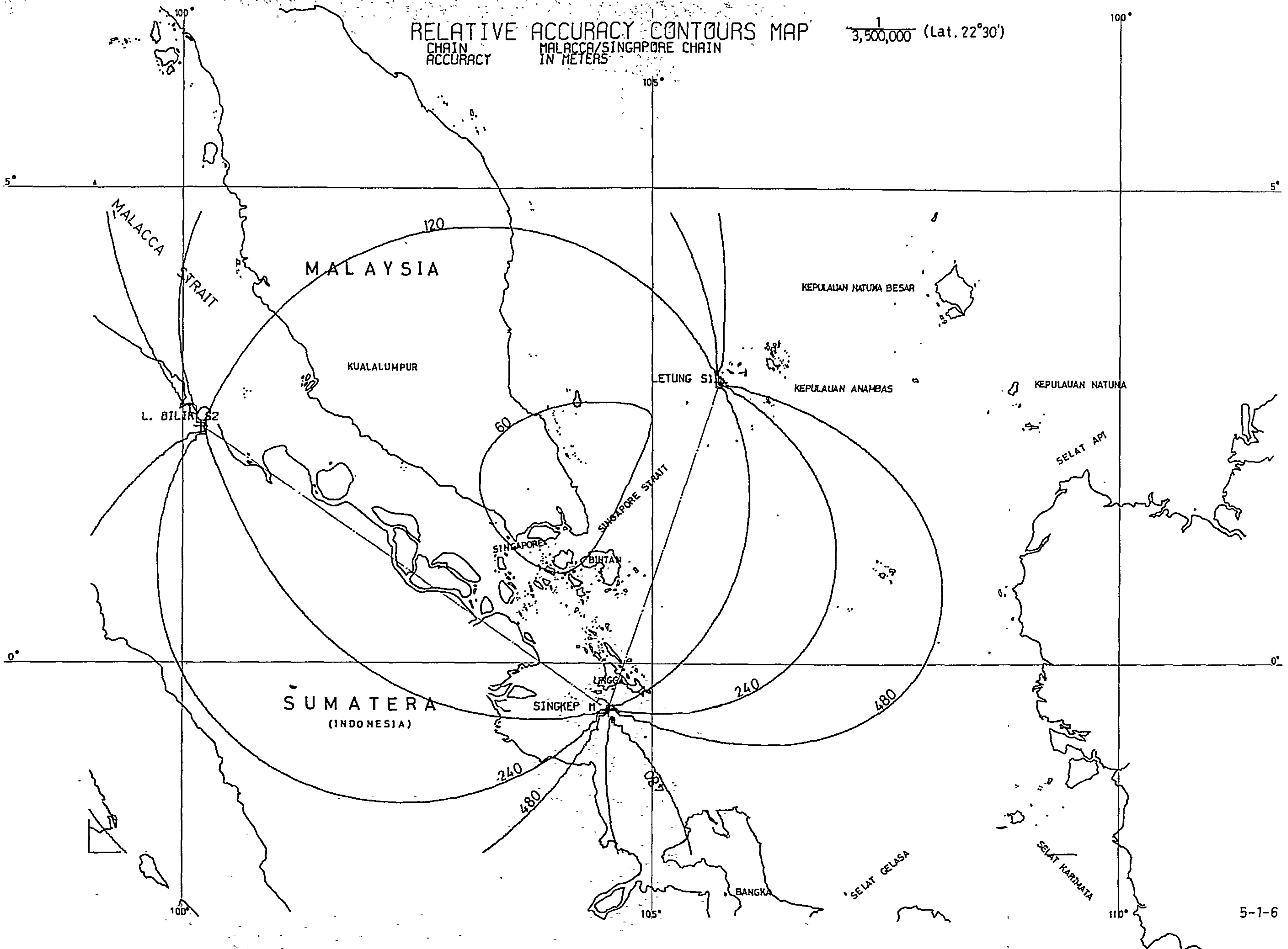
(4) Redundancy of the system

Normally, a Decca chain is so designed that it will cover accurately a small area. For this reason, redundancy is somewhat added with regard to the configulation of the chain. For example, in the event of an off-air in one of the Singapore stations as shown in Fig. 5-1-10 through Fig. 5-1-12 consideration is taken so as not to stop the whole service although it will degrade to some extent the positioning accuracy. In the transitional area between the Decca stations in Malacca Strait, both Decca chains can be used.


RELATIVE ACCURACY CONTOURS MAP
CHAIN MALACCA SINGAPORE STRAITS DECCA (DAY)
FREQ. DECCA MAIN CHAIN
ACCURACY IN METERS
SELANGOR
NEGRI SEMBILAN
MALACCA
MALAYSIA
JOHORE
RUPAT
P. SUMATRA
BENGKALIS
PADANG
TEBING TINGGI
RANGSANG
SINGAPORE
SINGAPORE STRAIT
BATAM
BINTAN
KUNDUR
One Fathom B.
Horsburgh
Middle Channel
S. BATU TENGA 53
BT. KANGKAR 52
SELAT PANJANG 51
TELUKBALAM 53
101°
102°
103°
104°
105°
3°
2°
1°

5-1-1


RELATIVE ACCURACY CONTOURS MAP
CHAIN MALACCA SINGAPORE STRAITS DECCA (NIGHT)
FREQ. DECCA MAIN CHAIN
ACCURACY IN METERS
SELANGOR
NEGRI SEMBILAN
MALACCA
MALAYSIA
JOHORE
RUPAT
BENGKALIS
PADANG
RANGSANG
TEBING TINGGI
P. SUMATRA
SINGAPORE
SINGAPORE STRAIT
BATAM
BINTAN
KUNDUR
One Fathom B.
Horsburg
Middle Channel
RIMBA TERJUN
SELATPANJANG
SUNGAI SIAM
P. TEKONG
TELUKDALAM
S BATUTENGA
BT. KANGKAN
SIKABOI
Tg. PUNAK
150km
100
50
0
101°
102°
103°
104°
3°
2°
1°



RELATIVE ACCURACY CONTOURS MAP
1/3,500,000 (Lat. 22°30')
CHAIN MALACCA/SINGAPORE CHAIN
ACCURACY IN METERS
100°
105°
110°
5°
0°
MALACCA STRAIT
MALAYSIA
KUALALUMPUR
L. BILIR S2
LETUNG S1
SINGKEP M
SINGAPORE
SINGAPORE STRAIT
BINTAN
LINGGA
SUMATERA
(INDONESIA)
KEPULAUAN NATUNA BESAR
KEPULAUAN ANAMBAS
KEPULAUAN NATUNA
SELAT API
BANGKA
SELAT GELASA
SELAT KARIMATA
60
120
240
480

5-1-6

5-1-3 Comparison between Decca and Loran-C

The Loran-C system is an electronic navigation aids system suitable for covering a large area with medium accuracy and the Decca system covering a relatively small area with high accuracy. The Loran-C system has developed for the purpose of extending the coverage of Loran-A system. Almost all Loran-C stations in the world have been established and operated by the United States Coast Guard.

Recently, the U.S.C.G. has decided to adopt the Loran-C system as the navigation aids system for the coastal confluence zone of the U.S. under the National Plan (Federal Register Doc. 74-16557), and discontinue the operation of Loran-A stations.

They had compared several systems for their suitability to high accuracy coastal navigation aids system. Those systems were Loran-C, Decca and Differential Omega. Loran-C was chosen mainly because there were economic advantages gained by a minimum number of transmitting stations to cover the entire US coast line. Decca was the 2nd choice and the 3rd system studied namely Differential Omega obtained only a small support. Loran-A was excluded because of its lack of accuracy.

In the past, the Loran-C system was not a preferable navigation system for commercial use because of high price of the receivers, etc. However, the U.S.C.G. had made great deal of effort to cut down the cost of Loran-C receiver and to stabilize the performance of transmitting equipments. As the result, the Loran-C system became to satisfy the requirements for the purpose.

In selecting a hyperbolic navigation system suitable for Malacca/Singapore and Lombok/Makassar straits, it was concluded that both of the Loran-C system and Decca Navigator system should be studied here as the candidate systems in recognition of its performance and all circumstances in recent years. Therefore, the proposed site survey was conducted for both systems.

The following is a comparison between the two systems in various points of view such as performance, reliability, universal character, economical efficiency, future possibility, etc:

(1) It is thought that both systems will be able to provide the accuracy required in Malacca/Singapore and Lombok/Makassar straits if special consideration is given to those configurations.

(2) In the case of a general configuration, Loran-C has the ability to cover a large area (For example, all of the Indonesian, Malaysian and Singapore waters), and Decca has the ability to cover relatively small area (For example, Malacca/Singapore and Lombok/Makassar strait waters) but with a higher accuracy.

(3) When we consider the construction cost and O/M cost with the coverage area, Loran-C will have an advantage compared with Decca. But when we concentrate our eye on a required small area, Decca will have the advantage. The value of the additional coverage outside the area of the Straits provided by Loran-C is worthwhile. But it is the worldwide trend to use the Omega system for the ocean navigation.

(4) It would be possible to configurate the Loran-C stations (For example, establishing many shortened base-line chains, the so-called minor chains) to obtain nearly the same accuracy as Decca in a certain small area such as a narrow channel, but the construction and O/M costs would be increased and there would increase the risk of cross rate interference.

(5) In a general concept, the service area of Decca is smaller than that of Loran-C. This means Decca will need to construct more stations than in the case of Loran-C. However, taking another point of view, the Decca configuration has a redundancy advantage, that is, a failure of a slave station would reduce the overall coverage but by a small amount and still provide fixing coverage of a lower accuracy. With regard to

the Decca chain construction schedule, it is possible to establish this in stages according to chain priority. In other words, it is possible to invest in stages and, therefore, it is easier than Loran-C to make a construction plan.

(6) Certainly, Loran-C and Decca are two coastal navigation systems of high accuracy. However, considering the expansion of Decca chains and Loran-C chains and the number of users throughout the world, the Decca System will be more practical.

(7) Comparative tables between two systems are as follows. Both system have merits and demerits and there is no absolute superiority in them. However, a comprehensive study shows the Decca system should be recommended.

1) Universal character

Comparative item	Decca	Loran-C
Time of when put in practical use	Developed in World War II and introduced in 1946 as a civil navigational aid.	Practically used from 1956 as a military system.
Operating states Number of countries operating	22 countries	2 countries
Number of chains in operation	42 chains (8 new chains are under construction in 4 countries)	14 chains (2 chains of U.S.S.R. are not opened to public)
Number of commercial type receivers in use	23,000 sets approx.	3,500 sets approx.
Users of the system	Passenger ships, freight ships, tankers, fishing vessels and so on.	Passenger ships, freight ships, tankers, fishing vessels and so on.
Expansion of the system (1972 - 1976)	14 chains	4 chains (5 chains opened 1 chain closed)

2). Specifications and dimensions

Comparative item	Decca	Loran-C
General		
Mode of propagation	Ground wave	Ground wave
Frequencies	70~130 KHz	100 KHz
Band width	10 Hz	20 KHz
Type of modulation	Continuous wave multi-pulse	Pulse
Radiation power	200 w (nominal)	400 kw (nominal)~1 Mw
Transmitting equipment		
Transmitter output	1.2 kw	570 kw~1.5 Mw
Cooling system	Natural air-cooling	Forced water-cooling
Transmitting Aerial		
Type	Umbrella aerial supported by guyed tower	Umbrella aerial supported by guyed tower
Height	110 m	190 m
Earth system	Buried radial earthing (approx.100m in radius)	Buried radial earthing (approx.100m in radius)
Receiver	Single superheterodyne linear amplification 4 channel system	Mostly hard limiting amplification 1 channel time shared system
Configuration of system	Suitable to cover a small area such as narrow channel with high accuracy since the short base-line is at the advantage in principle.	Suitable to cover a large area with a long base-line.

3) System error

Comparative item	Decca	Loran-C
Effect of propagation path	Decca is less affected when the electric constants(ε,σ) of propagation path change, because of a small service area and, therefore, the error is small. The absolute error based on change of secondary phase factor can be diminished to neglectable degree by carrying out correction at a monitor station because of short propagation path.	Loran-C is largely affected as compared with Decca when the electric constants(ε,σ) of propagation path change, because of a large service area and, therefore, the error is big. Because of a long propagation path, Loran-C is largely affected by variation of electric constants in mixed path of land and sea, and it is difficult to provide proper ECD over coverage area with data from limited monitor stations and results in incorrect cycle identification giving larger error.
Skywave effect	Skywave effect is unavoidable during the nighttime at the point of more than a certain distance from the station.	This system can eliminate skywave effect in medium distance. Theoretically, this system is never bothered by skywave, but in practice the capability of the Loran-C receiver's ground/skywave identification range can be greatly reduced according to the characteristics of transmission paths.
Resolution on base line	4.1m (red pattern) 5.5m (green pattern) 3.5m (purple pattern)	15m
Effect by noise		
(Band width)	(narrow)	(wide)
Impulsive noise	Small	Large
Inductive noise	Scarcely affected	Badly affected
Interference between chains	Not exist	Exist (especially at night)

(4) Reliability

Comparative item	Decca	Loran-C
Reliability of transmitting equipment		
Off-air hours by failure	Less than 10 minutes annually according to the Decca chain field data throughtout the world.	More than 7 hours annually according to the Loran-C chain field data in Europe.
Wave-form distortion of radiation power	No problem because of continuous-wave	Because a constant, Q,etc. in the aerial system changes according to change of weather conditions, which is difficult to be conpensated fully, distortion in the wave-form occurs and, therefore the error is caused by this.
Others	Multi-module system is adapted and in the event of failure in one of them, the off-air does not occur.	Because of pulse transmission system it is difficult to adapt the multi-module system.
Reliability of receiving equipment		
Specifications of receiver	Standardised by the specifications of the Decca Navigator Company throughout the world.	Because lack of standardised specifications, accuracy is different between receivers.

5) Economical efficiency

Comparative item	Decca	Loran-C
Transmitting equipment		
General discussion	Construction and maintenance cost per station of the Decca system is much lower than that of the Loran-C system, and in the case of a system to cover relatively a small area, Decca is more economical than Loran-C.	Because large coverage area can be obtained with less number of the stations, in the event that the large coverage area is required, Loran-C is more economical than Decca.
Expenses		
Suppose 23 Decca stations or 9 Loran-C stations will be established in Malacca/Singapore and Lombok/Makassar straits, the ratio of total cost of transmitting equipment (facilities cost + 10 year operation/maintenance cost) will be as follows:		
Total cost	575	720 (720/575 = 1.25)
Facilities cost/St.	13	40
10 year O/M cost/St.	12	40
Total cost/St.	25	80
Receiver		
Price	$ 2,000/year as a rental value	Economical type: $ 4,000 ~ 6,000 High-class type (receiver for military use): $20,000 ~ 100,000

5-1-4 Medium wave radio beacon

(1) Its importance and role

Medium wave radio beacon is one of the aids to navigation suitable for coastal use. It has an advantage that relatively accurate bearings can be obtained by this beacon for longer ranges than visual aids as well as even under the poor visibility conditions.

The importance, role and requirements of the medium wave radio beacon are similar to those of the visual aids, but the conditions under which this type of beacon should be established are as follows:

1) There are many medium wave radio beacon stations for aircraft use (NDB's) in the areas concerned. Vessels can utilise the service provided by these stations. These NDB's should therefore be properly charted and also listed in the Light List or list of Radio Signal Stations. This is clearly indicated in the International Hydrographic Bureau (IHB) Technical Resolutions B37 and E6.

2) The existing radio beacon stations for aircraft use which are located in the places vital also for marine traffic should advisably be made to provide a 24 hour service and made available to vessels navigating in the area at all times.

3) Medium wave radio beacon stations should be established in the approaches to the straits or important turning points to enable vessels to take two points bearings, while taking into consideration the types of vessel and peculiarity of the area.

4) A medium wave radio beacon station shall be installed in the proximity of an existing lighthouse. It would thus be convenient for the maintenance and operation.

5-1-5 Ramark

Ramark is a radio navigation aid to indicate the direction of its station by a bright dash line on the shipborne radar PPI (plan position indicator). It is advisable to install this system in an existing lighthouse where personnel and electric power are available for operating this system. During the recent field survey, the survey team could not hear comments from radar-fitted vessels and obtain photographs of radar images and other data. Efforts will be made to continue study of this sytem in the future.

5-1-6 Radarbeacons

Radarbeacon is a radio navigation aid by which a vessel fitted with radar can find its position on PPI. The purpose of this station is to indicate hazard, a small land or rock which are the useful target for navigation. The conditions under which this type of system should be installed are quite similar to the Ramark mentioned above.

5-1-7 Configuration plan

(1) Introduction

The following principles have been taken into consideration in making the configuration plan:

a) For the major sea area in the Straits, the configuration of Decca stations has been so planned that required accuracy (50m or more) is available at any time.

b) For the area where traffic separation scheme is contemplated to cope with a great number of transit vessels, the Decca Navigator system should be installed to provide high degree of accuracy. It has also been planned to make navigation through narrow channels possible along the L.O.P. of the Decca chains.

The configuration plan as shown in Fig. 5-1-7 has been prepared on the basis of the above consideration.

(2) Configulation of the Decca system

1) Planned Decca chains

The configuration of the Decca chains to be recommended is as shown in the following table:

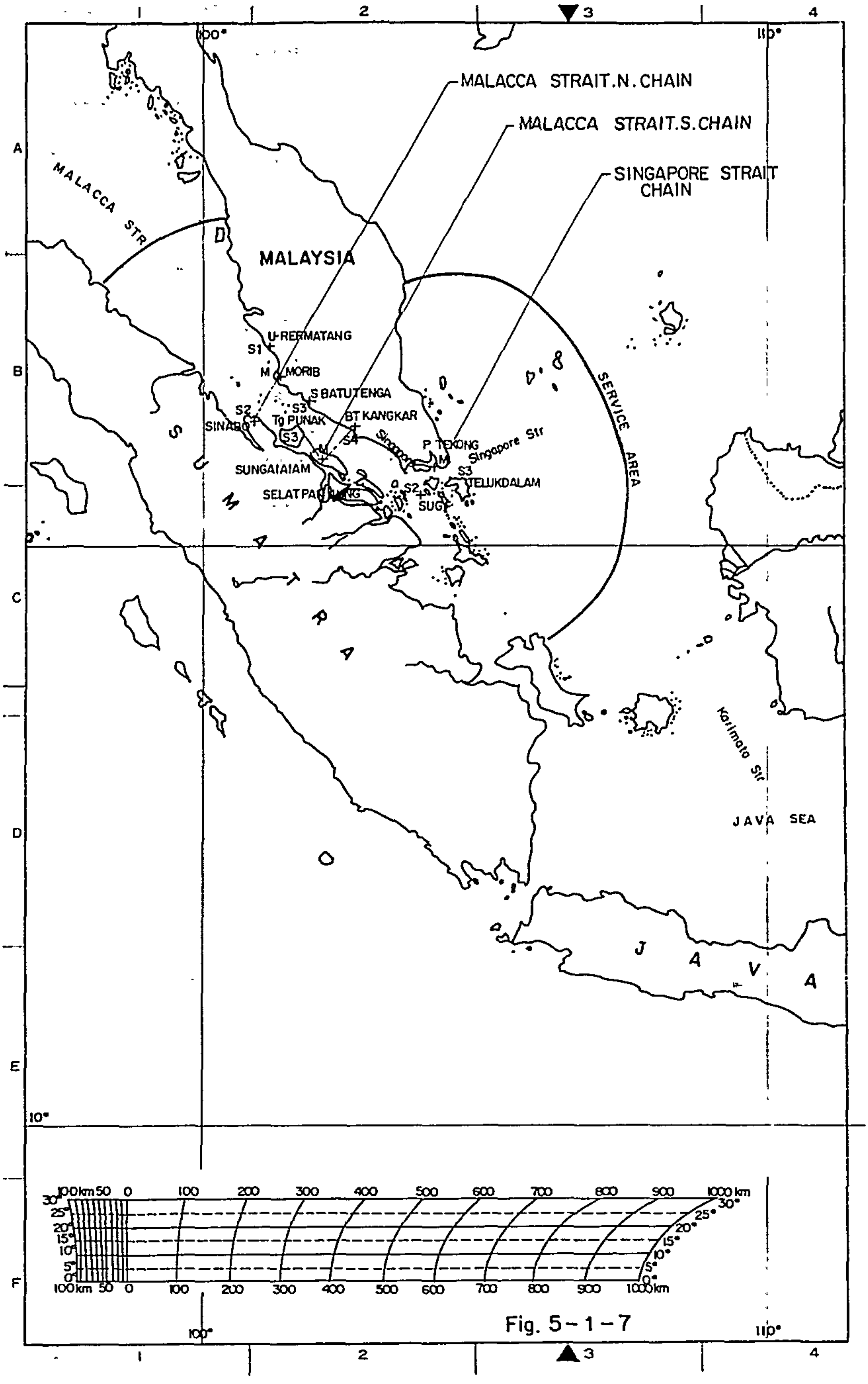

MALACCA STRAIT.N.CHAIN
MALACCA STRAIT.S.CHAIN
SINGAPORE STRAIT CHAIN
MALACCA STR
MALAYSIA
SUMATRA
SERVICE AREA
U-PERMATANG
MORIB
S BATUTENGA
BT KANGKAR
To PUNAK
SINABO
SUNGAIAIAM
SELATPANJANG
P TEKONG
Singapore Str
TELUKDALAM
SUGI
Karimata Str
JAVA SEA
JAVA
100°
110°
10°

Fig. 5-1-7

Table 5-1 Decca chains to be recommended

Name of chain	Type of station	Name of place	Latitude	Longitude
Singapore Strait Chain	Master	P. Tekong	01 - 25.1N	104 - 04.9E
	Red slave	Rimba Terjun	01 - 30.2N	103 - 27.1E
	Green slave	P. Mas	00 - 53.0N	103 - 46.2E
	Purple slave	Telukdalam	01 - 09.9N	104 - 34.9E
Malacca Strait South Chain	Master	Sungai Aiam	01 - 27.2N	102 - 09.2E
	Red slave	Selat Panjang	01 - 02.4N	102 - 45.2E
	Green slave	Bukit Kangkar	02 - 10.7N	102 - 33.7E
	Purple slave	Tg. Punak	02 - 06.2N	101 - 41.0E
Malacca Strait North Chain	Master	Morib	02 - 44.6N	101 - 27.7E
	Red slave	Ujong Permatang	03 - 23.7N	101 - 15.2E
	Green slave	Sinaboi	02 - 14.2N	100 - 59.7E
	Purple slave	Batu Tengah	02 - 20.7N	102 - 04.2E

It would involve many economical problems to implement all the foregoing plans at a stroke. The plans should be more advisably put in practice gradually, keeping in perfect step with and a little ahead of the progress in marine and air transportation and fishing industries.

2) Error of each Decca chain

Error figures calculated in accordance with the method of analysis described in Chapter 2 of Appendix A are listed as shown in Table 5-2. As shown in Fig. 5-1-8A and Fig. 5-1-9A is digitalized expression of error as for part of the area covered by Fig. 5-1-8 and Fig. 5-1-9.

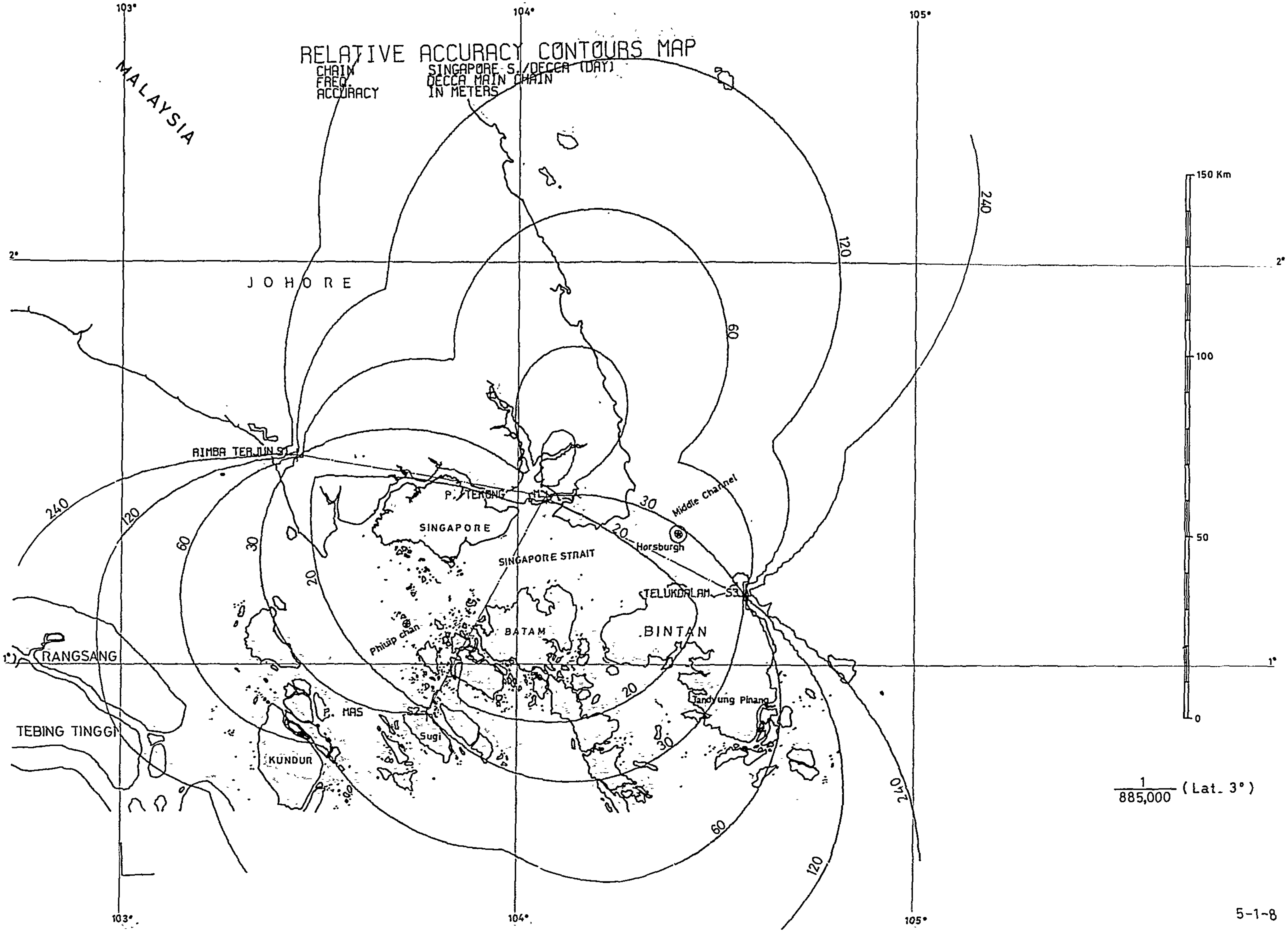
3) Latice chart of Decca chain.

As seen from the suggested Malacca Strait North Decca Chain and Malacca Strait South Decca Chain, the configuration is made so that the chains are composed of stations traversing the straits. One of the these lines of position is expected as going along the fairway as shown in the lattice charts of Fig. 5-1-24 and Fig. 5-1-25 and thus navigation of vessels would be easy. In addition, the errors in the direction of fairway width can be improved to something between 50% and 70% of the value indicated by circular errors. For reference, lattice charts of Decca chains are shown in Figs. 5-1-23 through 5-1-28.

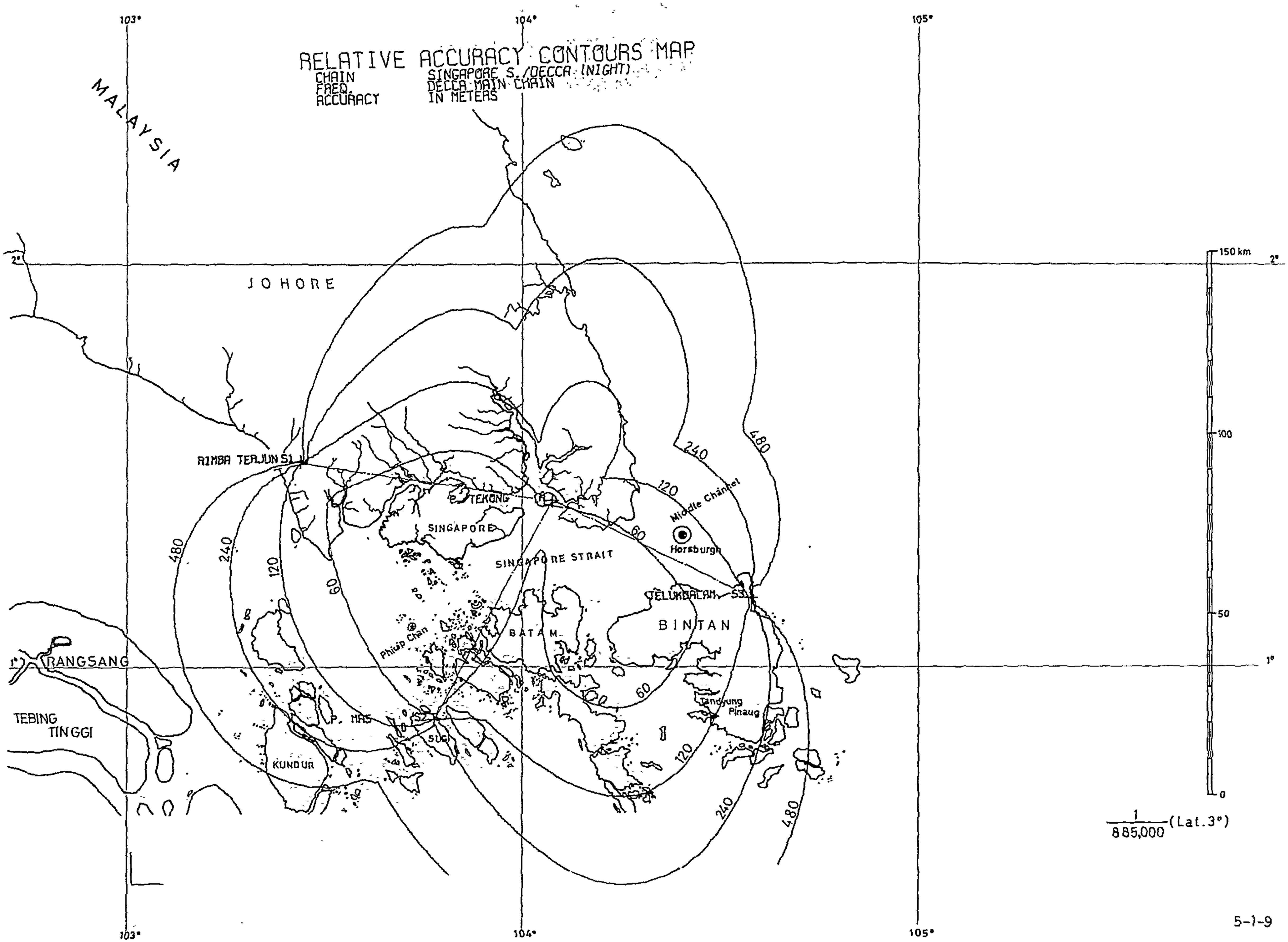
Table 2

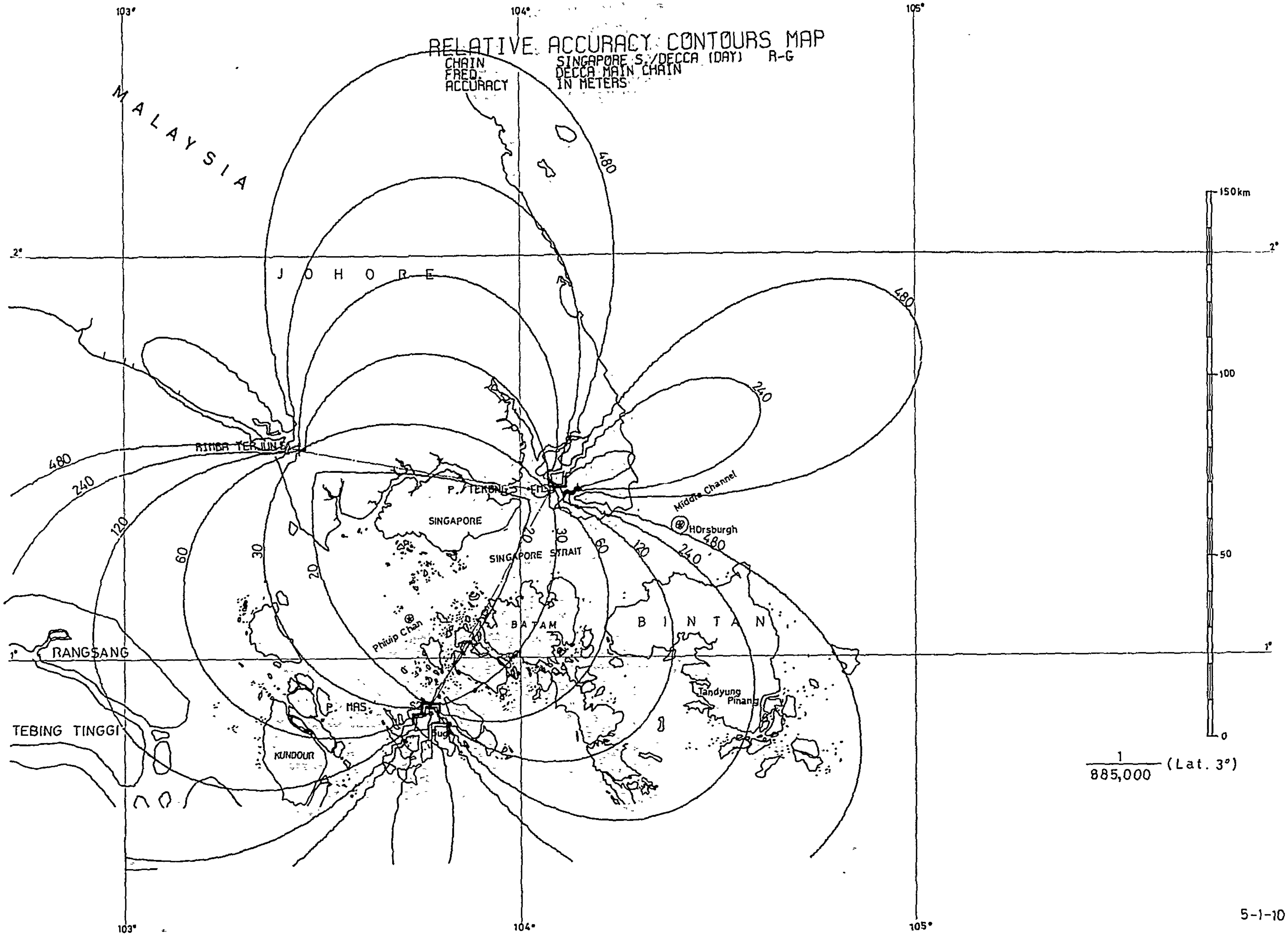
Identifying no. of drawing	Type of System	Name of chain	Day/Night	Remarks
5-1-8	Decca	Singapore St.	D	
5-1-9			N	
5-1-10		Singapore St.	D	Red-Green (Off-air at Purple)
5-1-11			D	Green-Purple (Off-air at Red)
5-1-12			D	Red-Purple (Off-air at Green)
5-1-13		Malacca St. South	D	
5-1-14			N	
5-1-15		Malacca St. North	D	
5-1-16			N	

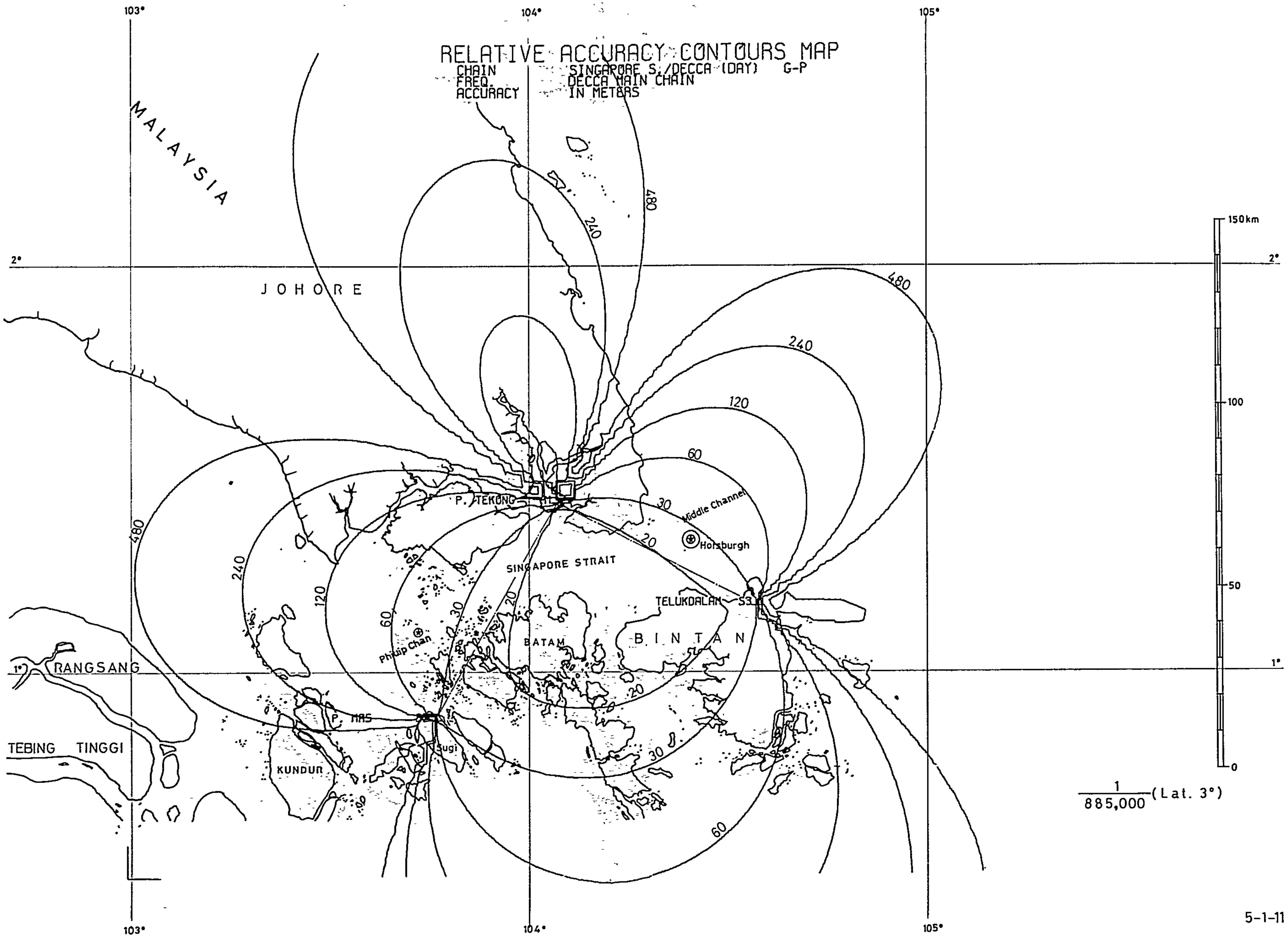
5-1-8A		Singapore Strait Central part	D	Digitalized expression of error
5-1-9A			N	

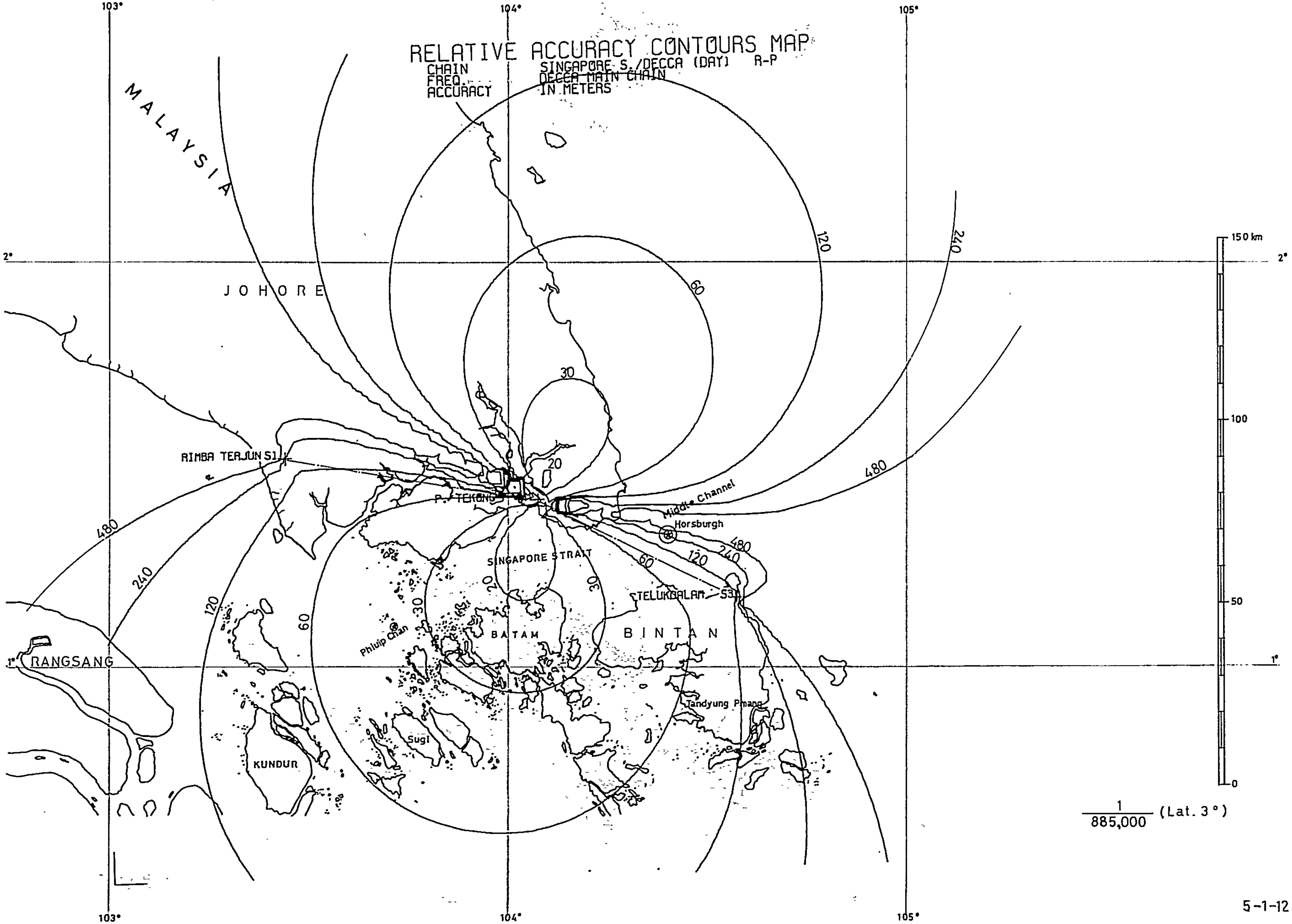

RELATIVE ACCURACY CONTOURS MAP
CHAIN SINGAPORE S./DECCA (DAY)
FREQ. DECCA MAIN CHAIN
ACCURACY IN METERS
103°
104°
105°
2°
1°
MALAYSIA
JOHORE
RIMBA TERJUN S1
P. TEKONG
M
SINGAPORE
SINGAPORE STRAIT
Middle Channel
Horsburgh
TELUKDALAM S3
BINTAN
BATAM
Philip chan
RANGSANG
TEBING TINGGI
P. MAS
S2
Sugi
KUNDUR
Tandjung Pinang
20
30
60
120
240
150 Km
100
50
0
1/885,000 (Lat. 3°)

5-1-8

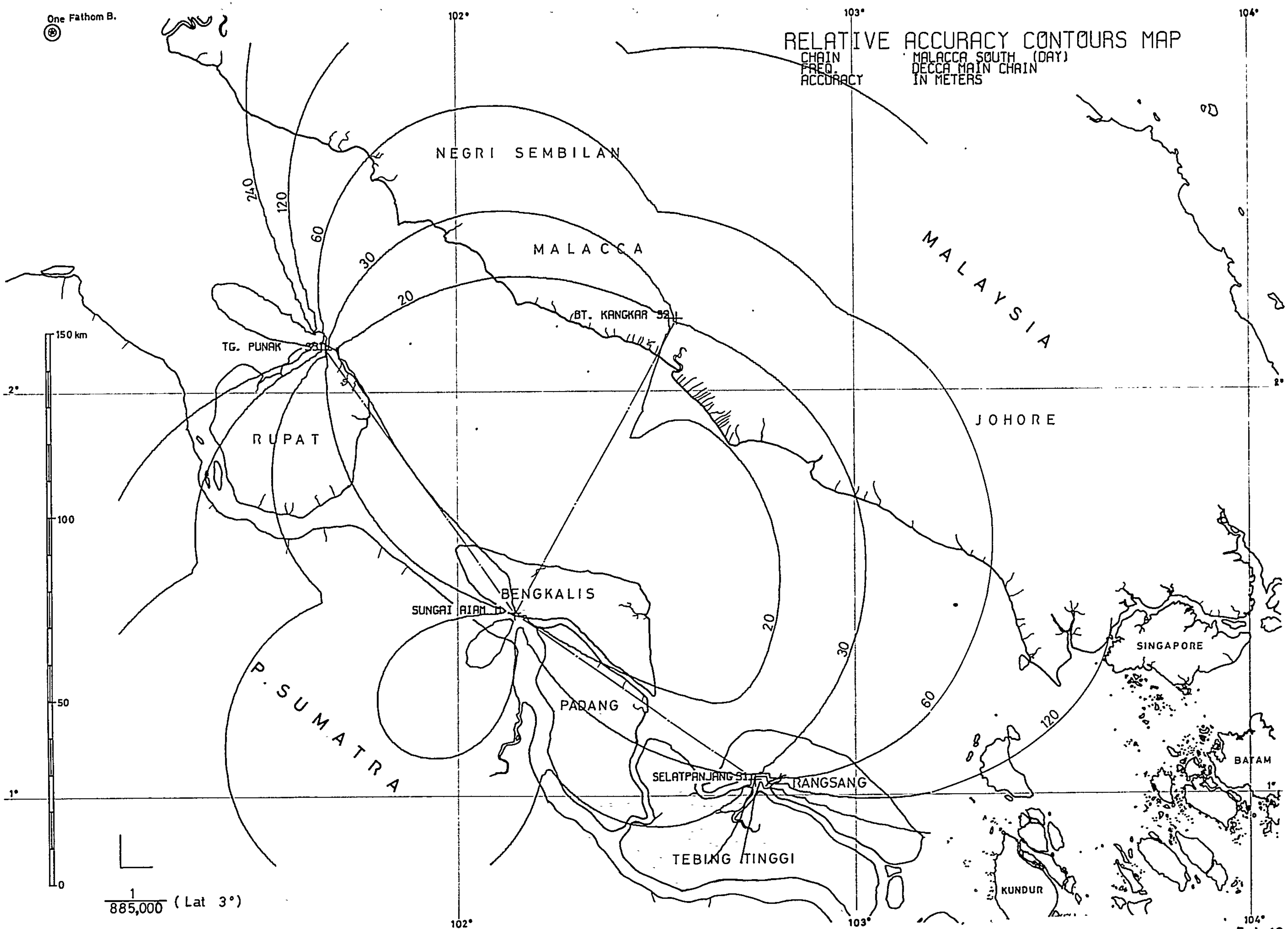

RELATIVE ACCURACY CONTOURS MAP
CHAIN SINGAPORE S./DECCA (NIGHT)
FREQ. DECCA MAIN CHAIN
ACCURACY IN METERS
103°
104°
105°
2°
1°
MALAYSIA
JOHORE
RIMBA TERJUN S1
P. TEKONG
SINGAPORE
SINGAPORE STRAIT
Middle Channel
Horsburgh
TELUKBALAM S3
BINTAN
BATAM
Philip Chan
RANGSANG
TEBING TINGGI
P. MAS
S2
SUG
KUNDUR
Tandjung Pinaug
480
240
120
60
150 km
100
50
0
1/885,000 (Lat.3°)


RELATIVE ACCURACY CONTOURS MAP
CHAIN SINGAPORE S./DECCA (DAY) R-G
FREQ. DECCA MAIN CHAIN
ACCURACY IN METERS
103°
104°
105°
2°
1°
MALAYSIA
JOHORE
RIMBA TERJUN
P. TEKONG
SINGAPORE
SINGAPORE STRAIT
Middle Channel
Horsburgh
Philip Chan
BATAM
BINTAN
Tandyung Pinang
RANGSANG
TEBING TINGGI
KUNDOUR
P. MAS
480
240
120
60
30
20
150km
100
50
0
1/885,000 (Lat. 3°)


RELATIVE ACCURACY CONTOURS MAP
CHAIN : SINGAPORE S./DECCA (DAY) G-P
FREQ. : DECCA MAIN CHAIN
ACCURACY : IN METERS
103°
104°
105°
2°
1°
MALAYSIA
JOHORE
P. TEKONG
SINGAPORE STRAIT
Middle Channel
Horsburgh
TELUKDALAM
S3
BATAM
B I N T A N
Philip Chan
RANGSANG
P. MAS
TEBING TINGGI
KUNDUR
Sugi
480
240
120
60
30
20
150km
100
50
0
1/885,000 (Lat. 3°)

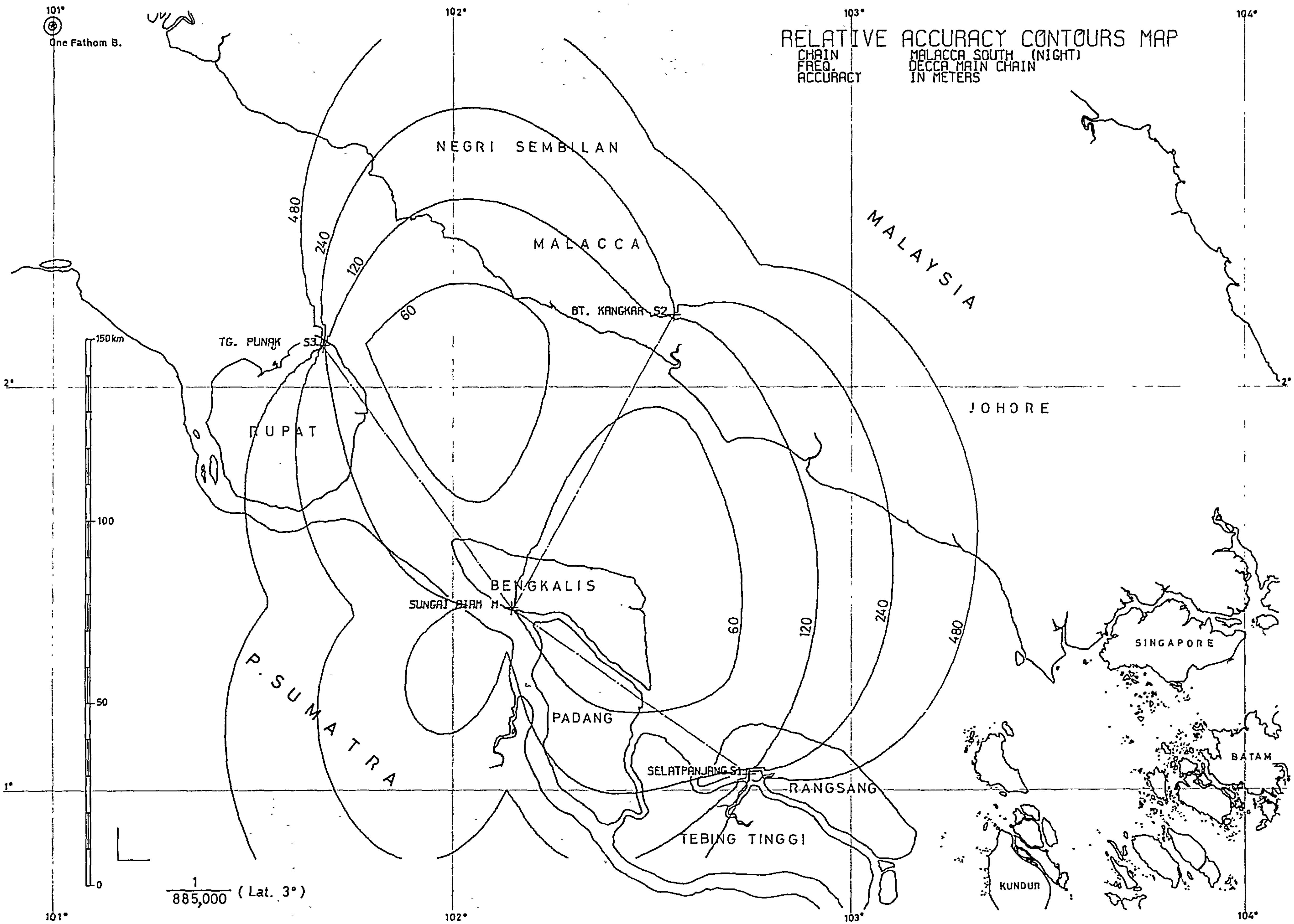


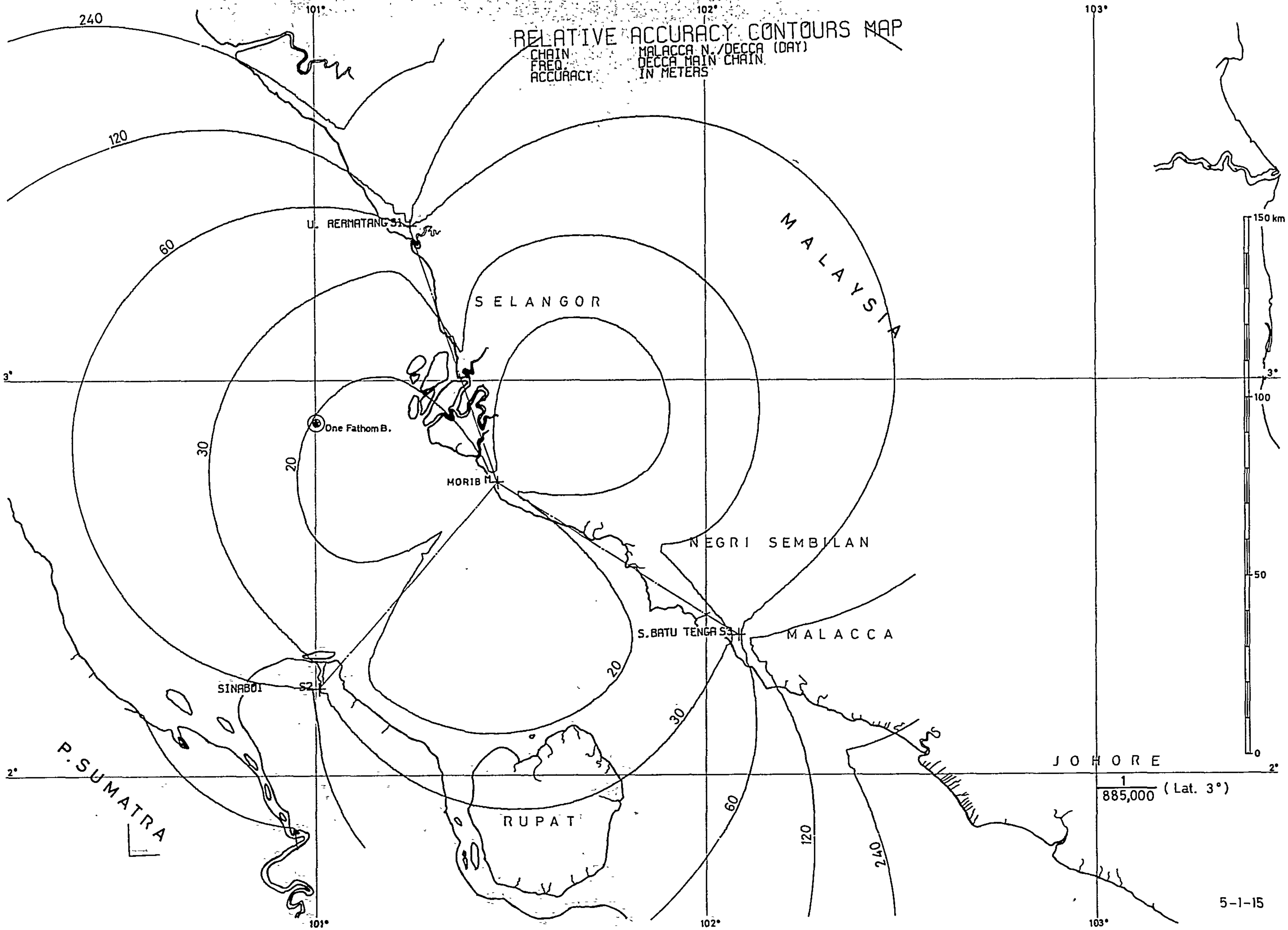
1/885,000 (Lat. 3°)

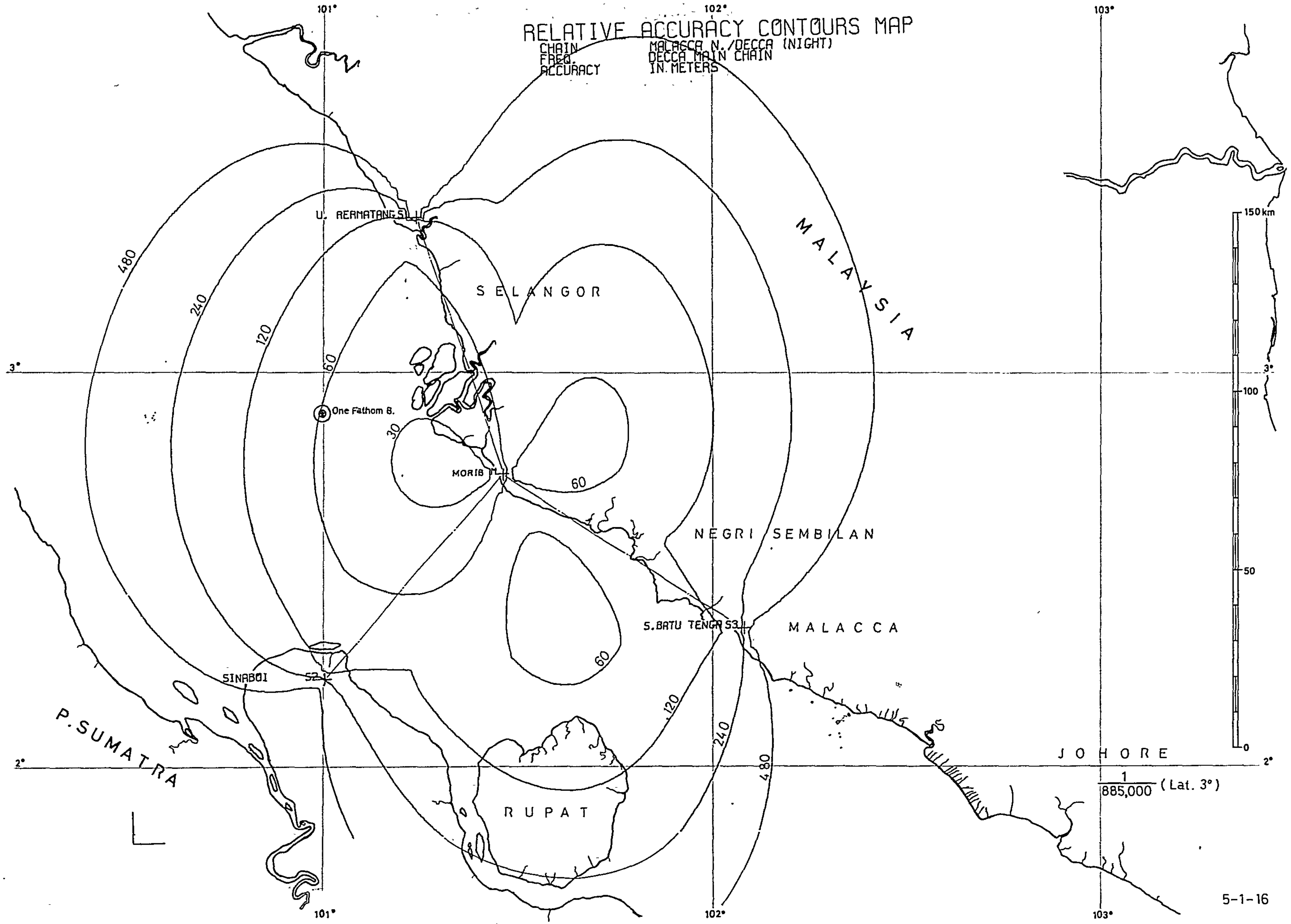


RELATIVE ACCURACY CONTOURS MAP
CHAIN MALACCA SOUTH (DAY)
FREQ. DECCA MAIN CHAIN
ACCURACY IN METERS
One Fathom B.
102°
103°
104°
2°
1°
NEGRI SEMBILAN
MALACCA
MALAYSIA
JOHORE
BT. KANGKAR S2
TG. PUNAK S3
RUPAT
BENGKALIS
SUNGAI AIAM M
PADANG
SELATPANJANG S1
RANGSANG
TEBING TINGGI
P. SUMATRA
SINGAPORE
BATAM
KUNDUR
240
120
60
30
20
150 km
100
50
0
1/885,000 (Lat 3°)

5-1-13

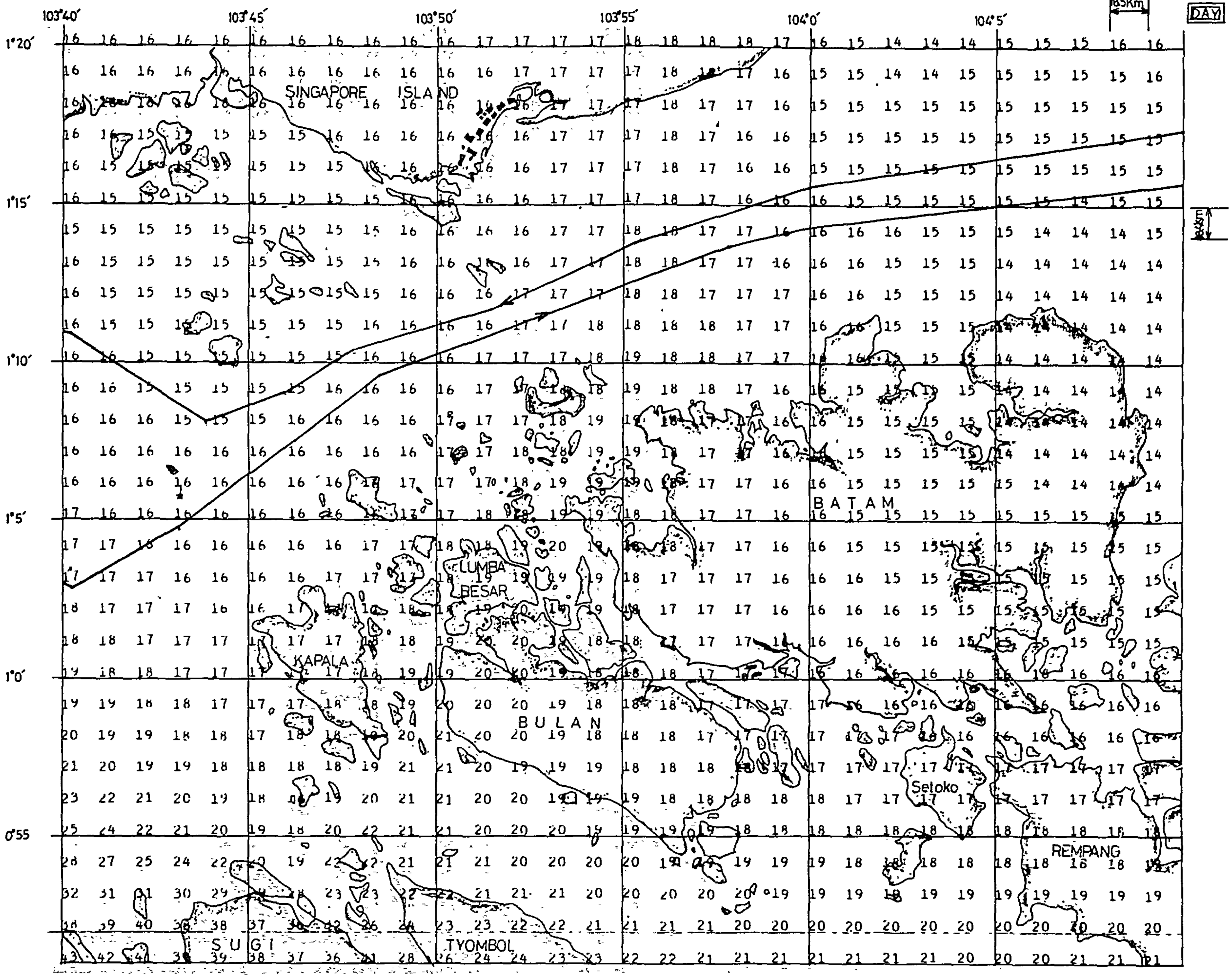

RELATIVE ACCURACY CONTOURS MAP
CHAIN MALACCA SOUTH (NIGHT)
FREQ. DECCA MAIN CHAIN
ACCURACY IN METERS
101°
102°
103°
104°
2°
1°
One Fathom B.
NEGRI SEMBILAN
MALACCA
MALAYSIA
JOHORE
SINGAPORE
BATAM
KUNDUR
RUPAT
P. SUMATRA
BENGKALIS
PADANG
RANGSANG
TEBING TINGGI
TG. PUNAK S3
BT. KANGKAR S2
SUNGAI AIAM M
SELATPANJANG S1
480
240
120
60
150km
100
50
0
1/885,000 (Lat. 3°)


RELATIVE ACCURACY CONTOURS MAP
CHAIN MALACCA N./DECCA (DAY)
FREQ. DECCA MAIN CHAIN
ACCURACY IN METERS
101°
102°
103°
3°
2°
240
120
60
30
20
U. PERMATANG S1
SELANGOR
MALAYSIA
One Fathom B.
MORIB M
NEGRI SEMBILAN
S.BATU TENGA S3
MALACCA
SINABOI S2
P. SUMATRA
RUPAT
JOHORE
150 km
100
50
0
1/885,000 (Lat. 3°)


RELATIVE ACCURACY CONTOURS MAP
CHAIN MALACCA N./DECCA (NIGHT)
FREQ. DECCA MAIN CHAIN
ACCURACY IN.METERS
101°
102°
103°
3°
2°
U. BERNATANG S1
SELANGOR
MALAYSIA
One Fathom B.
MORIB M
NEGRI SEMBILAN
S.BATU TENGA S3
MALACCA
SINABOI S2
P.SUMATRA
RUPAT
JOHORE
480
240
120
60
30
150 km
100
50
0
1/885,000 (Lat. 3°)

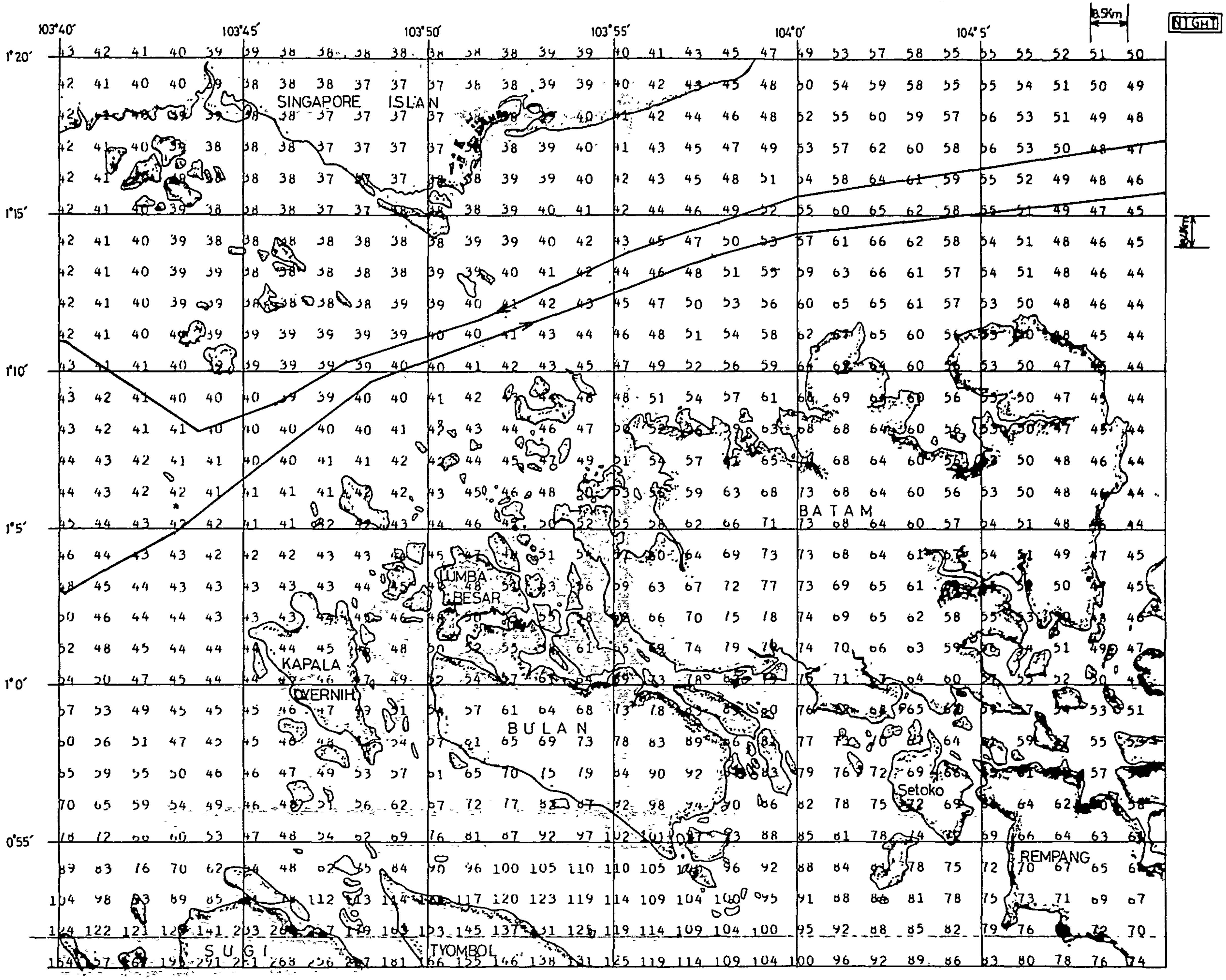
RELATIVE ACCURACY MAP

Fig.5-1-8A

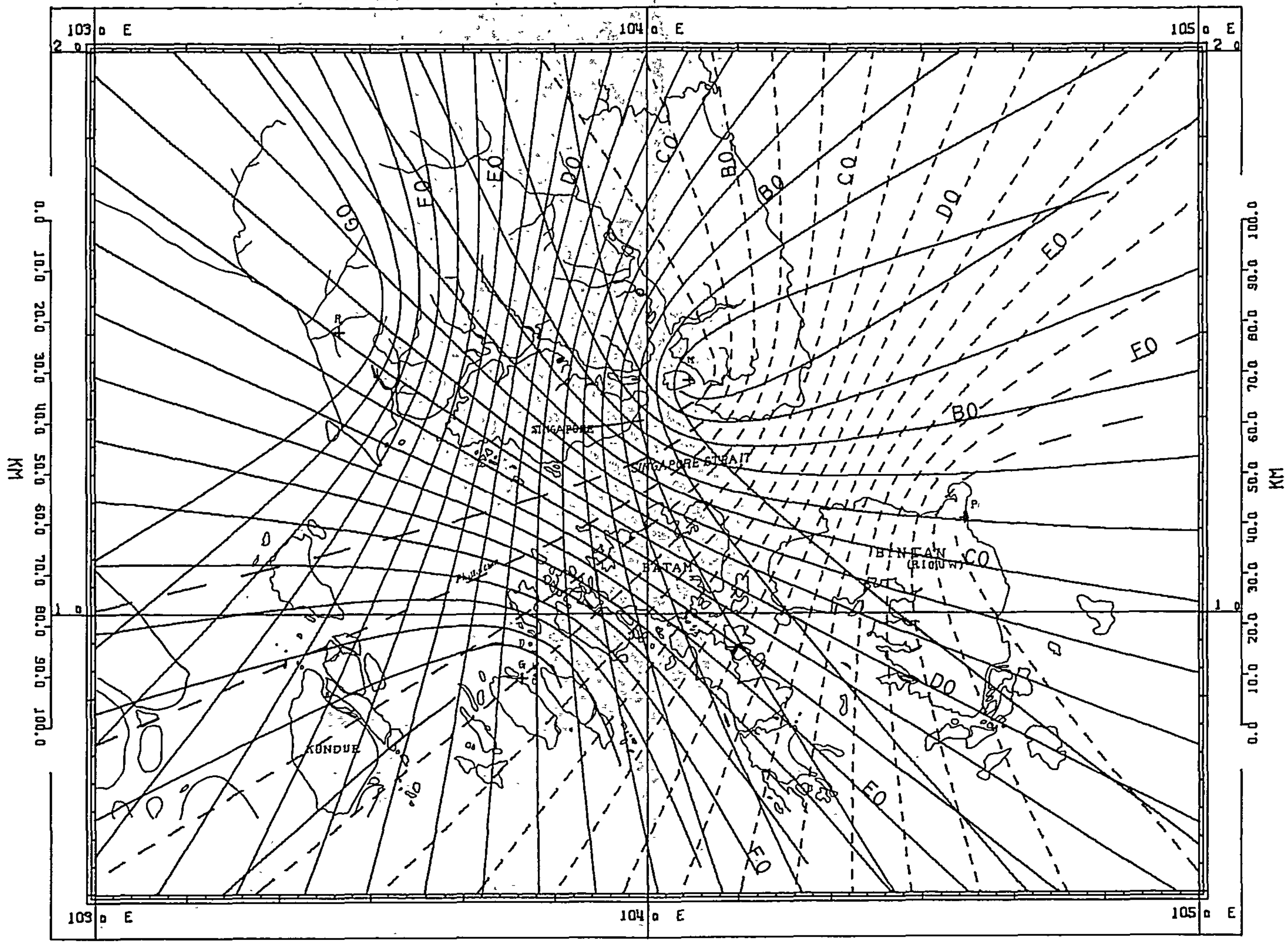


RELATIVE ACCURACY MAP

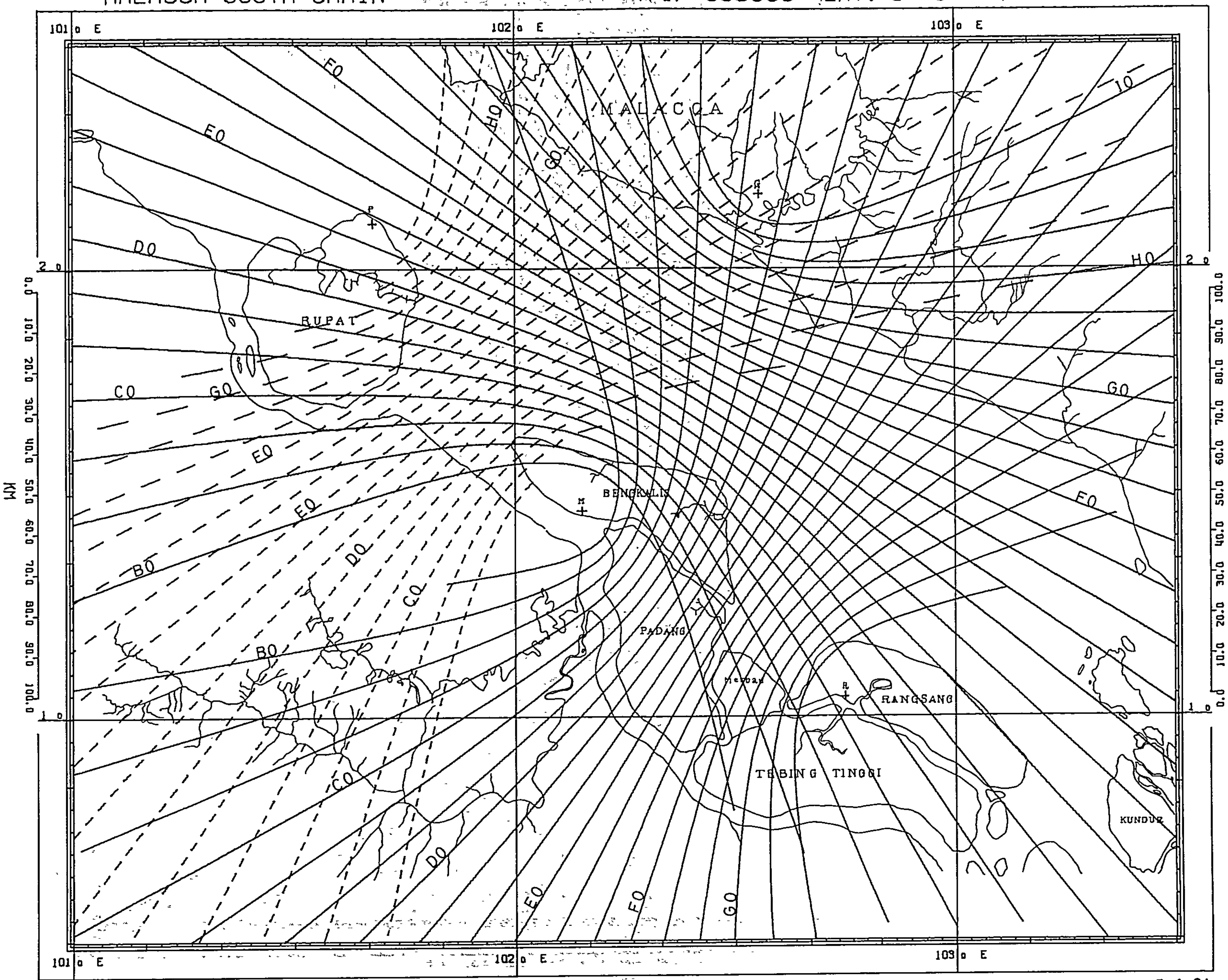
Fig 5-1-9A



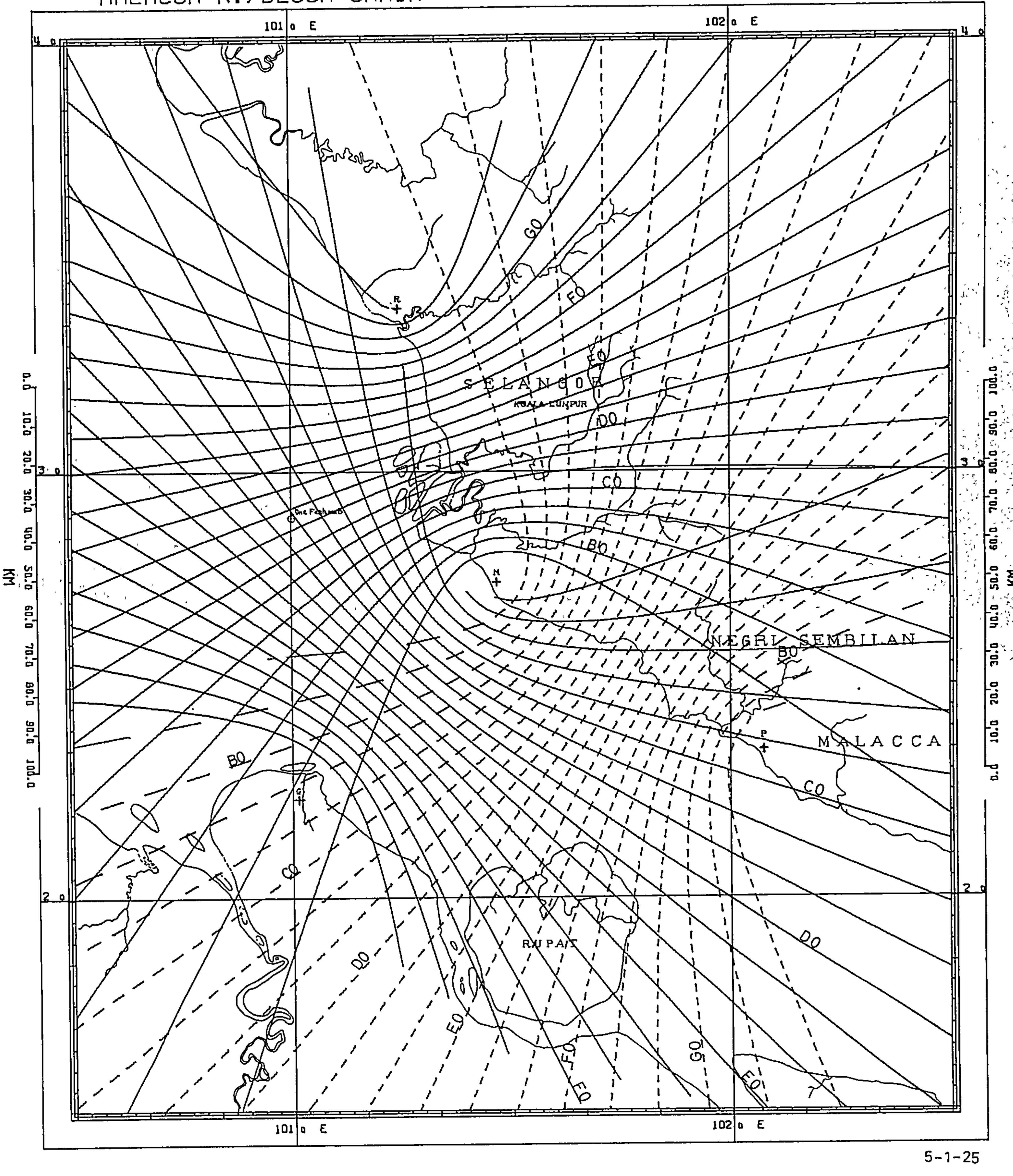
SINGAPØRE S./DECCA CHAIN (1/ 885000 LAT. 3 0)



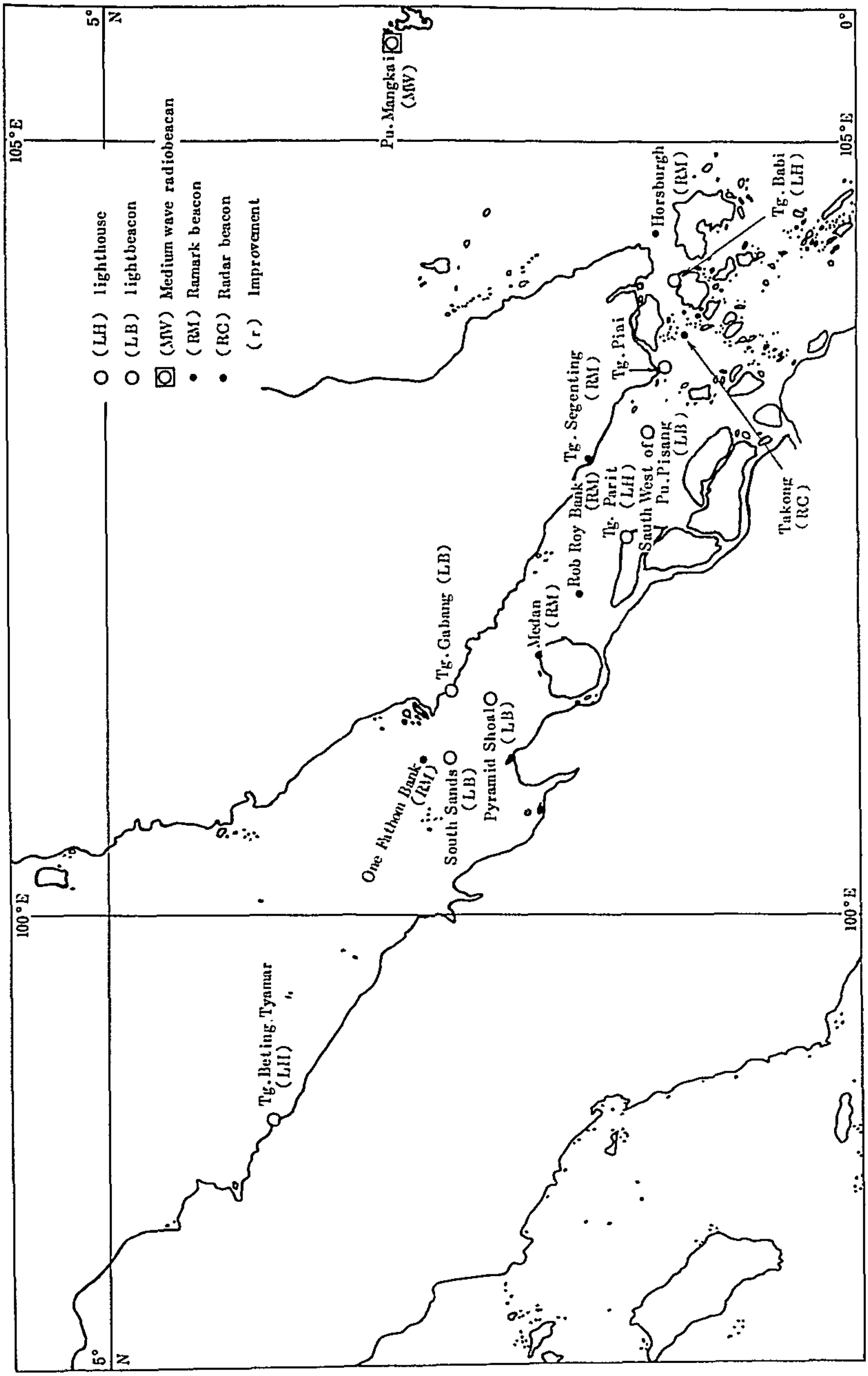
MALACCA SOUTH CHAIN (1/ 885000 LAT. 3 0)



MALACCA N./DECCA CHAIN (1/ 885000 LAT. 3 0)



5-1-25



○ (LH) lighthouse
○ (LB) lightbeacon
(MW) Medium wave radiobeacan
• (RM) Ramark beacon
• (RC) Radar beacon
(r) Improvement
Pu. Mangkai (MW)
Horsburgh (RM)
Tg. Babi (LH)
Tg. Piai
Tg. Segenting (RM)
Takong (RC)
Rob Roy Bank (RM)
Tg. Parit (LH)
South West of Pu. Pisang (LB)
Tg. Gabang (LB)
Medan (RM)
Pyramid Shoal (LB)
One Fathom Bank (RM)
South Sands (LB)
Tg. Beting Tyamar (LH)
105°E
100°E
5°N
0°

Fig. 5－1－29

5-2 Selection and layout of sites for Decca Navigator transmitting stations

5-2-1 Criteria of the selection and layout of sites for Decca Navigator transmitting stations.

(1) General requirements

The area of each site should be reasonably flat and level, and free of obstructions such as trees, buildings, etc. The conductivity of the soil comprising the site area should be as high as possible in order to provide the greatest efficiency of transmission. The site chosen should preferably be on high ground.

(2) Obstructions

Ideally, no hill or other similar obstruction should subtend an angle of greater than 2° from the site.

(3) Decca Slave and Monitor Stations

It is essential to observe certain minimum clearances (given below) from overhead wires and obstructions in order to prevent variations in the phase of the received locking signals. The clearance required is stated in terms of minimum distance from the receiving aerials located at the transmitter building. No specification is stated for clearance from the transmitting aerial, since such obstructions will not normally cause any operating difficulty for Decca equipment. There may, however, be a considerable induced voltage on overhead wires in the close proximity of the transmitting aerial which may render the removal of such wires desirable. In general all fence wires, etc. in the immediate area of the transmitting aerial should be effectively bonded to the earth system.

1) Telephone Wires

No overhead telephone or similar wires can be permitted within 200 metres of receiving aerials.

Overhead telephone cables enclosed in a screened outer cover may be permitted at a closer spacing providing the screening cover is effectively earthed at each pole.

2) Power Cables

Overhead power cables at a tension of less than 3 KV to earth cannot be permitted within 200 metres of receiving aerials. Overhead power cables at higher tension may require increased clearance owing to the high noise radiated by certain feeders. Clearances of the order of 2000 metres are advisable from lines of more than 100 KV tension.

3) Railway tracks

Electrified railway tracks may give rise to considerable interference, and a minimum spacing of 2000 metres is recommended.

4) Trees

No tall trees can be permitted within 200 metres.

(4) Master Station

There is no restriction on the proximity of overhead cables to the Master transmitting station.

(5) Site layout

The spacing between the transmitter room and the transmitting aerial mast is normally taken more than the distance equal to the height of the aerial mast. This separation may be increased if required by site conditions, but should not be reduced. Site requirements for this type of aerial are as follows:

110m aerial	400m x 400m

5-2-2 Results of site surveys by each site

This report has been prepared on the results of surveys conducted at sites in their order listed in the table below. Those sites which are considered suitable as the master or slave (or secondary) station sites respectively are indicated as such in the report. The evaluation of each site on its suitability as possible station site has been conducted on the basis of results of the survey carried out by the survey team at the site and the calculation by electronic computer of the accuracy to be provided by the proposed chains. The grades of evaluation are as follows:

A. Site for which the results of calculation are good and construction work will be relatively easy.

B. Site for which the results of calculation are good but the construction of a transmitting station will be difficult.

C. Site which is not considered particularly superior to other sites from the view point of both results of calculation and easiness of the construction work.

D. Site for which construction work will be easy, but the results of calculation show it is not possibly a good site.

Page	Drawing No.	Name of site	Assigned chain	master(M)/ slave (S)	Remarks
101	S-1	P. Tekong	Singapore	M	
102	M-13	Rimba Terjun	"	S red	
103	B-6	P. Mas	"	S green	
104	B-17	Telukdalam	"	S purple	
105	B-11	Sungai Aiam	Malacca Str. south	M	
106	B-9	Selat Panjang	"	S red	
107	M-10	Bukit Kangkar	"	S green	
108	B-13	Tj Punak	"	S purple	
109	M-6	Morib	Malacca Str. north	M	
110	M-3	Ujong Permatang	"	S red	
111	B-15	Sinaboi	"	S green	
112	M-8	Batu Tengah	"	S purple	
113	NIL	Kijang	Singapore Str.	(Site)	
114	M-12	Senggarang	"	(")	
115	B-7	Ransang	Malacca Str. south	(")	
116	B-8	Ransang	"	(")	
117	B-10	Simpengayam	"	(")	
118	B-12	Kundur	"	(")	
119	NIL	Dumai	"	(")	
120	M-11	Minyaku Buku	"	(")	
121	M-1	Rungkap	Malacca Str. north	(")	
122	M-2	Huntang Melingtang	"	(")	
123	M-4	Batu Tiga	"	(")	
124	M-5	Dengkil	"	(")	
125	M-7	Kg. Menyala	"	(")	
126	M-9	Telok Mas	"	(")	

1. Name of system: Decca

2. Name of chain and station: Singapore Strait P. Tekong

3. Location: P. Tekong Basar, Singapore

4. Lat. & long.: 01-25.1 N, 104-04.9E

5. Description of site: A hillock with gentle ups and downs at the east end of P. Tekong Basar. Approx. 10m above sea level. The level difference is 7m or less within the site. There is no object whose elevation angle exceeds 2 degrees. The ground is sandy hard clay and soil endurance is presumed to be $30t/m^2$. The present state is a thicket of assorted trees including abandoned rubber trees. 45m steel tower for weather observation and a few other facilities, but these other facilities are not in use now. From Singapore, transportation is 3 miles by sea from Changi to the west pier of P. Tekon and therefrom 6 km by car. No power and water available. Independent power plant and rain-collecting apparatus should be required.

6. Description of site from system requirements and construction work

   There is nothing detectable which would affect the system. No particular problem in transporting equipment and materials by the route mentioned above. The weather observation tower must be relocated and the other facilities be removed.

7. Overall evaluation and accompanying documents

   Evaluation A Drawing No. S1

1. Name of system: Decca

2. Name of chain and station: Singapore Strait Decca Rimba Terjun

3. Location: Rimba Terjun, Johor Baharn, Johor

4. Lat. & long.: 01-30.2N, 103-27.1 E

5. Description of site: A flat land extending in the basin of the S. Pontian Kechil. The ground is soft and about 3m above sea level. At the point 6.5 km NE of Pontian Kechil along the river, the road leading to Johor Baharn abuts. Except for G. Pulai (2147 ft high) in the NE direction, whose elevation angle is 2.4 degrees, there is nothing exceeding the elevation limit. The site is owned by Oee Sing Estate and used as rubber and coconut palm plantation.

6. Description of site from system requirements and construction work

   A power line of some 30 KV runs at 2.2 km north of the site, in the direction of east and west, but it will not affect the system configuration. As stated above, the ground is soft, and so a boring survey was conducted during the recent survey to find that some sort of piling will be required to make the ground firm. No problem in transporting equipment and materials because the good port is nearby and the road is well furnished.

7. Overall evaluation and accompanying documents

   B M13

1. Name of system: Decca

2. Name of chain and station: Singapore Strait Decca P. Mas/Sugi

3. Location: Riau, Riau Kepulauan Berurawak

4. Lat. & long.: 00-53 N, 103-46.2 E

5. Description of site: Situated in the central part of a small isle north of P. Sugi, 75 km west of Tunjung Pinang. The height above sea level is about 10 m. The place is a thicket of assorted trees, with gentle slopes. The level difference within the site is 5 m or less. The soil is soft clay and its endurance is presumed to be $5^t/m^2$. This place was selected as a possible site because the elevation angle of P. Sugi exceeds the elevation limit.

6. Description of site from system requirements and construction work

   There is no problem is making this place a possible site for a station. Equipment and Materials could be unloaded from vessels of 200 tons at a possible quay built on the west seashore. This, however, will require the building of a new road. As for the soil endurance, support floor can be expected at 10 m underground, and if adequate steps could be taken, it would be possible to construct an aerial. This place can be reached by ship from Tj. Pinang to the site through Moru.

7. Overall evaluation and accompanying documents

   B B6

1. Name of system: Decca

2. Name of chain and station: Singapore Strait Telukdalam

3. Location: Kampa Telukdalam Kep. Riau, Riau

4. Lat. & long.: 01-09 N, 104-34.9 E

5. Description of site: A flat lot with hard ground facing the north coast of P. Bintan. There is no problem in the elevation angle. The ground consists of sand with hard rocks here and there. The soil endurance is presumed to be $20\sim25t/m^2$. From 2.5 km south of the site and ahead is a hillock with ups and downs of $50\sim100$ m in height. At present plantation of coconut palm is under way. Privately owned land. To get to this place is use land transportation from Tj. Pinang. One half of the 60 km road is not available to car traffic. No berthing facilities, and in addition the coral reefs exist to a great distance. Water can be obtained from wells. Power is procured only by independent power plant.

6. Description of site from system requirements and construction work

   No particular problems in the system configuration. The construction work should be relatively easy, but the bad condition of the road will require a considerable amount of expenses.

7. Overall evaluation and accompanying documents

   B B17

1. Name of system: Decca

2. Name of chain and station: South Malacca Strait Decca Sungaiaiam Bengkalis

3. Location: Riau Bengkalis, Bengkalis, Sungaiaiam

4. Lat. & long.: 01-27.2 N, 102-09.2 E

5. Description of site: A perfect flatland, about 2 m above sea level at 6 km SSE of Bengkalis. There is a 5 m wide road running from Bengkalis, and so the place is easy of access. At present the place is a privately owned farm. The ground is clay, and there is a brick factory adjoining the site to utilise the clay. The soil endurance is presumed to be $10 \sim 15 t/m^2$. This place can be reached by ships of regular run once a day from Bengkalis. It takes 7~8 hours.

6. Description of site from system requirements and construction work

   Good topographical conditions and convenient transportation. There is no problem in constructing a station.

7. Overall evaluation and accompanying documents

   A B11

1. Name of system: Decca

2. Name of chain and station: Malacca Strait Decca Selat-Panjang

3. Location: Riau Bengkalis Selat-Panjang

4. Lat. & long.: 01-02.4 N, 102-45.2 E

5. Description of site: A flatland facing Selat Hitam in the central part of P. Ransang. The inhabitants are mostly fruit growers. There are some who work at a nearby lumber-mill. The site is perfectly flat, and the elevation angle is good all over the place. The underground water level is - 5m in the dry season and - 3m in the rainy season. Water from wells is not good for drinking, and the people rely on rain water. It takes 6 to 16 hours by ship on regular run from Selat-Panjang. The place is privately-owned, and there may be the problem of compensation for farming.

6. Description of site from system requirements and construction work

   There is nothing to affect the system configuration. Of construction equipment and materials, frame timber can be procured from Malaysia and nearby islands. Cement, steel, etc. must be brought from Medan or, in some cases, from Jakarta. The unloading of all equipment is possible at Port Selat-Panjang, and this helps in a way save the defects of this place where many items of equipment and materials are needed for foundation work.

7. Overall evaluation and accompanying documents

   B B9

1. Name of system: Decca

2. Name of chain and station: South Malacca Strait Decca Bukit Kangkar

3. Location: Bt.Kangkar, Selom Muar, Johor

4. Lat. & long.: 02-10.7 N, 102-33.7 E

5. Description of site: Situated close to the arterial road, 15km north of Muar. To get to the site, you must proceed 500m along a private road of 2m in width from Bt.Kangkar. A private lane runs through the middle of this place. This is a part of a hillock with gentle slopes, with the highest place is 10m above the sea level. The level difference in the required space of land is almost 6m or less. A rubber plantation at present. The ground is sand clay and its endurance is presumed to be $20t/m^2$. The rubber wood prevented the survey of the circumstances, but there seems to be no object whose elevation angle exceeds 2 degrees, except for G.Leading (4,187 ft high) whose elevation is calculated as 3 degrees in the direction of 23km NNE. The place is owned by Fourty Estate.

6. Description of site from system requirements and construction work

   Nothing particular can be detected which would affect the Decca system. The soft ground in the basin of the S.Muar was avoided during the recent survey, and therefore there will be no problem in performing construction work. Equipment and materials can be transported easily by the good road from the port to the site. As stated above, however, 500m of the private road must be repaired and transferred from the middle of the site to other place.

7. Overall evaluation and accompanying documents

   A M10

1. Name of system: Decca

2. Name of chain and station: Malacca Strait Decca Tj. Punak

3. Location: Rian Bengkalis, Rupat Tj. Punak

4. Lat. & long.: 02-06.2 N, 101-41 E

5. Description of site: A relatvely flat land about 2m above sea level, at NE end of P. Repat. Puddles form during the raing season. There is a 70~80m long beach on the seashore. Possible to land by boat. This is a site originally planned for a Decca station by Pertamina. The stone marks still remain. Soft clay and soil endurance is presumed to be $2t/m^2$. The place is owned by Pertamina. At present, just a wilderness with a few plam trees.

6. Description of site from system requirements and construction work

   There are no big problems in the system configuration. Equipment and materials for construction work can be transported 150km along the bad road from Dumai, but a better way would be transport by sea from Dumai and further by small craft to the site. The ground is soft and this will require all sorts of equipment and materials and a great amount of expenses for foundation work.

7. Overall evaluation and accompanying documents

   D B13

1. Name of system: Decca

2. Name of chain and station: North Malacca Strait Decca Morib (Rechar)

3. Location: Kg. Tg. Pechah, Morib Kuala Langat, Selangor

4. Lat. & long.: 02-44.6 N, 101-27.7 E

5. Description of site: Ten kilometres NE of Kanchong Laut, approx.2 km up north from a diverging point of the national highway connecting Kelang with Sepang, and this place can be reached. A perfectly flat land 2.5m above the sea level and in spite of the flat land, drainage is very good. No high place whose elevation angle exceeds the required limit. The place is currently owned by Duson Durian Estate, but there will be no problem in acquiring land. The surface soil is clay and the soil endurance of 1m underground is presumed to be $15 \sim 20 t/m^2$.

6. Description of site from system requirements and construction work

   No factors can be detected which would affect the system configuration. The existing road is available to lorry transport between the arterial road and the site. It is easy to carry the equipment and materials to the site. By addition of a certain length of leading line to the existing power line, power can be procured. Water can be obtained from a small scale of boring as in the case of other sites in Malaysia.

7. Overall evaluation and accompanying documents

   A M6

1. Name of system: Decca

2. Name of chain and station: North Malacca Strait Decca Ujong Permatang

3. Location: Ujong Permatang, Kuala Selangor, Selangor

4. Lat. & long.: 03-23.7 N, 101-15.2 E

5. Description of site: Situated at 5.5km north of Kuala Selangor. Approx. 2.8km after turning to the left from the arterial road to Kelang from Telok Anson. Perfectly flat with of course no high place whose elevation angle exceeds the required limit. The soil is sand clay and endurance is expected to be $15t/m^2$. Only a few trees within the site. No power line or railroad tracks are detected in the vicinity which would disturb radio waves. The place is privately-owned; S. Terap Estate is the owner.

6. Description of site from system requirements and construction work

Nothing particular to affect the system configuration. Equipment and materials can be unloaded at Port Kelang and carried by lorries 100km therefrom. A part of the road has not been paved, but no problem for lorry transportation. Two metres above sea level, and so there is nothing to worry about damage by floods. A high voltage line runs along the arterial road. A leading wire of 3km, and good quality of power could be obtained.

7. Overall evaluation and accompanying documents

A M3

1. Name of system: Decca

2. Name of chain and station: Malacca Strait Decca Sinaboi

3. Location: Riau Bengkalis Bangko, Sinaboi

4. Lat. & long.: 02-14.2 N, 100-59.7 E

5. Description of site: A flat land mainly to puddy field about one metre above sea level. It is approx. 8km NW of Dumai. The ground is soft clay and soil endurance is presumed to be only $2t/m^2$. Most of the inhabitants in the vicinity live in wooden houses of Bagan on the water or damp area. Water from wells is bad, so facility to collect rain water should be required. There are traces of trial oil digging here and there. Transportation is by ferry boat twice a week between Bagan Siapiape and Dumai. No commercial power is available, and the people living in about 30 houses have their own independent power plants.

6. Description of site from system requirements and construction work

   There is nothing to affect the system configuration. Equipment and materials for civil engineering and construction work are supplied from Pekanbaru, Jakarta, Singapore, etc. Port Sinaboi has berthing facilities for vessels of 100 tons to get alongside. As stated above, the area is a terrible damp and this will require a considerable amount of expense for foundation work.

7. Overall evaluation and accompanying documents

   B B15

1. Name of system: Decca

2. Name of chain and station: North Malacca Strait Decca Batu Tengah

3. Location: S. Batu Tengah, Northern Malacca

4. Lat. & long.: 02-20.7 N, 102-04.2 E

5. Description of site: A hillock consisting of rocks, 25m above the sea level, situated at 37km by land and 26km NW of Malacca. The required space of land for a site is almost flat. Most part of this place is wilderness with only a small part used as rubber plantation. The ground is sandy rock and soil endurance is presumed to be well over $50t/m^2$. Private owned land, but exact owners are unknown. The maximum angle of elevation measured was 1.8 degrees in the vicinity, which presents no problem.

6. Description of site from system requirements and construction work

   Two systems of power line run in the directions of NW and SE at 2.5km northwest of this place but these seem to affect the system configuration. There is a quarry in the neighbourhood and it is easy to procure frame materials for concrete, but, on the other hand, a fairly good amount of expense will be required to perform grounding work, particularly digging holes. Equipment and materials for construction work can be unloaded at Kuala Lumpur or Malacca and therefrom carried by land.

7. Overall evaluation and accompanying documents

   A M8

1. Name of system: Decca

2. Name of chain and station: Singapore Kijang (Kawal)

3. Location: Riau Kepriau, Kijang, Tj. Emot

4. Lat. & long.: 00-50 N, 104- 36.5 E

5. Description of site: A plateau which was formerly a bauxite ore stope, situated on the south coast of P. Bintan. The place is approx. 20m above sea surface and almost flat in the area of 150m in radius. Outside this area, the level difference is 10m at maximum. There is a mountain whose elevation angle is 3° in the northern direction (335°), but there is nothing that would exceed 1°. The soil endurance is presumed to be $100t/m^2$. Transportation to this place is airborne up to Tj. Pinang via Palembang and therefrom 30km by car. The road is good. The owner of this land is state-run bauxite company.

6. Description of site from system requirements and construction work

   Because of the firm ground and with the good port of Tj. Pinang nearby, the transport of equipment and materials is easy. Commercial power is available. Water can be obtained from the waterworks. All these will make the construction work much easier. The trouble is that this site lies closer to south which will present problems in the system configuration. This matter should be carefully reviewed.

7. Overall evaluation and accompanying documents

   C Drawing None

1. Name of system: Decca

2. Name of chain and station: Singapore Strait Decca Senggarang

3. Location: Senggarang, Minyak Beku, Batu Pahat, Johor

4. Lat. & long.: 01-46.3 N, 103-27.1 E

5. Description of site: A completely flat land situated at 15km SE of Batu Pahat. It is 2.4km north of the turning point at Senggarang on the national highway leading to Kukup. No object to exceed elevation limit. Approx. 2m above sea level. The ground is soft. A boring survey should be made to find if it is too soft. There is an airport at 6.5km WSW, but both approaches and angles would not affect the system. Mainly rubber plantation but also coffee and banana plantations are there at present. Privately owned place, and there will be no problem in acquiring the lot.

6. Description of site from system requirements and construction work

   Since it is a perfectly flat land and there is no high mountain and no source of noise, which would affect the system configuration. The road condition is good and makes the transport of equipment and materials easy.

7. Overall evaluation and accompanying documents

   B M12

1. Name of system: Decca

2. Name of chain and station: Malacca Strait Decca Ransang

3. Location: Riau Bengkalis Tebingtinggi Ransang Tengah

4. Lat. & long.: 01-04.5 N, 102-59.6 E

5. Description of site: Situated at the central part of Malacca Strait of P. Ransang. Traffic and economy of this place are closely related to Selat-Panjang and Tg. Balai. The whole island looks as though it were situated on reedy marshes. The site is a perfectly flat land and ideal electrically. At present, palm plantation is in progress. The height above sea level is only one metre. Water can be obtained from wells, but is not good for drinking. This place can be reached by ship from Selat-Panjang.

6. Description of site from system requirements and construction work

   No problems in the system configuration, but because of the soft soil, a considerable amount of expense will be required and many problems will be involved, for piling operation, even if a quay of 500m in length protruding seaward is newly built.

7. Overall evaluation and accompanying documents

   C B7

1. Name of sytem: Decca

2. Name of chain and station: Malacca Strait, Ransang

3. Location: Riau Bengkalis Tebingtinggi Sungai Ransang

4. Lat. & long.: 01-09.1 N, 102-48.2 E

5. Description of site: A perfect flatland about 2m above sea level, situated at the north end of P. Rangsang. Traffic and economy of the inhabitants of this place are closely related to Selat-Panjang. At present, coconut palm plantation is in progress. Soil erosion is going on at the seashore at a rate of 3~8m per year. The ground is extremely soft and soil endurance is presumed to be $1t/m^2$ or less. Water must be procured from rain water.

6. Description of site from system requirements and construction work

   No problems in the Decca system configuration. In addition to the extremely soft ground, the erosion at the seaside is very bad. Much time and expense would be necessary to counter these adverse conditions.

7. Overall evaluation and accompanying documents

   C B8

1. Name of system: Decca

2. Name of chain and station: Malacca Strait Decca Simpengayam, P. Bengkalis

3. Location: Riau Bengkalis, Bengkalis Miskum

4. Lat. & long.: 01-34.8 N, 102-02.7 E

5. Description of site: A perfect flatland, approx. 2m above sea level at west end of P. Bengkalis. This site can be reached by ship from the City of Bengkalis for 10 miles, landing at Perapat Tunggal and walking 3km of a road not available for vehicles. At present the place is a wilderness with a few trees. A stream is not available for the transport of equipment and materials. The ground consists of soft clay and the presumed soil endurance is $3t/m^2$.

6. Description of site from system requirements and construction work

   No problem related to the elevation limit and no adverse conditions to affect the system. Equipment and materials for construction work are brought from Singapore, Tj. Pinang, etc., but a wharf for small craft should be built at the unloading place and the road should be made wider to allow traffic by small lorries. A great amount of expense should be required for foundation work to overcome the soft ground and furnishing of transport routes.

7. Overall evaluation and accompanying documents

   C B10

1. Name of system: Decca

2. Name of chain and station: Malacca Strait Decca Kundur

3. Location: Riau Riau Kepulan Tanjung Baru Kundur

4. Lat. & long.: 00-48.4 N, 103-23 E

5. Description of site: A plateau with gentle slopes, approx. 30m above sea level, at NW end of P. Kundur. The level difference within the required area is 3m or less. Nothing to exceed the elevation angle of 1 degree. The ground consists of sandy clay. The presumed soil endurance is $30t/m^2$. Judging from the condition of exposed rocks in the vicinity, there may be foot rock within 10m below the ground surface. The place is owned by the State, but the farming rights are rested with the inhabitants. Transportation to this place is by ship twice a week from Pekanbaru for Tunjunbaru (takes 24 hours) and therefrom 30km by car.

6. Description of site from system requirements and construction work

   The condition of the land is generally good and the road requires just minor repairs, and therefore it is possible to construct a station without great difficulty. Sand and gravel for construction work can be procured at Kundur, and cement and steel materials at Singapore, Pekanbaru, Tj. Pinang, etc.

7. Overall evaluation and accompanying documents

   C B12

1. Name of system: Decca

2. Name of chain and station: Malacca Strait Decca Dumai

3. Location: Riau Bengkalis Dumai

4. Lat. & long.: 01-38.5 N, 101-25.8 E

5. Description of site: A hillock with gentle ups and downs, about 10m above sea level, 7km SSW of Dumai. Forest and the level difference within the site is 5m or less. No object exceeds the elevation angle of 1°. There is a runway of Dumai Airport 4km away, but it is not in the direction that would affect approach. The ground is sand and soil endurance is presumed to be $50t/m^2$. The whole area is owned by Pertamina and C.P.I. This place can be reached by car on the good road from Dumai.

6. Description of site from system requirements and construction work

   There are no adverse conditions to affect the system configuration. Because of the good ground and good road and, in addition, of equipment and materials being available in the locality, construction work can be carried out easily. Commercial power will also be available.

7. Overall evaluation and accompanying documents

   B Drawing None

1. Name of system: Decca

2. Name of chain and station: South Malacca Strait Decca Minyaku Beku

3. Location: Minyaku Beku, Batu Pahat, Johor

4. Lat. & long.: 01-47.8 N, 102-54.5 E

5. Description of site: Situated on the right coast near the estuary of the S. Batu Pahat and along the arterial road down south of Minyak Beku. It is in a good position, keeping off from G. Banang towering in the NE direction. This place is a part of hillock with gentle ups and downs. Geographically, it is situated at the southern end of the above-mentioned mountains. The level difference is about 10m in the required lot. The elevation angle exceeds 2 degrees in true bearing 70~100°. G. Minabuku in true bearing 79° has an elevation of as much as 7 degrees. The ground consists of hard sand and its endurance is presumed to be $30t/m^2$. Privately-owned and utilised now as rubber plantation.

6. Description of site from system requirements and construction work

   In selecting this site, all points where elevation angle exceeds the limit, likely to affect the Decca system configuration were kept clear of as far as possible. The equipment and materials for construction work can easily be transported from Batu Pahat by land for 8km along the first class national highway. It is not necessary to worry about possible damage to the equipment and materials on the way. Power can be obtained from a nearby power line and, as for water, a required amount could be obtained from rather shallow boring.

7. Overall evaluation and accompanying documents

   C M11

1. Name of system: Decca

2. Name of chain and station: North Malacca Strait Decca. Rungkap

3. Location: (Malaysia) T.O.L. Rungkap, Rungkap Perak Hiler

4. Lat. & long.: 03-56.8 N, 100-42.3 E

5. Description of site: Situated at 35km WSW of Telok Anson. A flat land, about 1.5m above the sea level along the coast, covered by mangrove trees 6 to 7m tall. The ground consists of soft water clay and the soil endurance at 1m underground is presumed to be $20t/m^2$ or so.

6. Description of site from system requirements and construction work

   The whole area is relatively low, and there is an embankment in the adjacent S. Rungkap. A water gate is provided and mechanical draining is carried out, but the site surveyed does not enjoy such benefit. In transporting equipment and materials, it is possible to go through Land Rover, but the road to the site from the crossing point of Simprang Empat Rungkop must be repaired for lorry transportation. State-owned place. Power can be obtained from power line of about 1km newly installed. Convenient, but difficult for construction work.

7. Overall evaluation and accompanying documents

   B M1

1. Name of system: Decca

2. Name of chain and station: North Malacca Strait Decca. Huntang Melintang

3. Location: (Malaysia) Huntang Melintang, Perak Hiler, Perak

4. Lat. & long.: 03-51.6 N, 100-57.4 E

5. Description of site: A flat land approx. 2.5m above sea level, 18km SSW of Telok Anson. The length of the road is 22km, and required time is some 40 minutes. A section of the coconut tree plantation estate. Almost perfect flat land with drainages furnished in all directions. The ground is firm, and soil endurance is presumed to be $30t/m^2$. The land is owned by Flemington Estate. There is no high place whose elevation angle exceeds the required limit.

6. Description of site from system requirements and construction work

   There are no factors detected which would affect the accuracy of the Decca system. The road from Telok Anson is perfectly furnished, which makes the transport of equipment and materials easy. Water should be obtained from wells. Power can be procured from the power line between Telok Anson and K. Selangor. This place is superior to Rungkap in respects of road conditions, flood and foundation work.

7. Overall evaluation and accompanying documents

   A M2

1. Name of system: Decca

2. Name of chain and station: North Malacca Strait Decca Batu Tiga

3. Location: Batu Tiga, Damansara, Kelang Selangor

4. Lat. & long.: 03-01.7 N, 101-34.6 E

5. Description of site: Situated at 19km SW of Kuala Lumpur, this place is a well-kept rubber plantation owned by Seafield Estate. A plateau with gentle ups and downs, about 20m above the sea level. The level difference is a few metres within the site. Except for Bt. Lanchong (489m) observed 2.4 degrees in the direction of 185°, there is no other object whose elevation angle exceeds the required limit. The soil is hard clay, and soil endurance is presumed to be $20t/m^2$. It is situated at 18° ten kilimetres away from the approach of Kuala Lompol Airport, and there is no fear that the location violates the national law.

6. Description of site from system requirements and construction work

   A power line of presumed voltage of 30KV is laid in 25m south of this place and a railroad track for unelectrified trains runs at a point 5km north, but these lines will present no problems. The distance is only 24km and so the place can be said to be a convenient place. And, power can very easily be obtained. Except for the problem of water which must be procured from wells, the place is one of the best possible sites for a station.

7. Overall evaluation and accompanying documents

   B M4

1. Name of system: Decca

2. Name of chain and station: North Malacca Strait Decca Dengkil

3. Location: Dengkil, Kajang, Ululangat, Selangor

4. Lat. & long.: 02-52.4 N, 101-40.4 E

5. Description of site: Situated at 30km south of Kuala Lumpur, 48km by land. A flat land 9m above the sea level. The existing condition of the place is that the land is overgrown with weeds and miscellaneous trees. There is a mountain, Tebing Tinggi (260m), in the direction of 350°～20°, whose elevation angle was observed as 3.2 degrees. The ground is sand and soil endurance is presumed to be $15t/m^2$. The whole site is Choong Keow estate and no problem is foreseen for acquisition of land.

6. Description of site from system requirements and construction work

A power line seemingly of 30KV is laid at 3km in the north direction, but this is not considered to affect the Decca system configuration. The equipment and materials for construction work will be unloaded at the port and carried to the site by lorry. The road is well furnished and so no problem. Water should be procured from wells, but it is possible to obtain required amount of water from shallow wells.

7. Overall evaluation and accompanying documents

B M5

1. Name of system: Decca

2. Name of chain and station: North Malacca Strait Decca Manyala

3. Location: Pasia Panjang, Port Dickson, Negri Sembilan

4. Lat. & long.: 02-26.2 N, 101-52.7 E

5. Description of site: Four kilometres NE of Cape Rachado, and in between Port Dickson and Malacca. The site can be reached by going 1.3km up north from the guide-post on the road. The place is a killock with gentle ups and downs. The level difference within the site is less than 10m at maximum. At present the place is a well-kept rubber plantation owned by Siginting Estate. No high objects can be detected whose elevation angle exceeds the required limit. The soil is hard clay and its endurance is presumed to be $30t/m^2$.

6. Description of site from system requirements and construction work

No particular problems are found which will affect the Decca system configuration. The equipment and materials can easily be brought via the arterial road running between Port Dickson and Malacca. It is also easy to obtain commercial power. Water can be procured by relatively shallow boring.

7. Overall evaluation and accompanying documents

B M7

1. Name of system: Decca

2. Name of chain and station: North Malacca Strait Decca Telok Mas

3. Location: Telok Mas, Contral, Malacca

4. Lat. & long.: 02-10.9 N, 102-19.9 E

5. Description of site: Nine kilometres ESE of Malacca, and 13km down south and 2km up north along the road of 5m in width, and an area with shrubs and miscellaneous trees can be reached. Partly cultivated as pineapple farm. Approx. 25m above the sea level. A few ups and downs of about 5m. The mountain ridges extend in north and south directions. The surface soil is clay mingled with conglomerates, and soil endurance is presumed to be $50t/m^2$. There is nothing in the vicinity to exceed the required limit of elevation. The place is owned by the State and so no problem in acquiring land, but a certain extent of compensation may be needed for the cultivation of the farm. The farming condition is not very good.

6. Description of site from system requirements and construction work

   There is nothing particular in the place which would affect the Decca system configuration. Equipment and materials for construction work can be brought from Malacca which is very near and the road is good. It should be added that a power line runs from NW of the point 1.6km SE in the direction of SE. The southern end of the runway of Malacca Airport is 12km away in the direction of 314°, and so no problem.

7. Overall evaluation and accompanying documents

   A M9

5-3 Designing of station

5-3-1 Transmitting station building and billets

(1) Layout

Layout of the site has been so designed as to locate the transmitting aerial at the core of the site with the transmitter building arranged, outside the earthing area, to occupy the place where is convenient for taking the equipment in and out and for the maintenance as well. The place for the communications aerial has been selected under the consideration of the pair stations and the effect of transmitting aerial of the Decca Station, to which the communications facilities belong.

(2) Scale and structure of the transmitting station building

1) Plane

The station building area is divided into two parts; work area and living quarters. The layout of the rooms described in the table below has been so designed that they may give full play to their respective functions and may also be satisfactorily situated. The engine generator room has been arranged to be made independent of other rooms lest it should affect the function of the station or physiological conditions of personnel by the noise and vibration of the generators in operation.

The total floor space is $386.4m^2$. The dimensions of each room are as shown in the table below.

Table 5-3-1 Decca transmitting station building (Master and slave stations)

Name of room	area	No.of room	Remarks
Power building			
Engine generator room	$96m^2$	1	Accommodates 3 engine generators to be operated alternatively to supply power to load.

			In addition to the 3 engine generators, non-breake power supply unit engine, generator control panel, power distribution panel, etc. are also housed. In this room also is a noncombustible gas fire-extinguisher. Wiring trenches are provided underneath the floor.
<u>Radio building</u>			
Transmitter room	54m^2	1	Room to perform operation and maintenance of electronic equipment. Accommodates Decca transmitters, phase power distribution control rack, switching gear panel, communications transmitter/receiver, terminal equipment, teletype, and remote control/monitoring console. Also housed are measuring apparatuses for testing and maintenance of various types of equipment. Wiring trenches are provided underneath the floor.
Battery room	8m^2	1	A battery room for non-breake and other power supply equipment. The storage batteries are accommodated with supporting frames.
Storage room	6m^2	1	Tools for outdoor work.
	12m^2	1	Steel shelves are prefabricated.
Office room	20m^2	1	Office for station personnel. (Desks, chairs and library.)

Chief's office	$20m^2$	1	Office for the chief of the station (desk, chair and sofas).
Rest room	$9m^2$	1	To be provided with lodging and resting facilities.
Locker room	$14.4m^2$	1	To be used as a changing room by personnel and also as a store-room for personal property.
Janitor's room	$12m^2$	1	To be used by employees working on miscellaneous duties
Air-conditioning equipment room	$20m^2$	1	For cooling of electronic equipment and air-conditioning of the living quarters. Package, condenser water pump should be provided
<u>Facilities for joint use</u>			
Entrance and recreation hall	$37.5m^2$		The hall should be of lobby type and used also for recreation and resting for personnel.
Lavatory and shower bath	$15.75m^2$	1	A toilet stand, wash stand, changing and shower bath should be provided
Corridor	$18m^2$	1	
Dining kitchen	$25m^2$	1	Personnel on night duty eat here. A small water boiler, tables, dish packs and chairs should be provided.

Gas cilinder storage	$1.6m^2$	1	Gas for cooking and shower bath.
<u>Coil house</u>			Total floor space is 32.1m^2.
Vestibule	$2.7m^2$	1	To house the distribution panel.
Transformer room	$3.12m^2$	1	To accommodate Austine transformer for aircraft warning light.
Coil room	$26.27m^2$	1	To house the loading coil, A.T.A.M. unit and matching unit.

2) Structure

The station building has been designed as a one-storied and wall-type ferro-concrete structure with high floor to facilitate natural draught. The foundation, roofs and walls are all made of ferroconcrete. The height from the floor to the eaves is 4.8m for the radio building and 4.5m for the power building. In view of the grave importance of the facilities, the building has been designed to be earthquake-proof. The coil house is from its peculiar usage, of reinforced concrete block.

3) Finishing

Special consideration has been paid in finish designing of the roofs for the heat isolation and water-proof, and the materials for the finishing of the inside and outside of the building are those to be easily avilable, to be easily maintained and to be satisfactory both-economically and functionally.

4) Facilities

a) Electric equipment

The following types of equipment are provided:

i) Power supply equipment

The power for the station is 200V 50Hz 3 phase, which is uded directly for the electronic equipment, and also transformed into the voltages which meet the local power conditions in 3 phase 4 line type for such general uses as illumination, air-conditioning, etc.

ii) Power board

The power transformed is supplied through the power board to the illumination, air-conditioning, ventilating, water supply, cooling, oil supply and other equipment.

iii) Electric lights and outlets

The major rooms in the work section of the building (engine generator room and transmitter room) are lighted with illumination intensity of about 500 luxes. The lighting of the various rooms in the living quarters is planned according to their respective usages. Fluorescent lights are mostly used, and in some places incandescent electric lamps are used. A required number of outlets are also provided.

iv) Telephone and interphone

Interphone sets are provided in the main rooms of the work section and living quarters and in the coil house to accommodate the internal communications, and commercial telephone is also provided.

v) Fire alarm system

Smoke and heat detectors are provided in the three areas of work section and living quarters and the coil house to give warning at the time of a fire.

b) Air-conditioning equipment

i) Cooling system

The central cooling system is provided for the living quarters while the independent cooling system is provided for the work section. Water is supplied from the underground water tank to the cooling towers built outside for both systems.

ii) Ventilation equipment

The engine generator room and the storage battery room require the forced-ventilation equipment. The equipment with air-filters are provided.

c) Water supply, etc.

i) Water supply system

Rain and well water is collected in the underground water tanks, pumped up and supplied via the pressure tanks.

ii) Hot water supply system

Small water heaters using propane gas are installed to supply hot water to the kitchen, wash stand and shower bath.

iii) Sanitation facilities

Various types of sanitation ware are installed in the lavatory, shower bath and other places.

The urinal is a flash valve type and the close stool is a low tank cleaning type.

iv) Sewer and draining

All the draining inside the building is of natural flow type. The soil pipe and draining pipe are connected to the underground sewage tank outside the building to perform draining by permeation.

v) Fire extinguisher

A fixed type of non-combustible gas fire extinguisher is installed in the engine generator room. Portable fire extinguishers are provided for other rooms.

(3) Ancillary equipment

1) Water reservoir

Rain water collected is disinfected and supplied for drinking. The tennis court is also used in collecting rain water. Water from wells is used for the lavatory, shower bath and air-conditioning equipment and for other miscellaneous uses. The rain water tank has the effective capacity for 3 month's supply the pump house is made of reinforced concrete. The water reservoir built under the ground of the pump house is made of ferro-concrete.

2) Oil Tank

Fuel oil tanks are provided outside for the engine generator. The capacity of the tanks is made for 3 month's supply. For the safety and easy initial transportation, the capacity of each tank is limited to 17.5 kl. Four tanks are installed at a station where no commercial power is available.

3) Other facilities

i) Septic tank

Two septic tanks of different capacities are installed for the transmitting station and the billets respectively.

ii) Propane gas cylinder storage

The gas cylinder. storage is capable of storing the cylinders necessary for 3 month's supply for cooking and shower bathing, and built independent sufficiently separated from other structures for safety.

iii) Access roads and environment conservation

Access roads to each facility are built at the station site, and a gate is built for the approach to the station premises. Trees and lawns are planted for the environment conservation of the station premises.

(4) Basic plan

See Annex 1, Drawings of basic plan.

5-3-2 Transmitting aerial of Decca station

(1) Electric design of Decca transmitting aerial

1) General requirements

The general requirements for the transmitting aerial of a Decca station are as follows:

a) Only the ground wave is used in the Decca system, and the skywave is regarded as harmful element in the same system. For this reason, the vertical radiation pattern of an aerial should be of the characteristics of low angles.

b) The area of use of the Decca system is unrestricted in direction and therefore the horizontal directivity of an aerial should be omni-directional.

c) The effective height of an aerial should be made high and the electrostatic capacity be made over 3,000 PF.

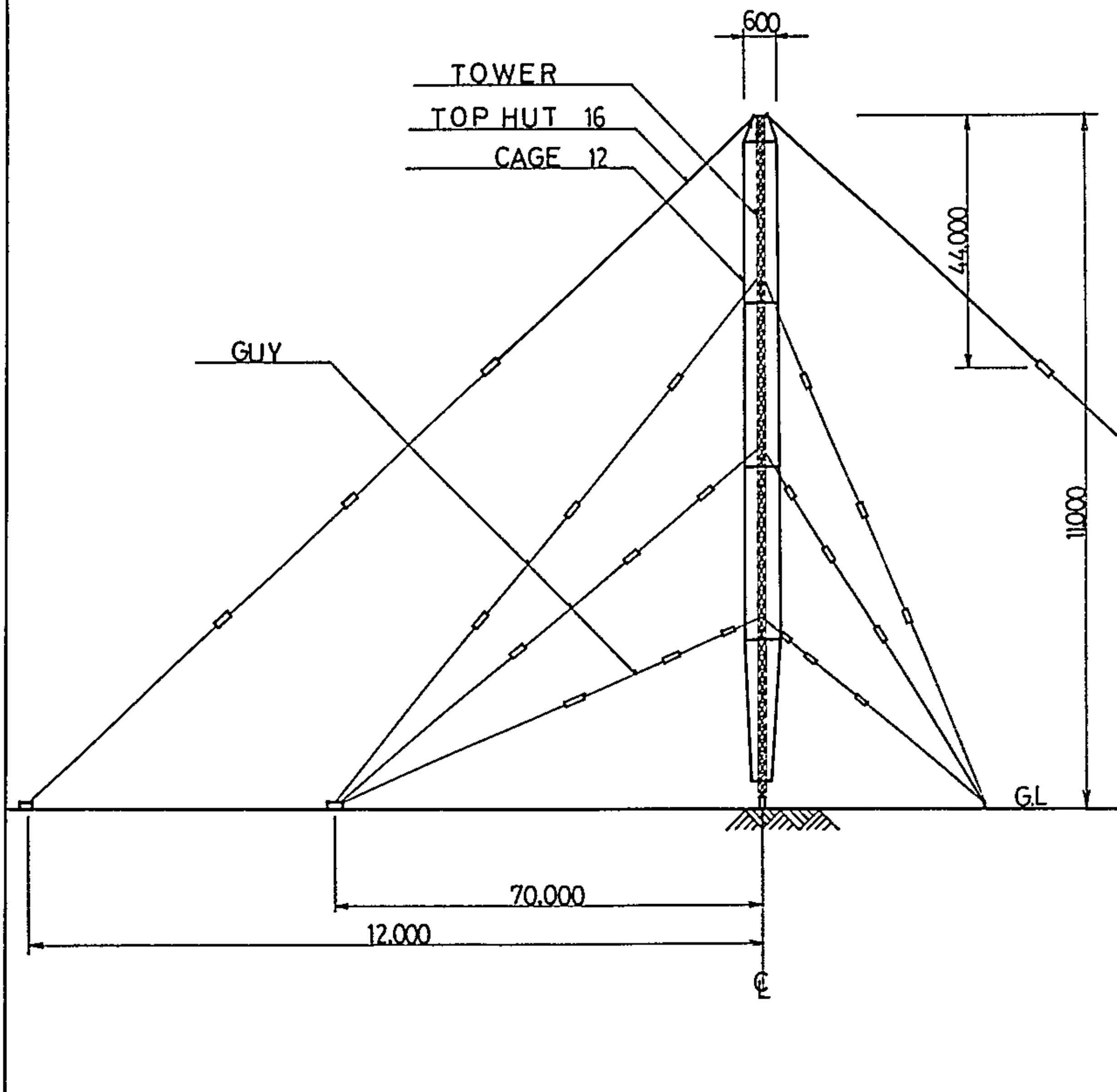
d) As it is necessary to perform multiplex feeding of five frequencies for lane identification, the resonance frequency of the aerial should be made 300 KHZ or more and the gradient of reactance should be made small.

e) The aerial loss (earthing loss, conductor loss, dielectric loss, corona loss, etc.) should be made as small as possible.

f) Changes in aerial constants to be caused by changes in weather conditions should be few.

These requirements have been considered, and the umbrella type aerial with cage has been dicided to be most suitable for the transmitting aerial of a Decca station.

Fig. 5-3-1



This type of aerial consists of a steel tower about 110 metres tall, an umbrella type top-hat from the top of the tower and a cage of several metres in diameter attached to the tower. The umbrella type top-hat extends aerial wires athwart from the top of the steel tower toward ground.

The dimensions and shape of the transmitting aerial of a Decca station, designed under such concept are shown in Table 5-3-2 and Fig. 5-3-1.

Table 5-3-2

Type of steel tower		Base insulated type guyed steel truss tower
Guy system		Four level guy system The topmost level also serves as an aerial
Height of tower		110 metres
Type of aerial		Umbrella type aerial with cage
Cage	Diameter	6m
	Number of wire	12
	Wire	110 mm^2 almoweld strand
Top-hat	Length	62m
	Number of radial	16
Grounding		
	System	Radial earth
	Number	120
	Radius	110m
	Wire	2.9mm copper wire

2) Method of design and expression of aerial constants

For an electrically short aerial (whose electrical effective length from the aerial base to the end of the top hat radial is /8 or less), accurate design is possible on the basis of the results of experiment by means of scale model.

The electrical characteristics of the aerial which are measured at the scale model experiment are effective height, effective electrostatic capacity and resonance frequency.

The aerial taken up in this report has been designed on the basis of the results of study of the aerials in practical use at Decca stations of the Maritime Safety Agency of the Japanese Government and the scale model aerials of the same Agency.

The effective height and other constants of an aerial can be obtained by the following expressions:

a) Effective height: he

$$he = \frac{E\,d\,\lambda}{120\pi\,Ib}$$

or

$$he = \frac{Vi}{Ei}$$

where Ib is Aerial current at base (A)
E is Field intensity at point of distance d (v/m)
λ is Wave length (metre)
d is Distance between the aerial and the point of measurement (metre)
Vi is Open circuit voltage of an aerial (v)
Ei is Field intensity at the point (v/m)

b) Radiation resistance Rr

$$Rr = 160\pi^2 \left(\frac{he}{\lambda}\right)^2$$

c) Current at base Ib

$$Ib = \sqrt{\frac{Pr}{Rr}}$$

where Pr is Radiation power

d) Voltage at base Vb

$$Vb = Vt \left[1 - \left(\frac{f}{f_0}\right)^2\right]$$

Where Vt is Voltage at end of top hat (v)
f is Transmitting frequency (Hz)
f_0 is Resonance frequency (Hz)

e) Voltage of top-hat Vt

$$Vt = \sqrt{\frac{P}{6.95 \times 10^{-13} \; Co^2 \; he^2 \; f^4}}$$

Where Co is effective electrostatic capacity (PF)

f) Inductance of tower Lt

$$Lt = \frac{1}{4\pi^2 \; f_0^{\,2} \; Co}$$

g) Reactance at base Xb

$$Xb = \frac{1}{2\pi Co f} \left[1 - \left(\frac{f}{f_0}\right)^2\right]$$

3) Electric characteristics of top loaded aerial

The composition of an umbrella type top loaded aerial is as stated above, and by adopting this type of aerial it is now possible to increase the effective height and electrostatic capacity of the aerial. By an increase in the effective height of an aerial is meant the improvement of radiation efficiency of the aerial, as shown in the foregoing expressions. On the other hand, the electrostatic capacity becomes larger and the insulation becomes easy.

As a result of the design, the elctric characteristics of the aerial system at frequency of 100 KHZ are calculated as follows:

Effective height	he	63 m
Effective electrostatic capacity	Co	3770 PF
Resonance frequency	f_o	380 KHZ
Radiation resistance	Rr	0.71 Ω
Efficiency	η	25%
Reactance at base	Xb	390 Ω
Voltage at end of top-hat	Vt	8.7 Kv
Voltage at base	Vb	8.2 Kv
Current at base	Ib	21A

The voltage and current at the time of lane identification show five times the above figurea at the time of peak and twice those on an average because of the multiple transmission of five frequencies.

The electric characteristics of an umbrella type aerial are influenced by such other factors as given below. They have been taken into consideration for producing the best design of the aerial system given above.

(a) Shape of top-hat radial

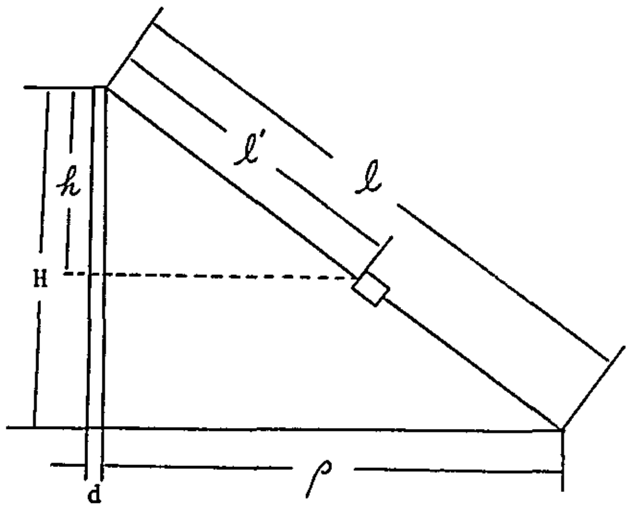
Following are items which influench the electric characteristics:

a) Number of top radials N

b) Height H and diameter d of tower

c) Distance between the base of the tower and anchor point of the radial ρ (indicated as multiples of the tower)

d) ℓ is the total length L of the top-hat radials, ℓ' the active length, and h the projection of the height H, then as can be seen from Figure 5-3-11.



Changes in the effective height, effective electrostatic capacity and resonance frequency for these various values mentioned above are as shown in Fig. 5-3-2 through Fig. 5-3-10.

(b) Cage

The cage attached to the tower affects to increase the elctrical effective diameter of the steel tower and to decrease the reactance gradient in the working frequency band. The effective diameter a' of the cage is indicated by the equation shown below. To take the foregoing aerial as an example, of which the diameter of cage conductor is 1.35cm, radius of the cage 300cm and number of cage wire 12, the effective diameter of the cages becomes 2.3m, and this indicates the cage has great effect.

$$a' = \left\{ a(2b)^{n-1} \left(\sin\frac{\pi}{n}\right)\left(\sin\frac{2\pi}{n}\right)\cdots\left(\sin\frac{(n-1)\pi}{n}\right) \right\}^{\frac{1}{n}}$$

a: Radius of cage conductor

b: Radius of cage

n: Number of cage wire

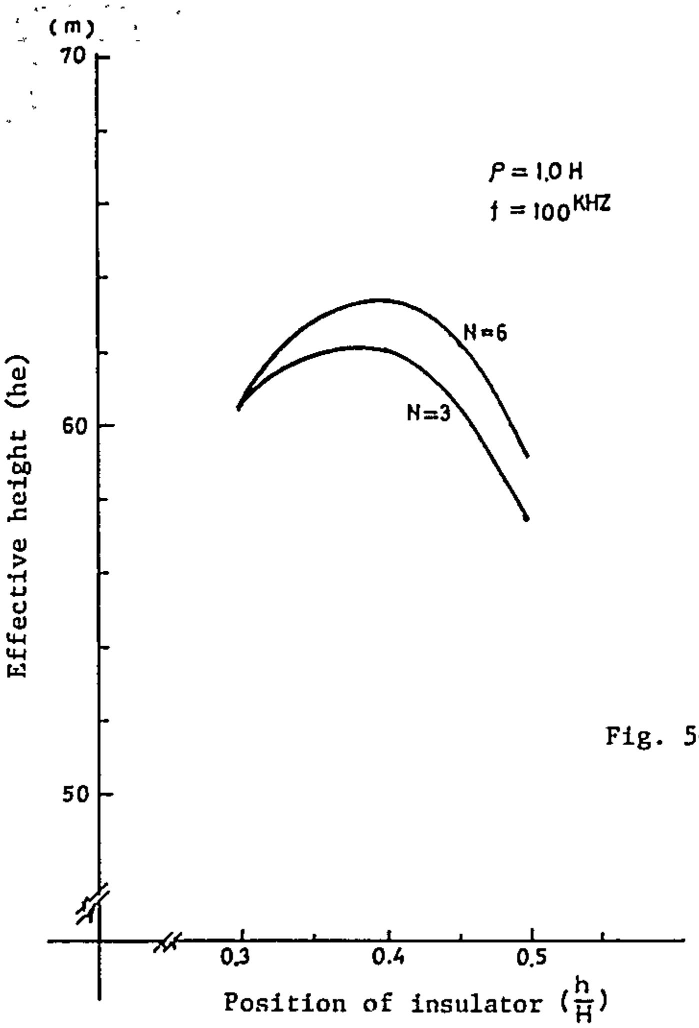


Fig. 5-3-2

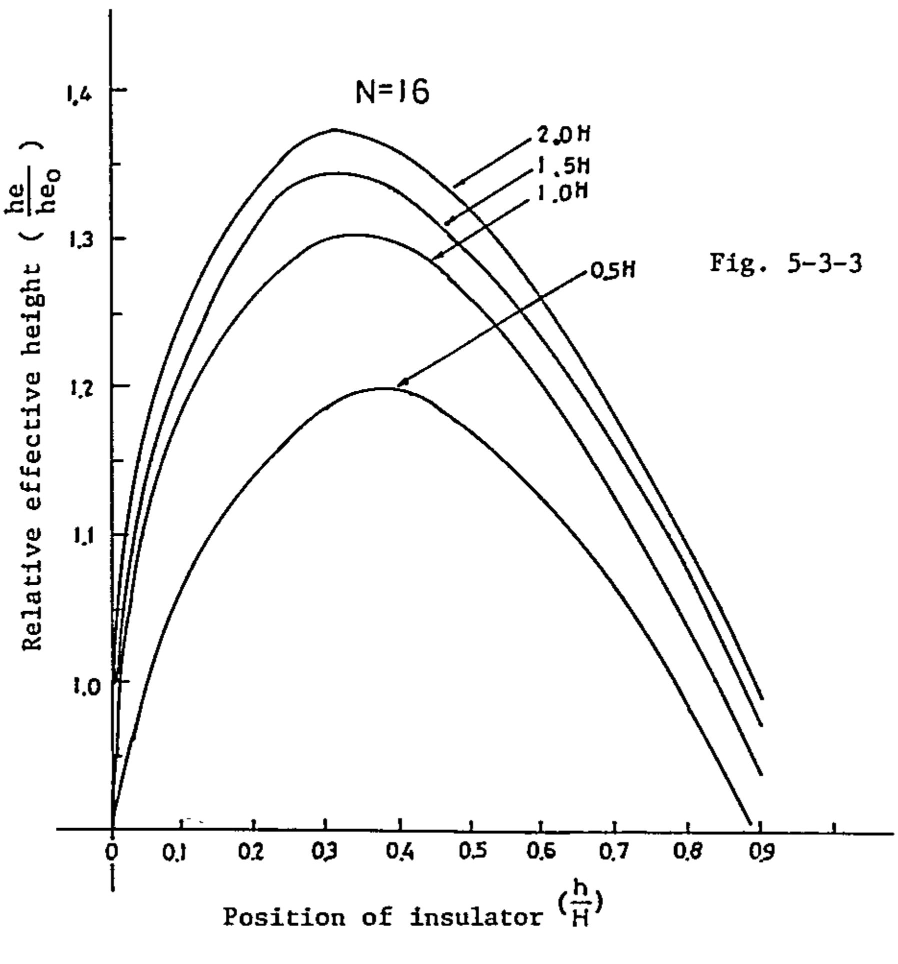


Fig. 5-3-3

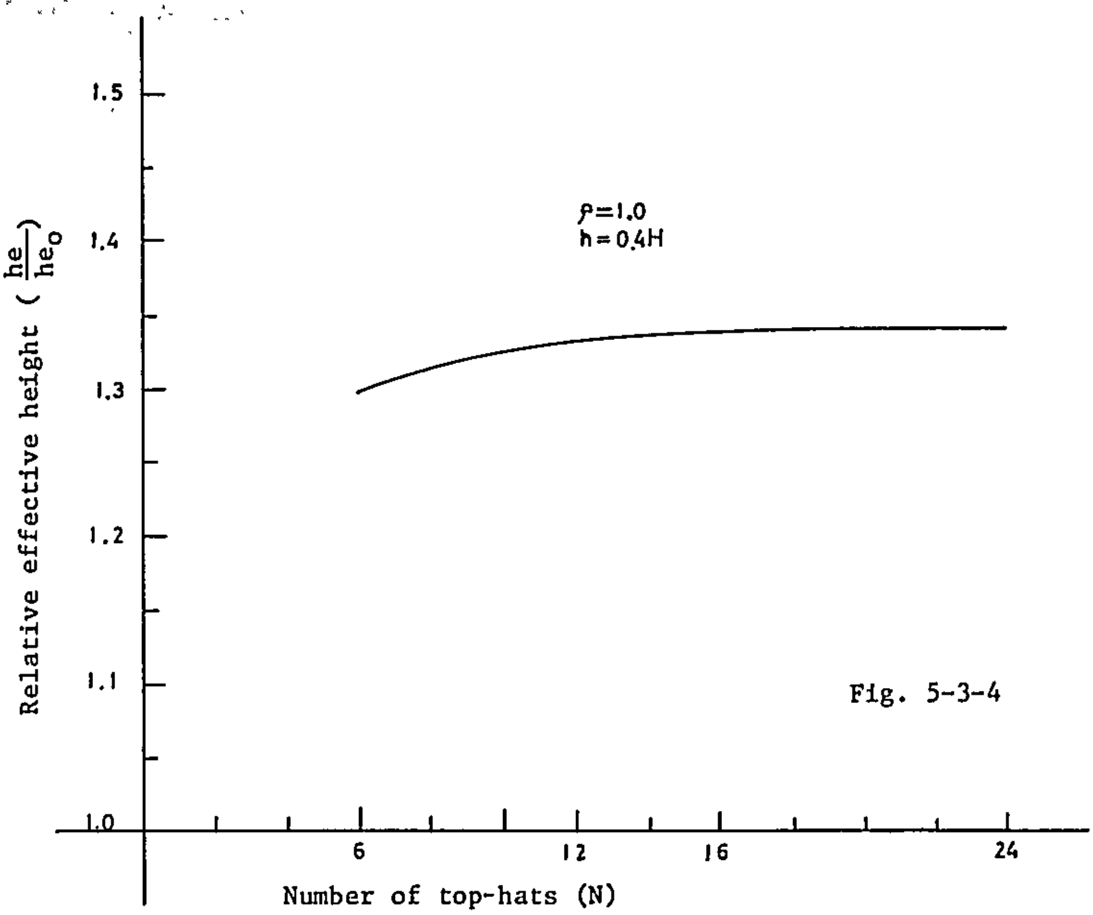
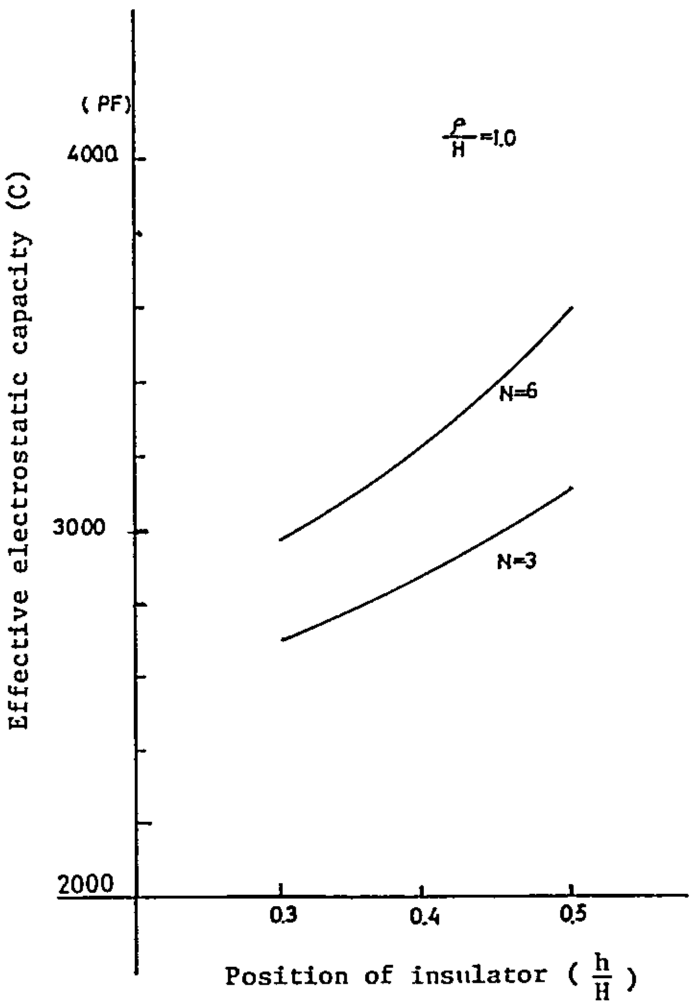


Fig. 5-3-4

Fig. 5-3-5



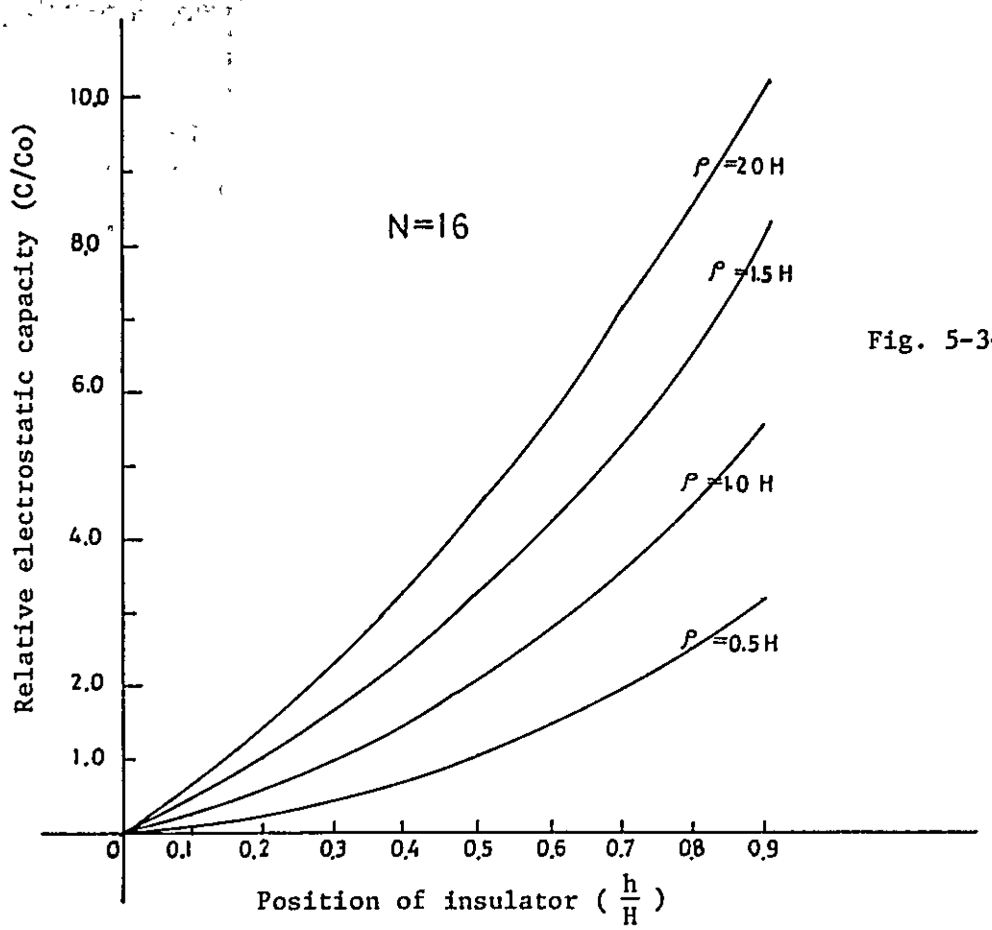


Fig. 5-3-6

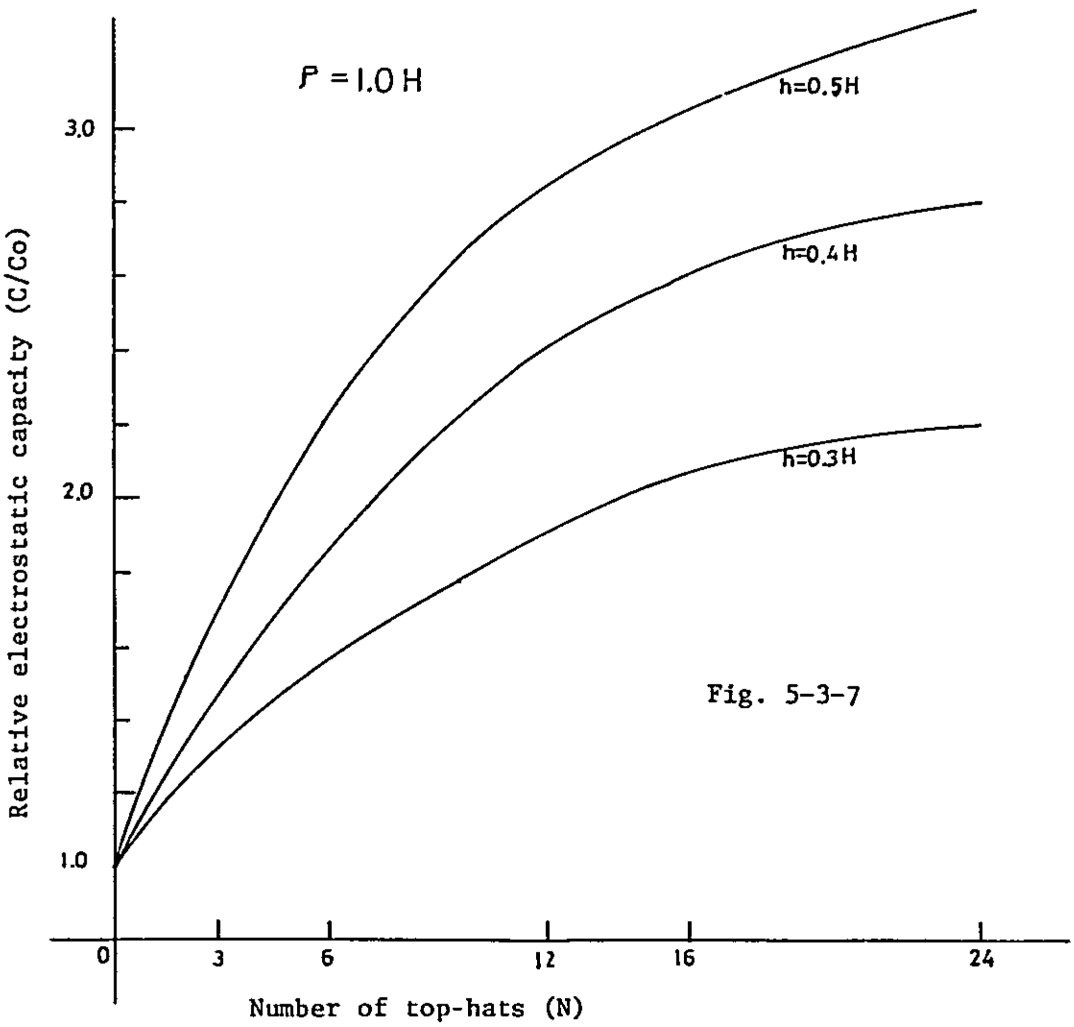


Fig. 5-3-7

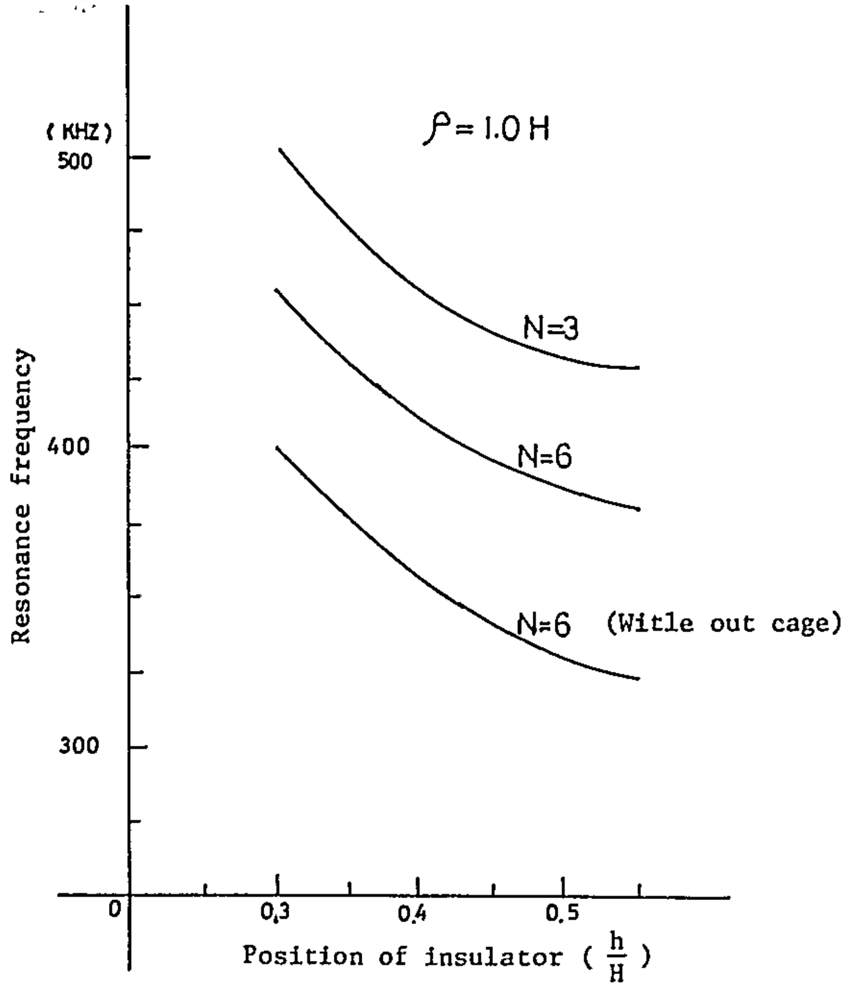


Fig. 5-3-8

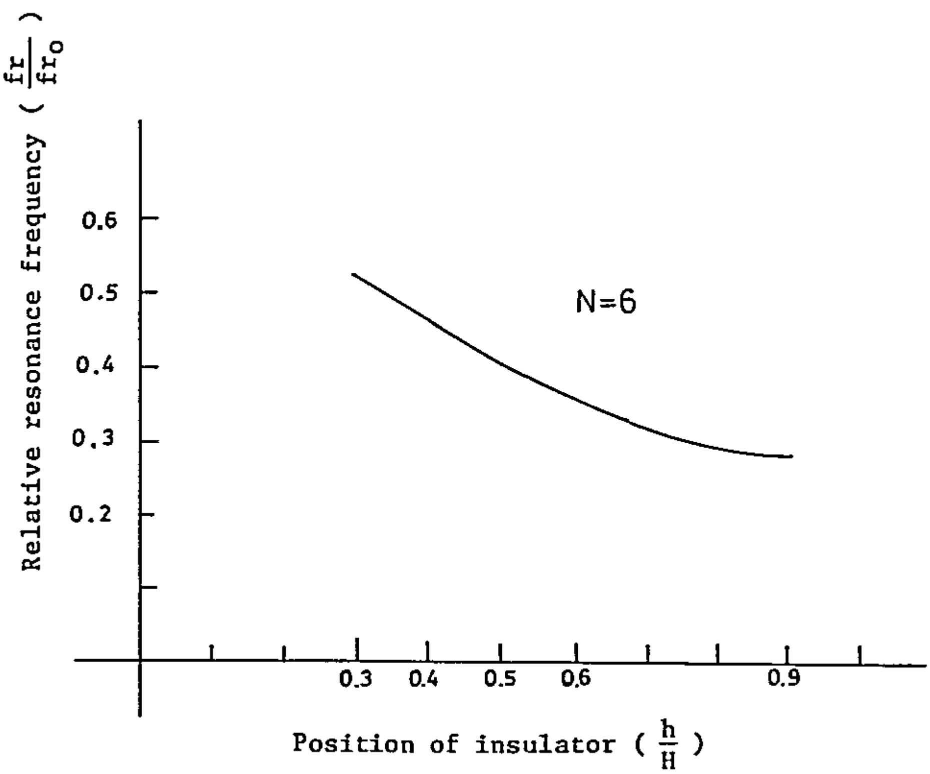


Fig. 5-3-9

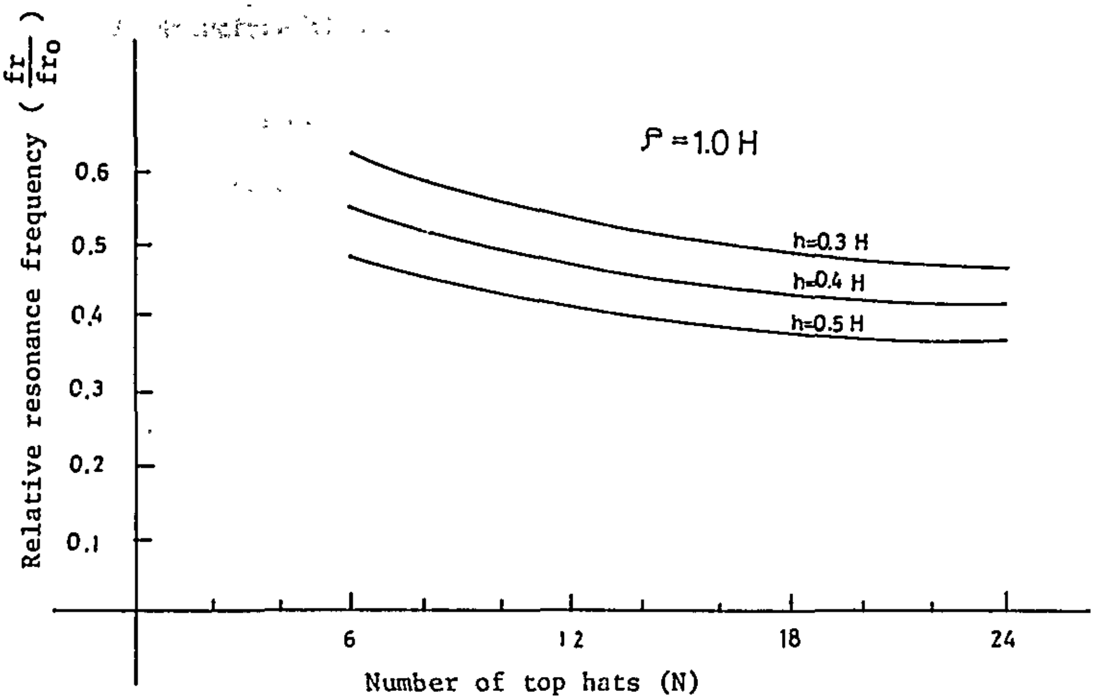

Relative resonance frequency (fr/fro)
0.6
0.5
0.4
0.3
0.2
0.1
6
12
18
24
Number of top hats (N)
ρ = 1.0 H
h=0.3 H
h=0.4 H
h=0.5 H

Fig. 5-3-10

(2) Structure of Decca transmitting aerials

1) Introduction

The structural features of Decca transmitting aerial are that the tower has 12 cage wires along the tower mast, which are arranged in a circle in a circle of 6 metres in diameter surrounding the tower, and also it has 16 lines of a large scale umbrella type radials extended in all directions from the cop of the tower. The details of the aerial are shown in the annex.

2) Tower body

The body of the steel tower is of steel tubular triangular truss structure and its dimensions are as follows:

a) Sectional dimension

Regular triangle of 1000mm side length

b) Main posts

Diameter	114.3 mm$^{\phi}$
Thickness	4.5 mm
Material	STK 41 JIS G 3444 (Carbon steel pipe for natural construction)

c) Diagonal mumber

Round bar	20 mm$^{\phi}$
Material	S 20C JIS G 4051 (Carbon steel members for mechanical works)

d) Lateral members

Channel	100 x 50 x 7 mm
Material	SS 41
	JIS G 3101 (Rolled steel members for natural construction)

e) Blocks and Joints

The tower mast is broken down into four kinds of blocks: standard block, guy fitting block, base block and top block. Jointings of these blocks are friction coupling by high tensile bolts.

f) Sectional charactistics

Table 5-3-3

Section (mm)	Geometrical moment of inertia (cm^4)	Sectional area (cm^2)	Radius of gyration of area (cm)	Weight (kg/m)
3-PIPE 114.3^{ϕ} x 4.5	77,600	46.56	40.82	120

3) Guy and aerial

a) Type of guy 3 direction 3 level

b) Type of aerial

i) Extending umbrella type of aerial in 16 different directions from the top of the tower

ii) Extending 12 cage wires in a circle of 6 metres in diameter surrounding the tower.

c) Specifications of materials for guy and aerial

Table 5-3-4

		Type	Diameter (cm)	Sectional area (cm^2)	Breaking load (t)	Weight (t/cm)	Young's modulus (t/cm^2)
Guy	I	Spiral rope (1 x 37)	2.2	2.9	39.8	2.38×10^{-5}	1600
	II		2.2	2.9	39.8	2.38×10^{-5}	1600
	III		2.2	2.9	39.8	2.38×10^{-5}	1600
Umbrella type aerial		7/4.2 of almo-weld	1.26	0.95	10.65	6.45×10^{-6}	1600
Cage wire		7/4.5 of almo-weld	1.35	1.11	11.78	7.41×10^{-6}	1600

4) Ladder, etc.

a) Ladder

To be fitted inside the truss.

b) Platform

To be fitted inside and outside of each guy step.

c) Obstruction light

Obstruction lights are fitted on two places of top, I, II and III

(3) Design

1) Design criteria

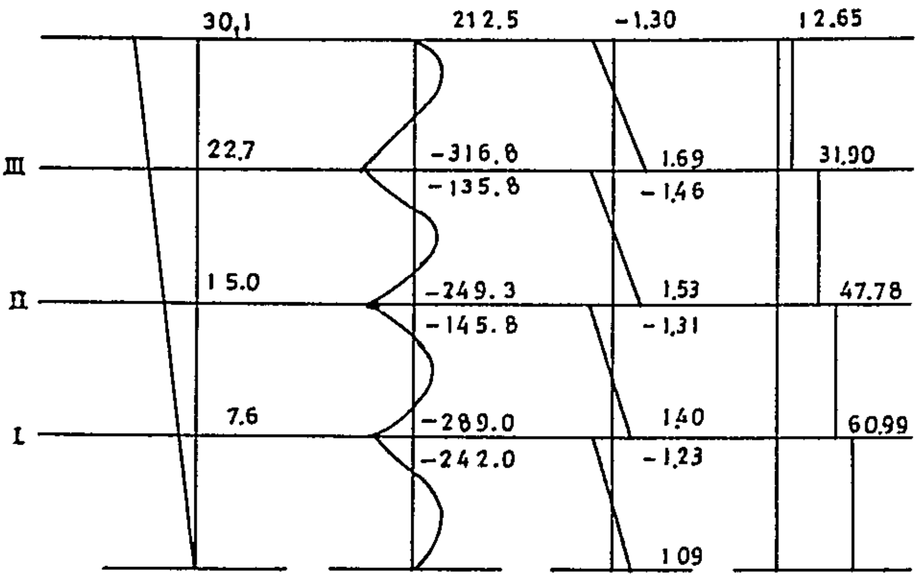
The wind velocity adopted as design criteria is 35 metres/second.

2) Computation of stress of tower

The stress of the tower has been calculated by using in the method explained in the Appendix B.
The summary of stress of wind load on the tower and guys is as shown in Tables 5-3-5 and 5-3-6.

Table 5-3-5

Stress diagram of tower



Displacement (cm) | Bending moment (t.cm) | Shearing force (ton) | Axis force (ton)

Table 5-3-6

Stress of guy

Level of guy	Direction of guy	Tension of guy (ton)	Guy fitting Position						Initial tension (ton)
			Guy anchor (ton)			Tower (ton)			
			Uplift	M	N	Wind	Normal	Vertical	
I	1	4.66	1.32	4.11	0.06	-2.11	3.54	2.17	5.06
	2	7.53	2.41	6.77	-0.00	6.76	0.00	3.32	
	3	4.66	1.32	4.11	-0.06	-2.11	-3.54	2.17	
II	1	3.72	1.72	2.63	0.09	-1.41	2.28	2.59	4.03
	2	7.68	4.16	5.77	-0.00	5.71	0.00	5.13	
	3	3.72	1.72	2.63	-0.09	-1.40	-2.28	2.59	
III	1	3.85	2.22	2.18	0.12	-1.22	1.90	3.12	4.39
	2	9.51	6.48	5.93	0.00	5.80	0.00	7.54	
	3	3.85	2.22	2.18	-0.12	-1.22	-1.90	3.12	

3) Main materials and their allowable unit stress and safety factor

Table 5-3-7

Place where materials are used	Materials	Tensile strength (t/cm^2)	Yielding point (t/cm^2)	Allowable unit stress (t/cm^2)	Remarks
Tower Body	STK 41	4.1	2.5	2.1	
	SM 41A	4.1	2.4	1.5	
Hardware for guy	SC 46	4.6	2.3	1.3	Casted steel product
	SS 41	4.1	2.4	1.2	Plate material
	SNCM-2	9.5	8.5	4.1	Pin material
Anchor frame	SS 41	4.1		1.4	

4) Computated results by computer

Part of the computed results are attached to appendix B

(4) Design plan

As shown in the attached drawings

5-3-3 Pier and road

1) Landing pier

A pier, where necessary, consisting of simple piles should be built for unloading of the construction equipment and materials at the time of station construction and for the logistic support. General design for a pier is shown in Annex (Drawing No.K064). It should, however, be noted that due consideration be given to the soil conditions for the piling and to the tidal level for a pier. The piles are of pre-cast type and the structure of the pier should be ferro-concrete. Fender should be provided for vessels in getting alongside.

2) Road

A road for vehicle traffic from the major road or the pier to the station site is desiged as is 3.5m wide and asphalt-concrete paved.

5-4 Designing of equipment

5-4-1 Decca transmitting equipment

(1) Composition

The Decca Navigator system is composed of a phase control equipment to synchronise the phase of transmitting radio wave, a transmitter to amplify the power to the required transmission level, an aerial coil assembly to effectively feed electric power to the aerial, a monitoring and switching equipment to monitor the operational status of a station and a central monitoring equipment to monitor the operational conditions of the whole system.

The components of the transmitting equipment are as shown in Table 5-4-1 and Table 5-4-2 below, and the Decca Navigator system configuration is illustrated in Fig. 5-4-1.

Table 5-4-1 Transmitting equipment components (cf: Table 5-4-2)

Name of item	Quantity		Remarks
	Master station	Slave station (each station)	
Phase control equipment	1 set	1 set	One set consists of 3 racks
Transmitter equipment	1 set	1 set	One set consists of 5 transmitters for each frequency (5 racks)
Aerial coil assembly	1 set	1 set	ATAM unit is included
Monitoring and switching equipment	1 set	1 set	One set consists of 2 racks
Central monitoring control equipment	1 set	——	Monitoring receiver (monitor site), remote control console and data logger

The outer view of each equipment is shown in Figs. 5-4-2 through 5-4-17.

(2) Main ratings of the transmitting equipment

An outline of the specification of the transmitting equipment is as follows:

1) Transmission frequencies

Five specific frequencies are used for a Decca chain. They are as follows:

5f	One frequency in the band of	70,083~ 71,587 KHz
6f	"	84,100~ 85,905 KHz
8f	"	112,134~114,540 KHz
8.2f	"	114,940~117,400 KHz
9f	"	126,150~128,860 KHz

2) Master oscillator

Rubidium oscillator system

3) Frequency stability

Within $\pm 3 \times 10^{-11}$/month

4) Transmitter output

1.2 KW for each of 5f, 6f, 8f, 8.2f and 9f

5) Type of emission

A0

6) Transmission mode

MK-10 system

Table 5-4-2 Station equipment components

Name of item	Quantity						Rating	Remarks
	Master	Slave			Control Center	Monitor site		
		Red	Green	Purple				
Phase control equipment	3	3	3	3				
Receiving aerial	4	4	4	4			5m	Wire or whip type for phase control equipment and station monitor
Monitoring and switching equipment	2	2	2	2				Monitors on 14 items and selects optimum phase control rack
Transmitter	5	5	5	5			1.2^{kw}	5f, 6f, 8f, 8.2f and 9f
Spare rack	1	1	1	1				Accommodates PA, exciter spare unit and dummy load
Aerial coil assembly	1	1	1	1				Multiple feeding for an aerial
A.T.A.M. unit (Automatic Tuning And Matching)	1	1	1	1				5 frequencies simultaneously
Data recorder					1			
Remote control console					1			
Monitor receiver						1		Including receiving aerial
UHF transmitter/receiver						1		

(3) Phase control equipment

In the Decca Navigator system, the phase of the radio waves transmitted from all slave station should be synchronised with that of the master station.

The phase control equipment is a device to synchronise the phase of the radio waves and to control the time of tramsmission.

The phase control equipment in a slave station is slightly different in function from that of the master station. The former is required to be operated synchronously with the latter by receiving radio signals from the master station. Figs. 5-4-3 and 5-4-4 show the outer view of phase control equipment in the master and slave stations.

1) Functions of the phase control equipment

a) In the master station

i) Generation of basic frequency and reference phase signal of a Decca chain.

ii) Generation of reference time signal of a Decca chain and of time signal of own station.

iii) Feeding of phase-shnchronised radio signals of 5f, 6f, 8f, 8.2f and 9f to the transmitter, on the frequencies.

b) In a slave station

i) Reception of radio waves from the master station and generation of the signals whose phase is synchronised with that of the master station.

ii) Generation of the time signals of own slave station, which are synchronised with those of the master station.

iii) Feeding of phase-synchronised radio signals of 5f, 6f, 8f, 8.2f and 9f to the transmitter equipment on the frequencies as in the case of the master station.

2) Composition

Tabele 5-4-3 Phase control equipment components

Name of unit		Quantity	
		Master station	Slave station (each)
Master oscillator (Rb OSC)		3	3
Drive unit	5f	3	3
"	6f	3	3
"	8f	3	3
"	8.2f	3	3
"	9f	3	3
Time signal generator		3	3
6f receiver		—	3
8.2f receiver		—	3
Frequency synthesiser and clock		3	3
Power supply unit		3	3
Phase shifter		3	3

(4) Transmitter

The transmitter functions as a power amplifier to amplify the radio signals of 5f, 6f, 8f, 8.2f and 9f which are fed from the phase control equipment, and to provide an output of 1.2 KW of each of these frequencies. In Fig. 5-4-5 is shown the outer view of the transmitter.

1) Functions

a) The transmitter amplifies the signals from the phase control equipment to 1.2 KW and feed them to the aerial through the aerial coil assembly.

b) The transmitter compensates the fluctuation of input signal from the phase control equipment and fluctuation of load with the aim at insuring the optimum operation at all times.

c) The transmitter PA of each frequency consists of 12 units and can be operated almost with the rated power even in the case of failure of two units out of them. The alarm signal will be sent in the case of failure in a fan unit exciter units of two or more and 8 transistors in PA units (warning signal in the case of 4 transistors.)

2) Composition

Table 5-4-4 Transmitter components of each frequency

Name of unit	Quantity	Remarks
Exciter unit	4	
Power amplifier unit	12	
Tuning unit	1	
Fan unit (1)	1	
Monitor indicator	1	
Air filter	1	
Aerial/dummy load changer	1	

(5) Aerial coil assembly

The aerial coil assembly is a matching and tuning device to feed the radio signal power from the transmitter to the aerial effectively. The outer view of the aerial coil assembly is shown in Figs. 5-4-6 through 5-4-11.

1) Functions

a) The tuning coils enable the aerial to be tuned simultaneously to the five frequencies.

b) The matching unit matches the coil assembly input impedance to the characteristic impedance of the feeder cable.

c) The change of aerial impedance, caused by environmental conditions is automatically compensated by the functioning of A.T.A.M.

d) In order to control the phase of each radio wave, phase of the aerial current is fed back to the phase control equipment.

2) Composition

Table 5-4-5 Aerial coil assembly components

Name of unit	Quantity for each station	Remarks
Loading coil	1 set	Five coils
Matching unit	5 cases	For each frequency
Feeder corrector unit	1 set	For five frequencies
Tuning condenser	24 pieces	
Phasing loop transformer	1 set	
ATAM unit	1 set	

(6) Monitoring and switching equipment

This unit is a device for monitoring the operating conditions of the phase control equipments. In case any abnormality occurs in the set on duty, the unit detects it and selects the optimum phase control equipment and switches automatically. In Figs. 5-4-12 and 5-4-13 are shown outer views of the monitoring and switching equipment of the master and slave stations.

1) Functions

a) Detection of abnormality of the phase control equipments and of itself.

b) Automatic (or manual) switching of the phase control equipment.

c) Indication of the abnormality

d) Monitoring of station operation

2) Composition

Table 5-4-6 Monitoring and switching equipment components

Name of rack	Name of unit	Quantity		Remarks
		Master	Slave for each	
Changer	Indicator unit	1	1	
	Switching unit	1	1	
	Auto selector unit (1)	1	1	For phase control equipment
	Auto selector unit (2)	3	3	
	Frequency counter unit	1	1	
	Interface unit	1	1	
	Power unit	1	1	
Monitor	Indicator & Control unit	1		

Monitor	Monitoring unit	1	1	0.2f & 6f comparison unit, OSC4, MK-10 identification unit (master station) Station monitor receiver, MK-10 identification unit (slave station)
	Monitoring receiver unit	—	1	Zone, subzone indicator
	Aerial current metre unit	1	1	
	Interface unit	1	1	
	Power unit	1	1	

(7) Central monitoring equipment

This is an apparatus to monitor the operation of a chain. It consists of the monitor console, monitoring receiver, data recorder, etc. The outer view of each component is shown in Figs. 5-4-14 through 5-4-17.

1) Functions of remote monitoring console

Monitoring of chain operation by the monitoring receiver

2) Composition

Table 5-4-7 Remote monitoring console components

Name of unit	Quantity	Remarks
Display unit (1)	1	
Display unit (2)	1	
Reception data unit	1	Including D/A converter
Interface unit (1)	1	
Interface unit (2)	1	
Power unit (1)	1	
Power unit (2)	1	

3) Other equipment

The monitoring site and the remote monitoring console are connected with each other by UHF link to perform the transmission of phase control signals.

4) Functions of the monitoring receiver

a) This receiver receives radio waves transmitted from the master station and slave stations and obtains pattern value, L.I. and zone data of each of the red, green and purple pattern.

b) These receiving data are transmitted by UHF transmitter to the remote monitoring console in order to monitor and record such data.

5) Composition

Table 5-4-8 Monitoring receiver components

Name of unit	Quantity	Remarks
Receiver	2	Five frequencies
Receiving aerial	2	
D/A Converter	1	
Power unit	1	

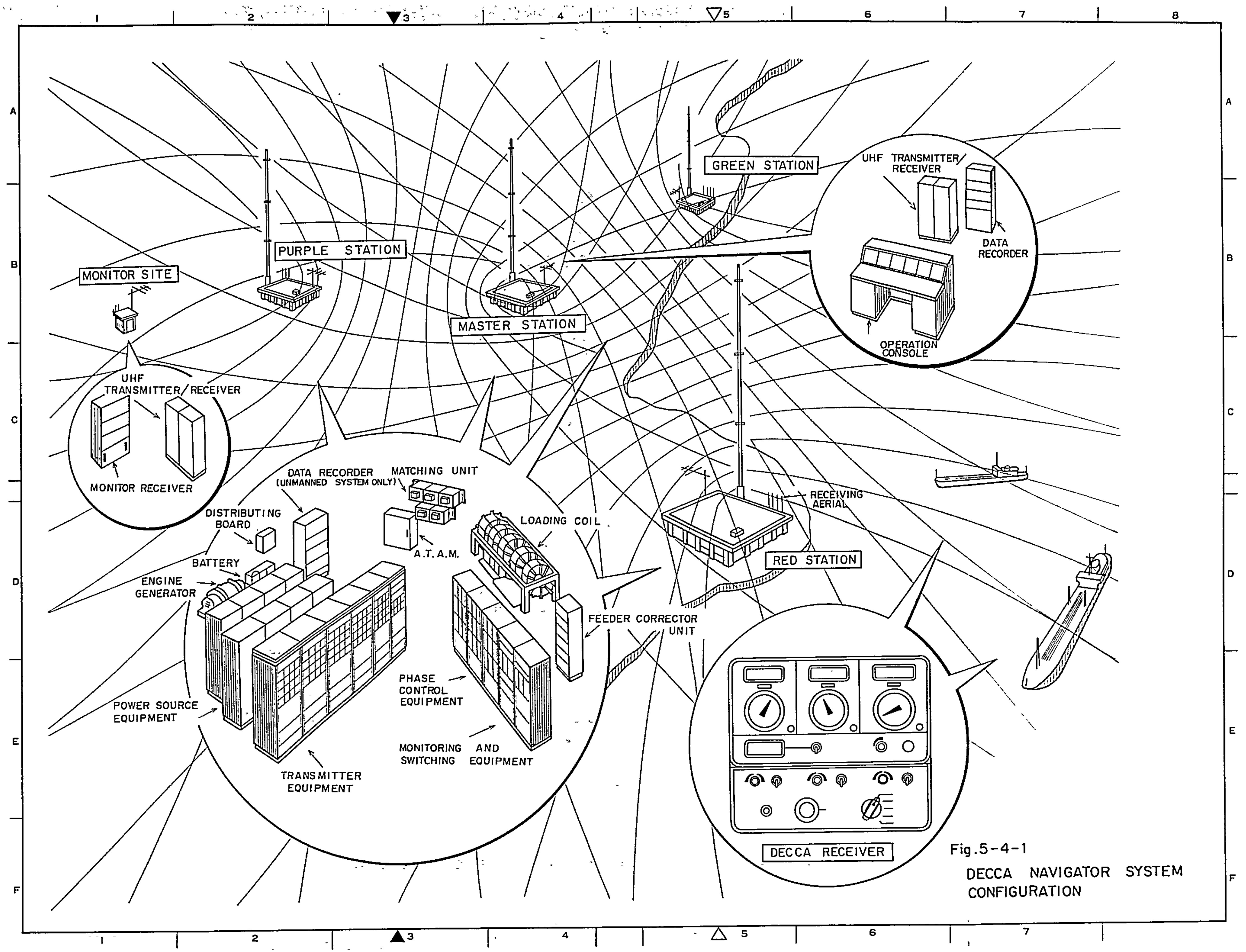


Fig.5-4-1
DECCA NAVIGATOR SYSTEM CONFIGURATION

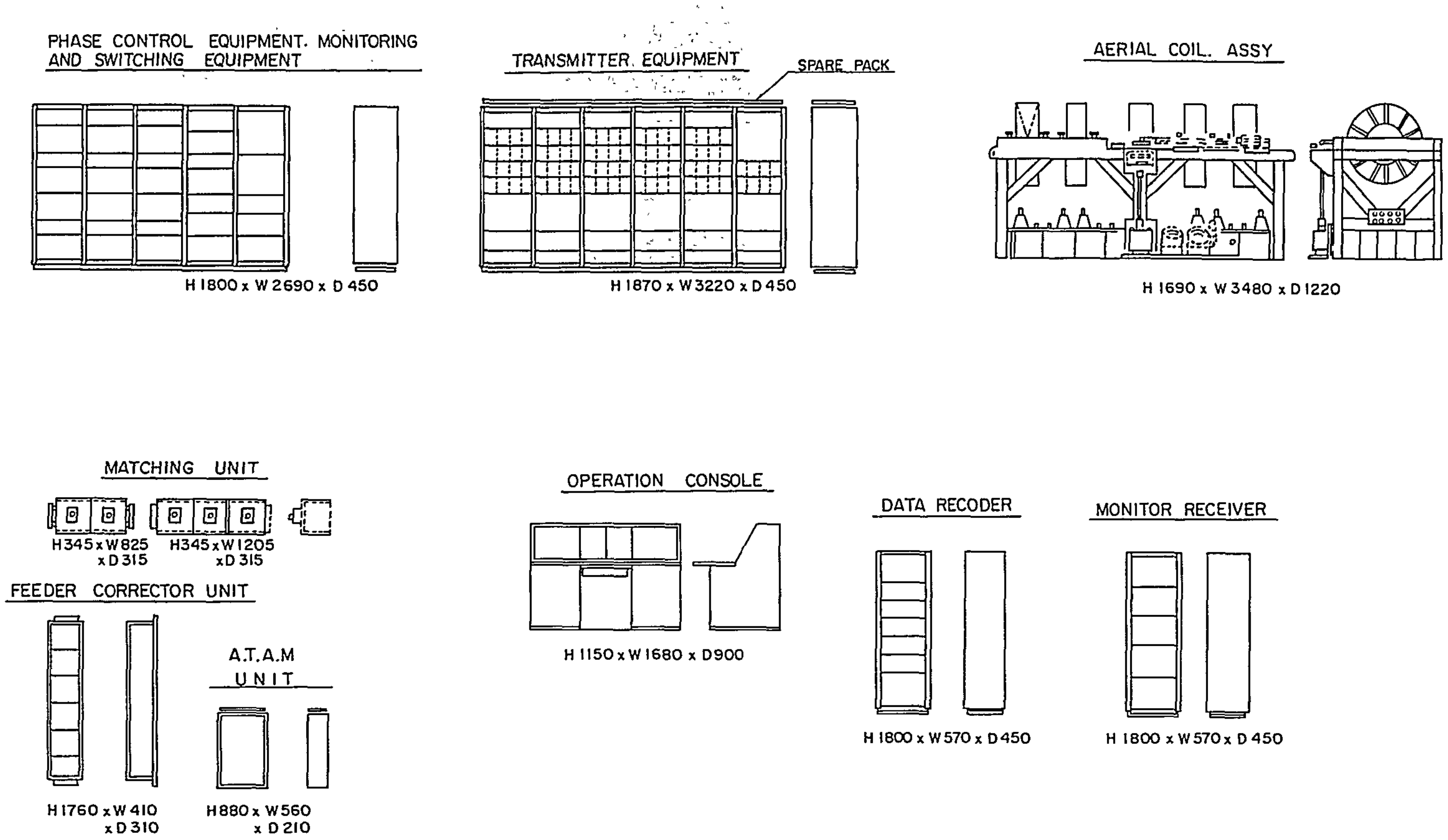


Fig. 5-4-2 OUTER VIEW OF DECCA TRANSMITTING EQUIPMENT

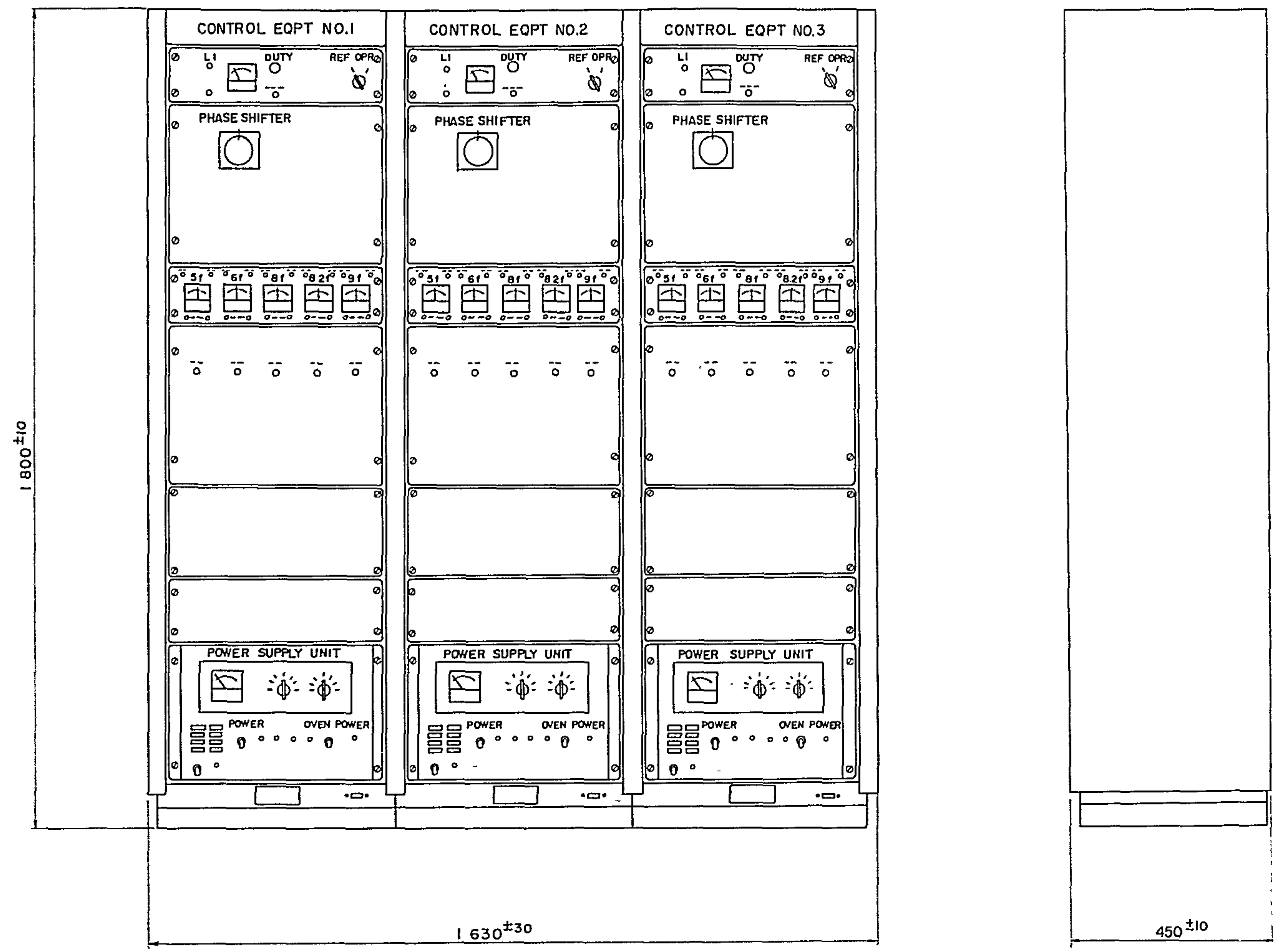


Fig. 5-4-3 PHASE CONTROL EQPT. OUTER VIEW FOR MASTER STATION

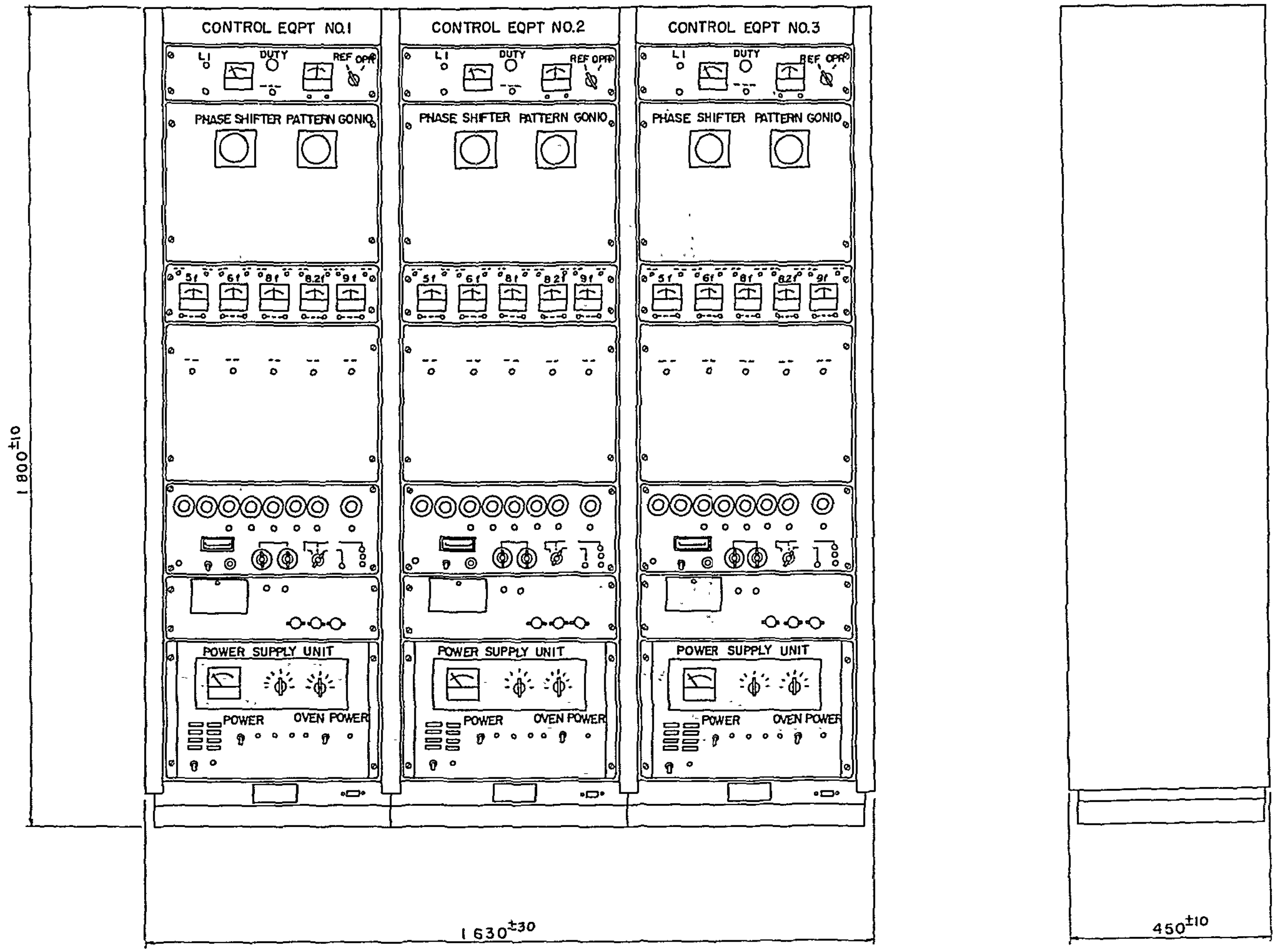


Fig. 5-4-4 PHASE CONTROL EQPT. OUTER VIEW FOR SLAVE STATION

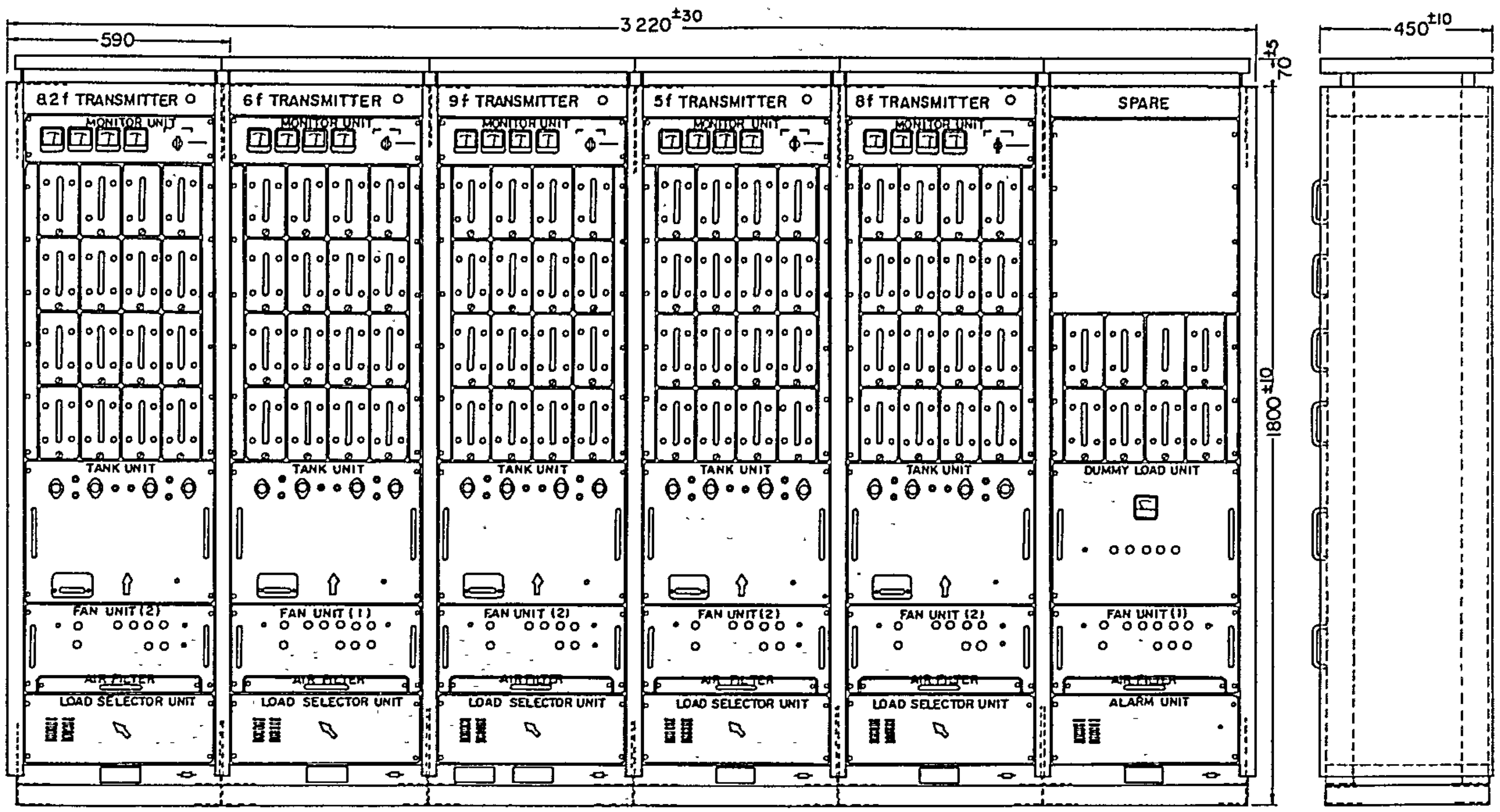


Fig. 5-4-5 DECCA TRANSMITTER OUTER VIEW

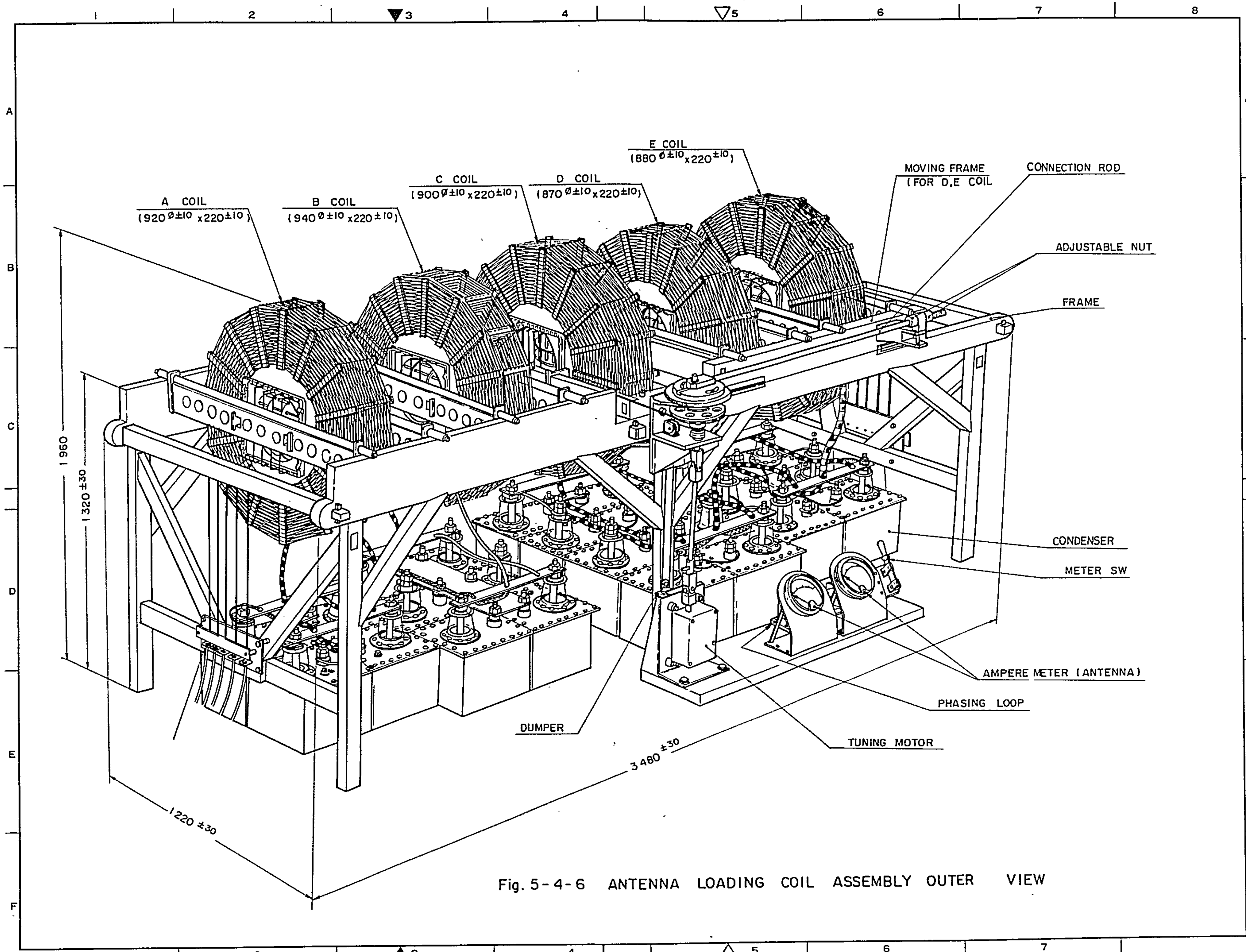


Fig. 5-4-6 ANTENNA LOADING COIL ASSEMBLY OUTER VIEW

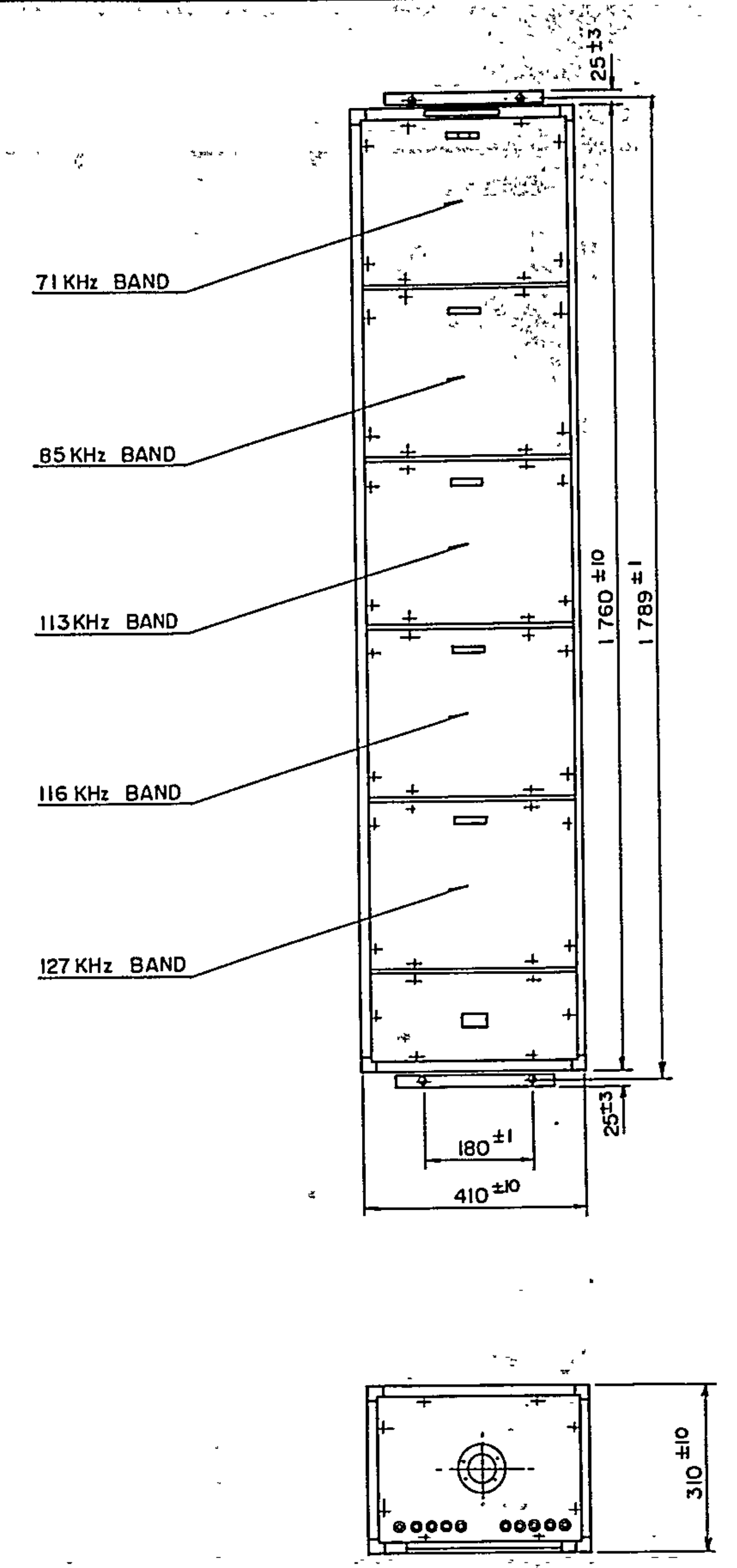


Fig. 5-4-7 FEEDER CORRECTOR UNIT OUTER VIEW

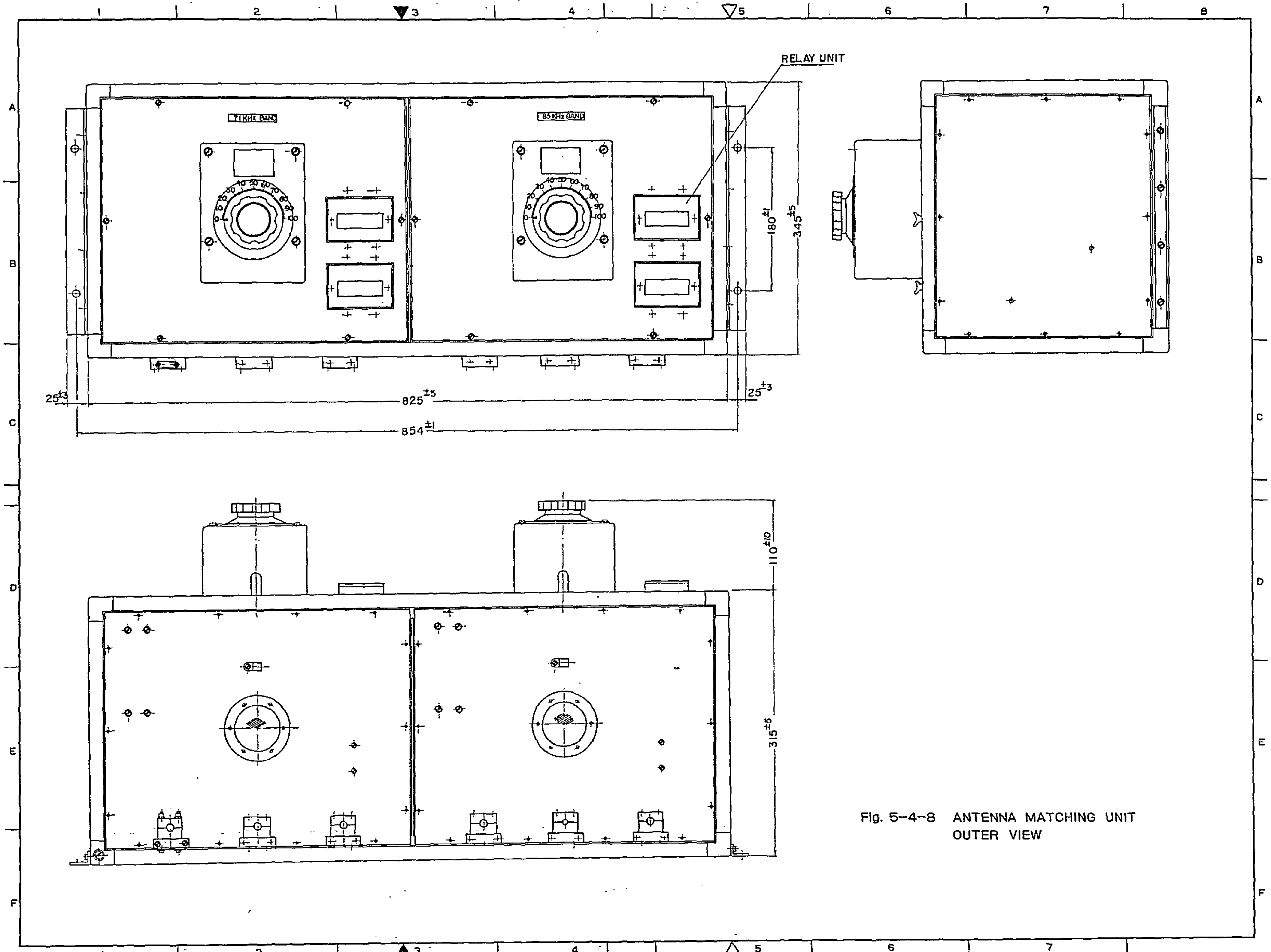


Fig. 5-4-8 ANTENNA MATCHING UNIT OUTER VIEW

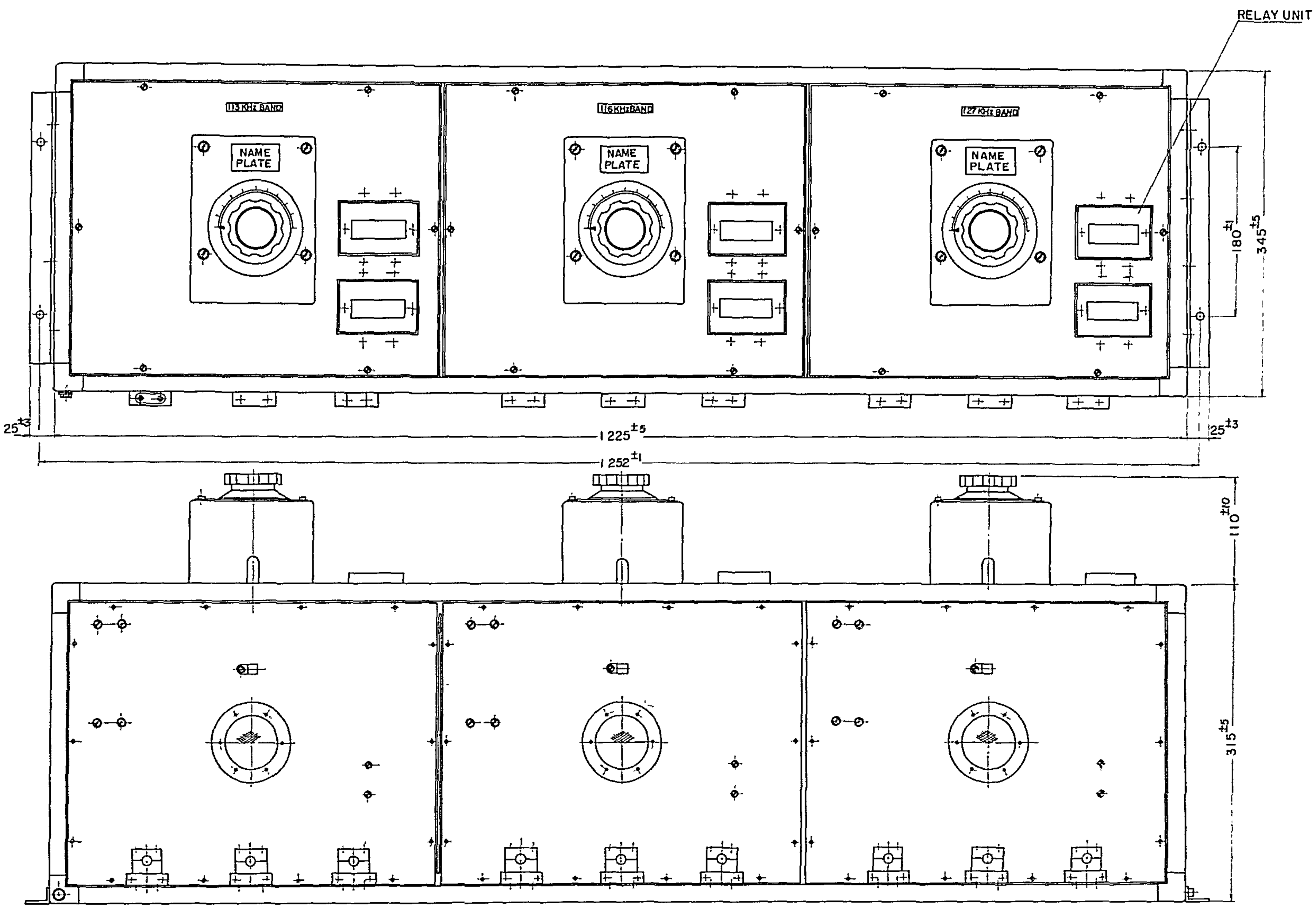


Fig. 5-4-9 ANTENNA MATCHING UNIT OUTER VIEW

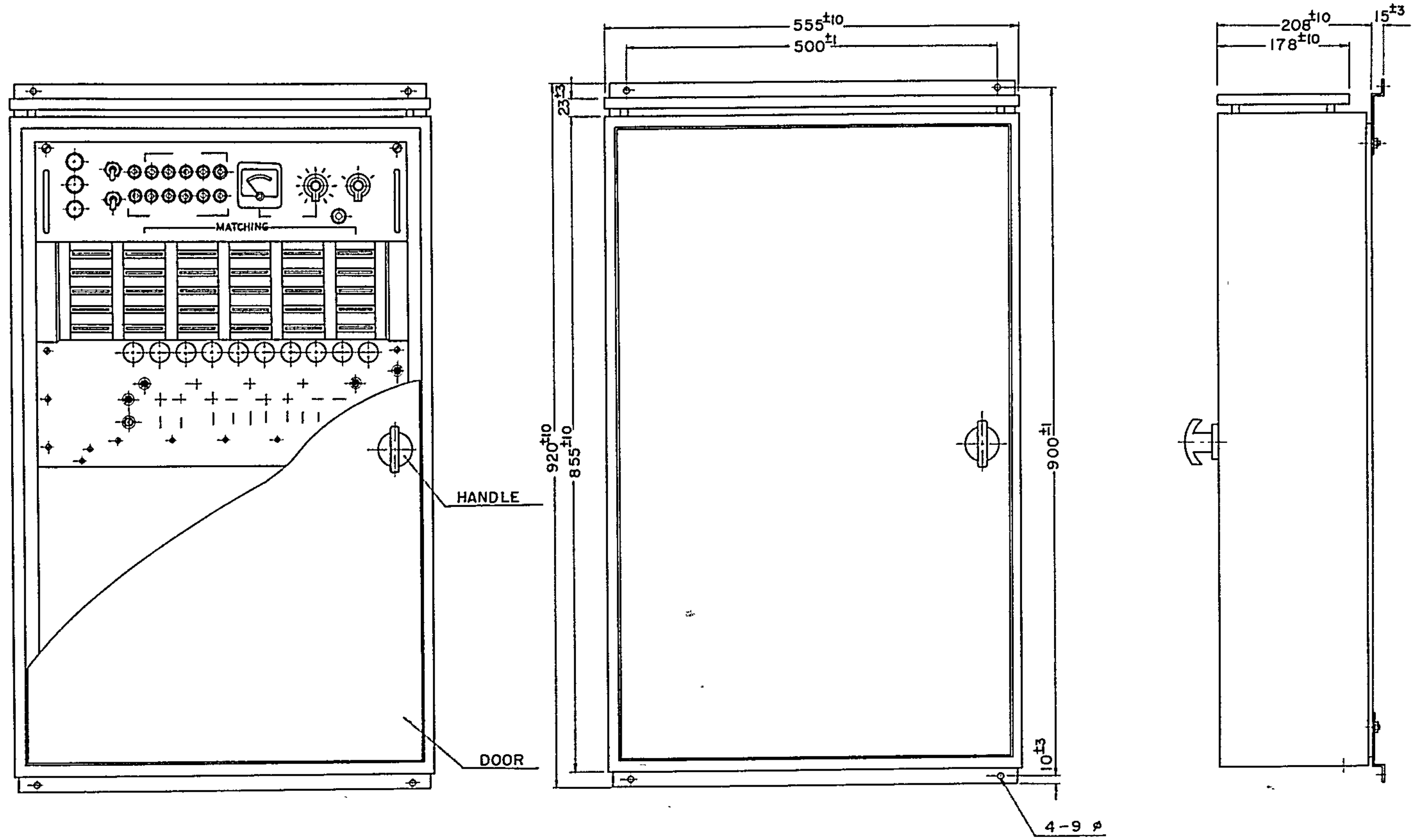


Fig. 5-4-10 ANTENNA TUNING AND MATCHING CONTROL UNIT OUTER VIEW

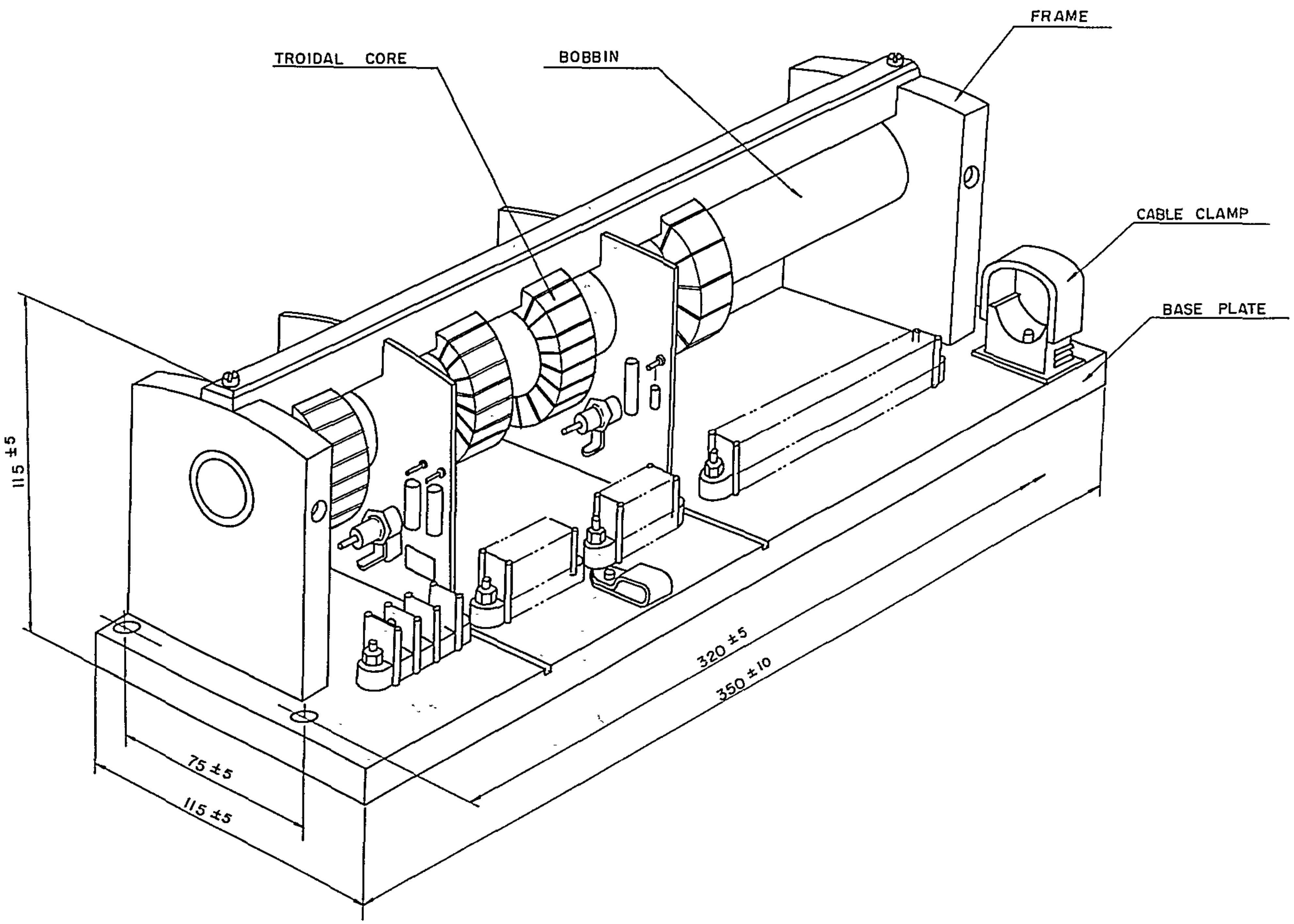


Fig. 5-4-11 PHASING LOOP UNIT OUTER VIEW

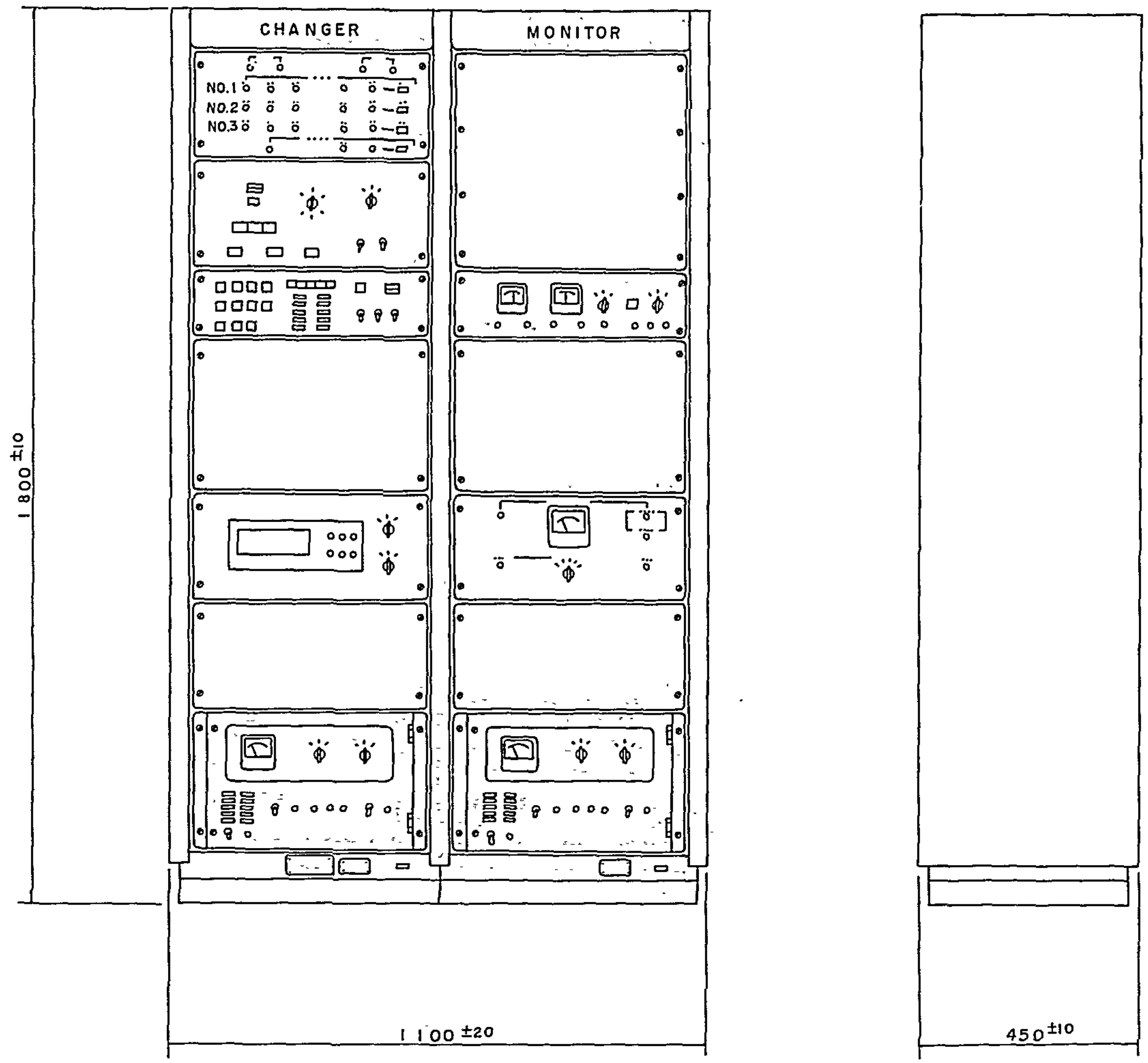


Fig. 5-4-12 MONITORING AND SWITCHING EQUIPMENT OUTER VIEW FOR MASTER STATION

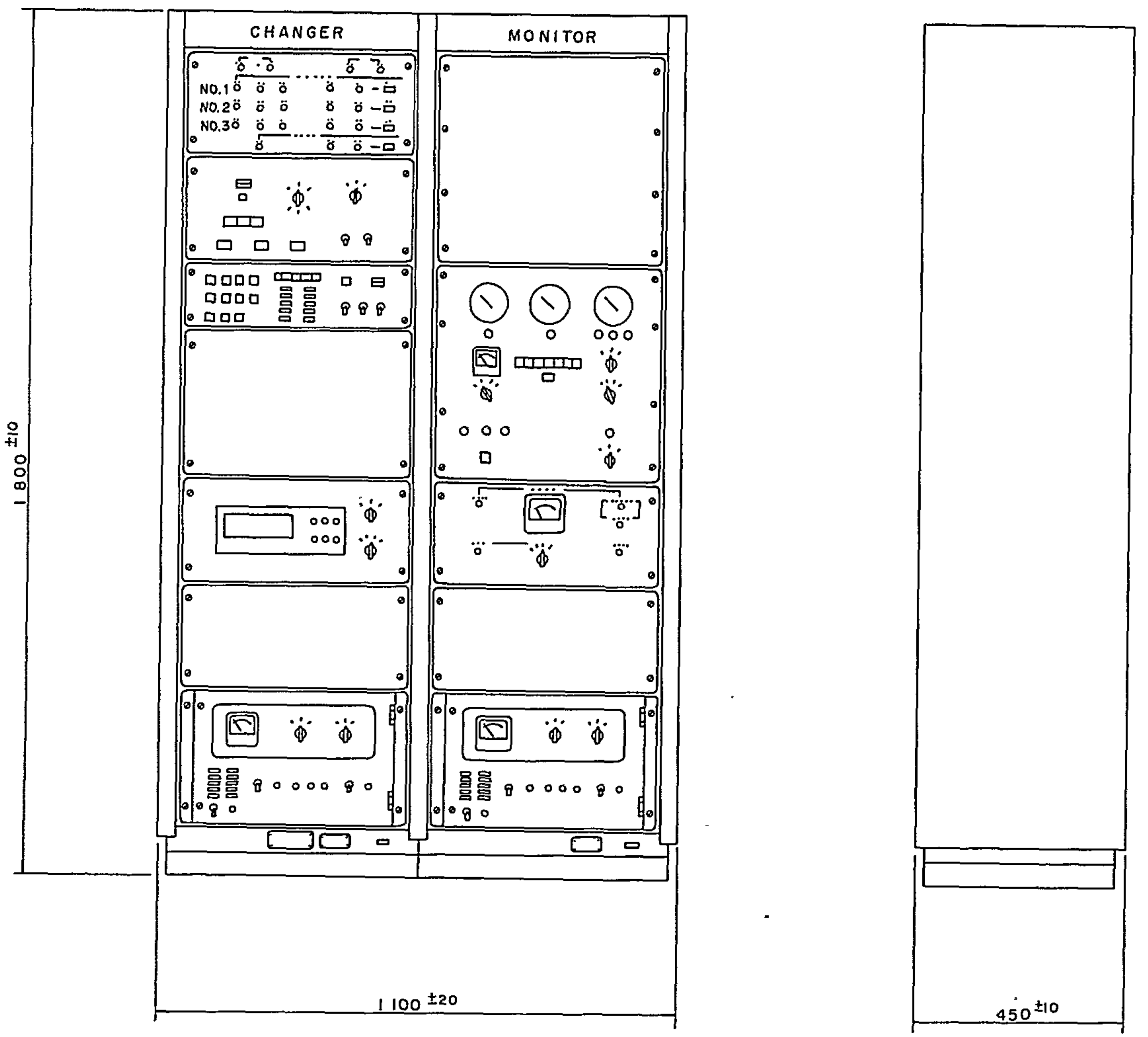


Fig. 5-4-13 MONITORING AND SWITCHING EQUIPMENT OUTER VIEW FOR SLAVE STATION

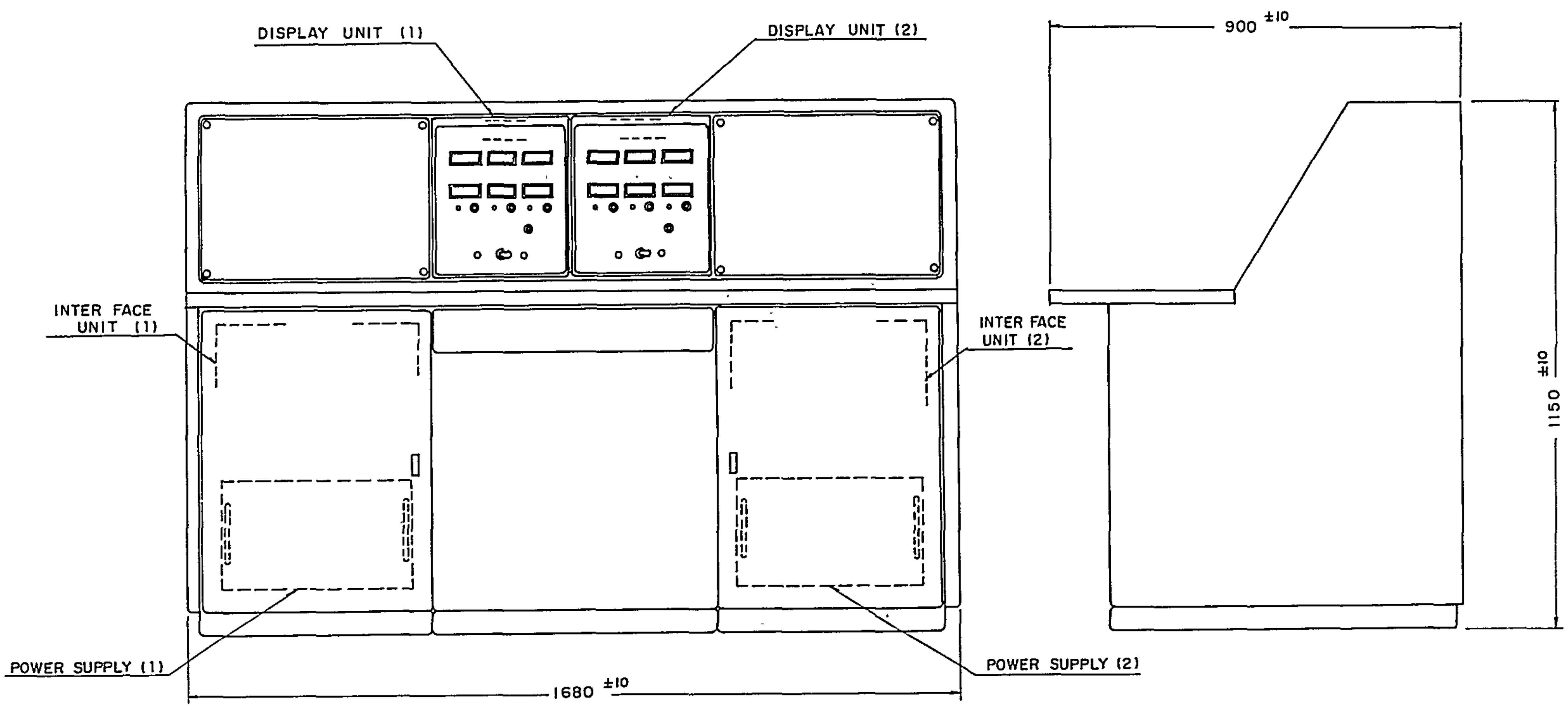


Fig. 5-4-14 OPERATION CONSOLE OUTER VIEW

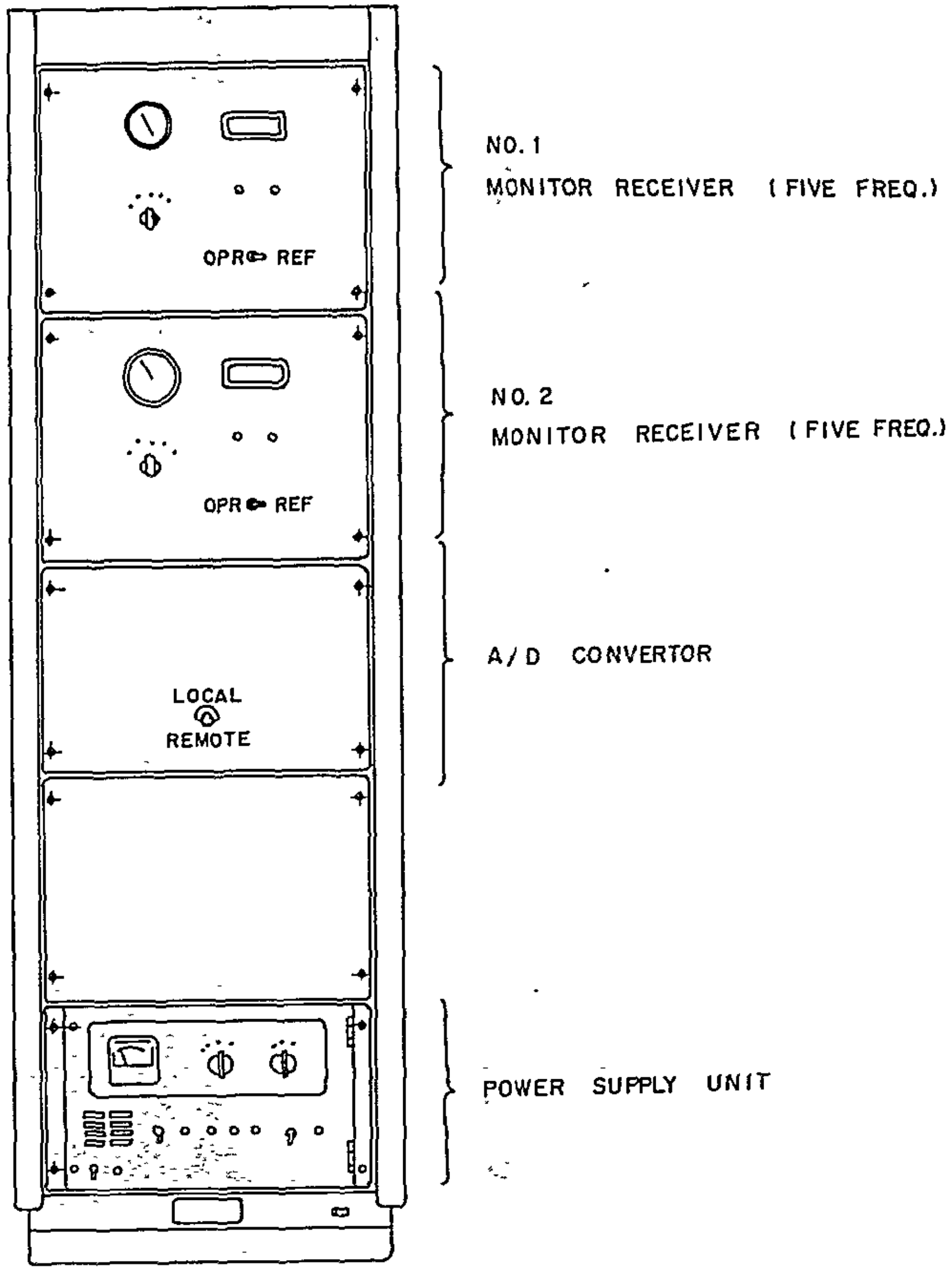


Fig. 5-4-15 MONITOR RECEIVER OUTER VIEW AT REMOTE MONITOR STATION

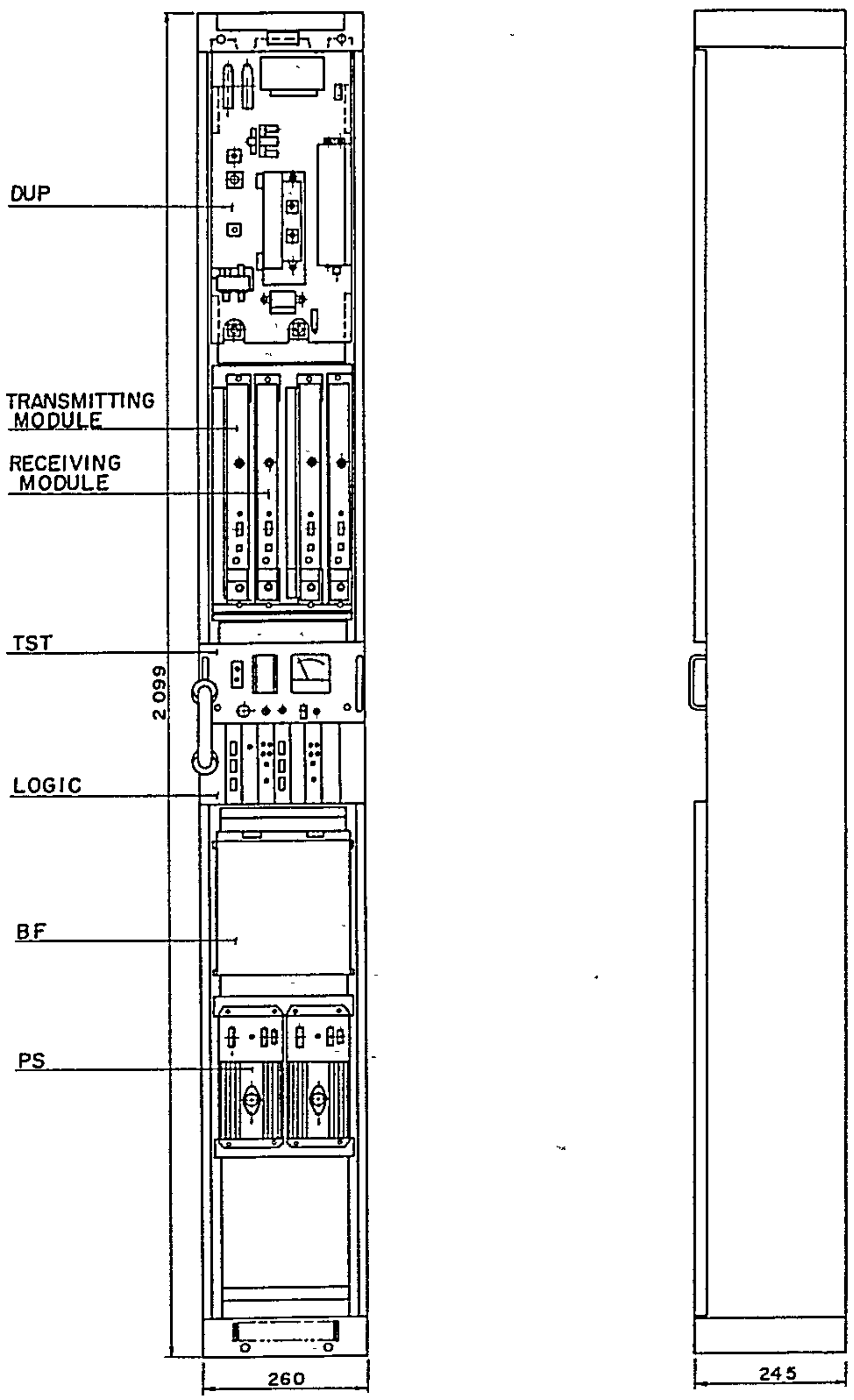


Fig. 5-4-16 UHF TRANSMITTER/RECEIVER OUTER VIEW

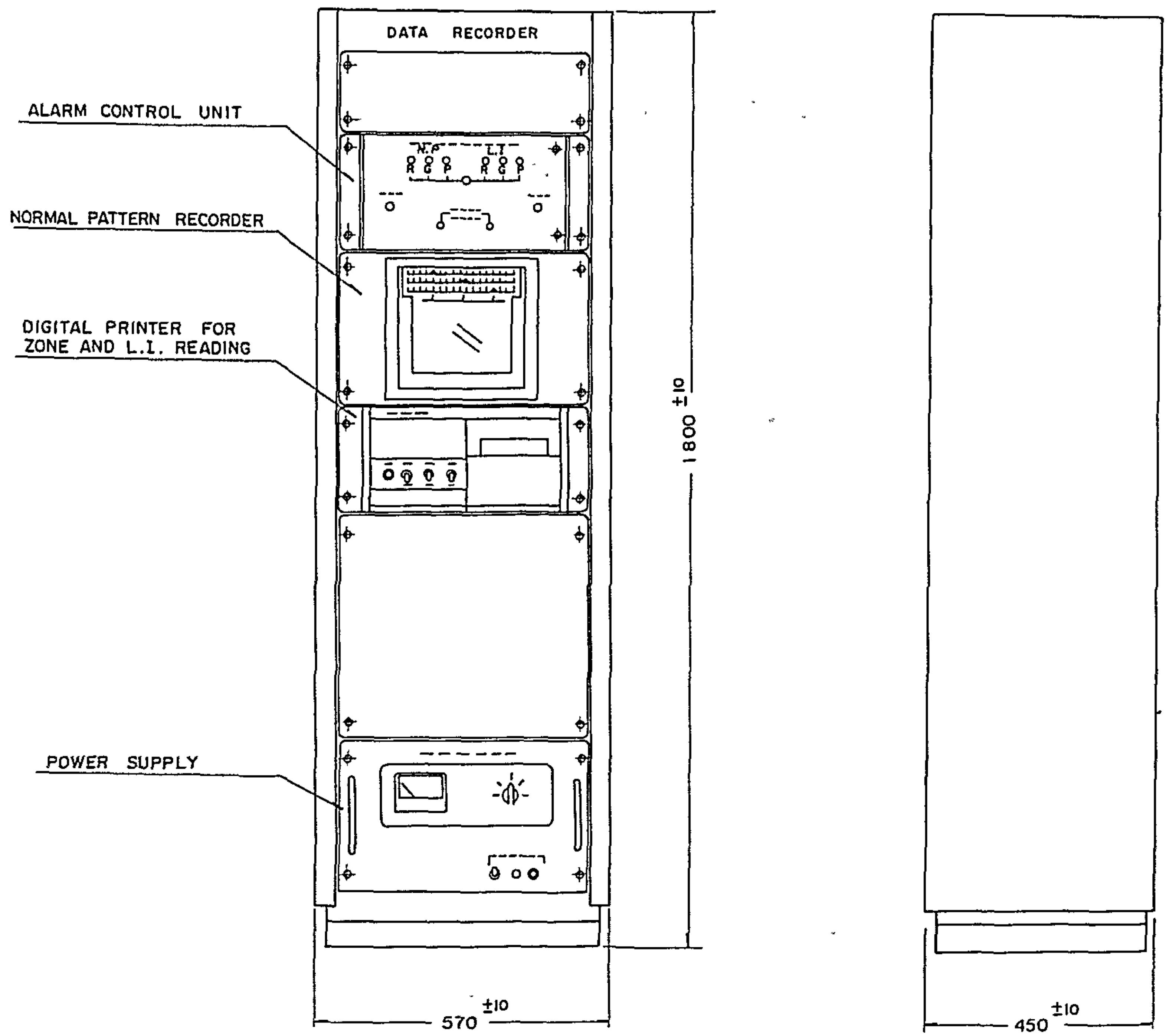


Fig. 5-4-17 DATA RECORDER OUTER VIEW

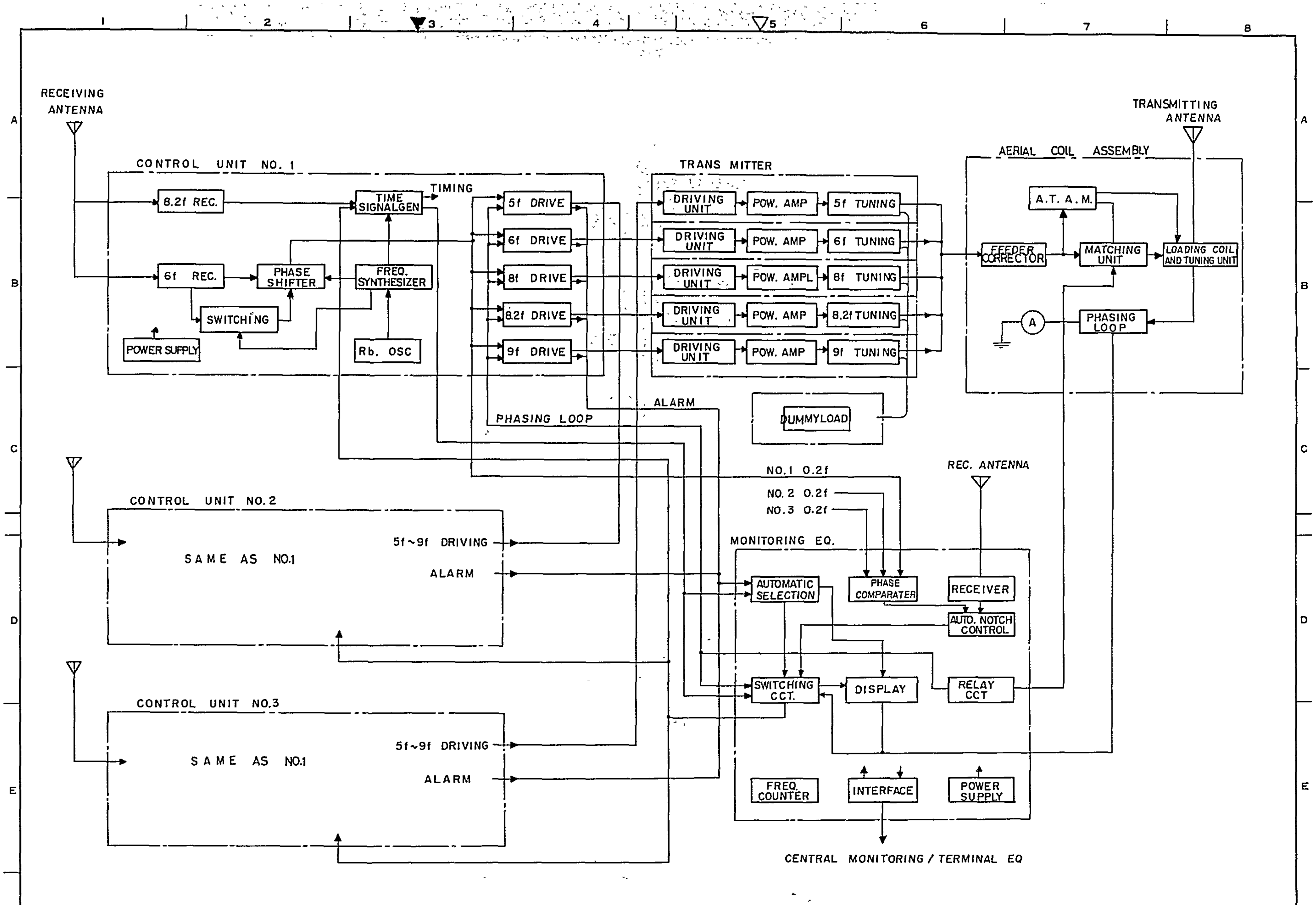


Fig. 5-4-18 BLOCK DIAGRAM FOR DECCA SLAVE STATION

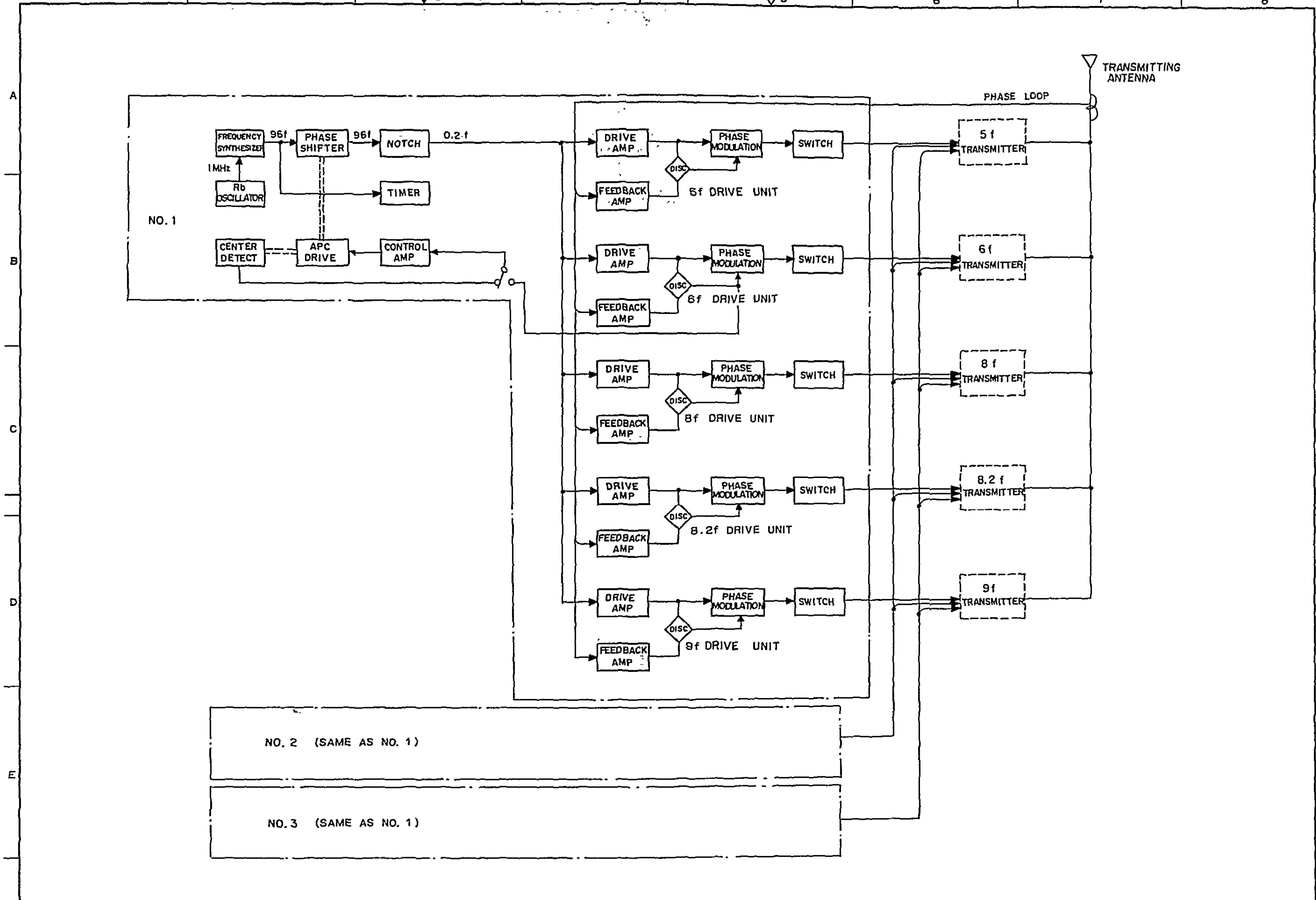


Fig. 5-4-19 PHASE CONTROL EQUIPMENT BLOCK DIAGRAM FOR MASTER STATION

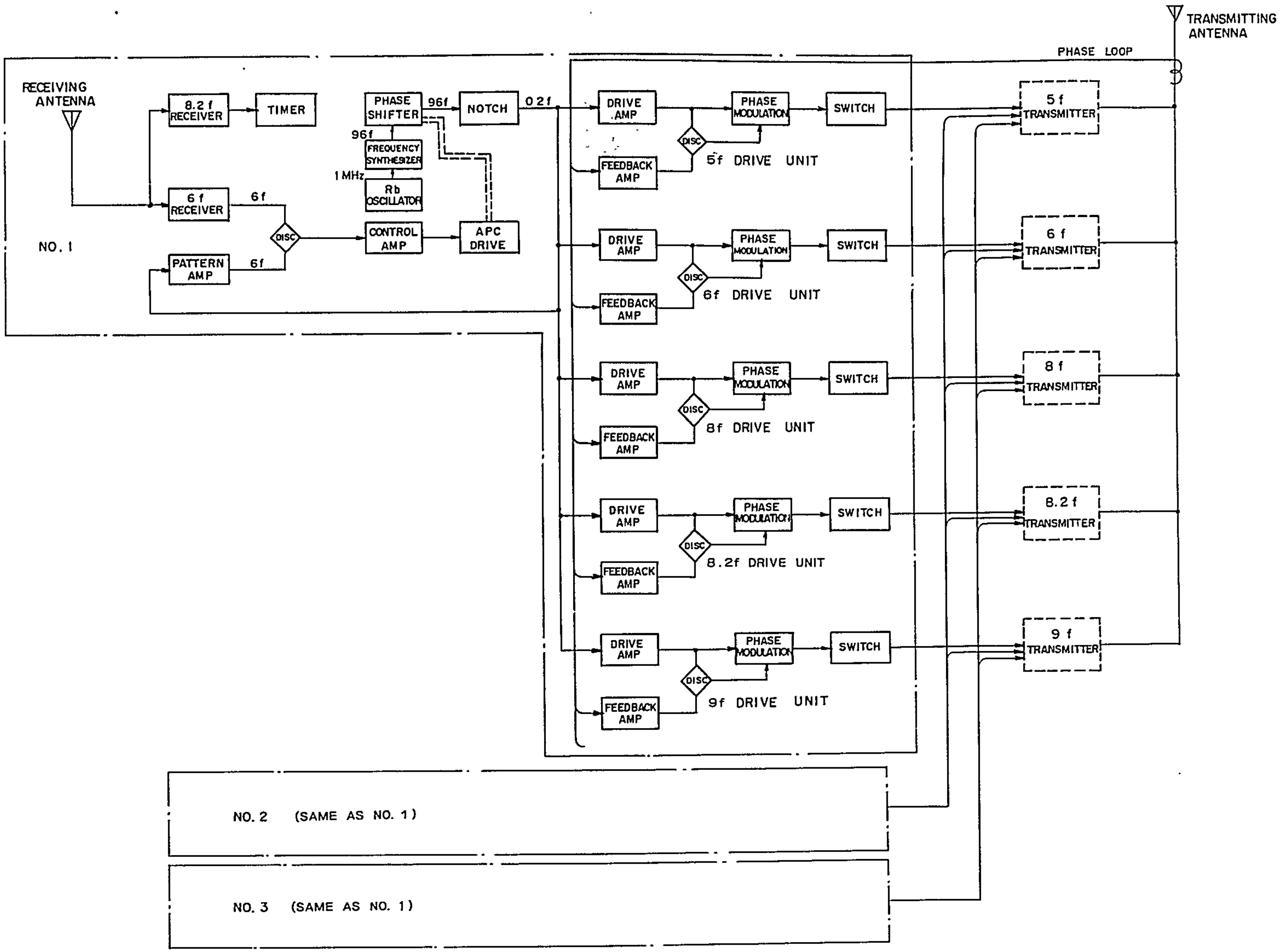


Fig. 5-4-20 PHASE CONTROL EQUIPMENT BLOCK DIAGRAM FOR SLAVE STATION

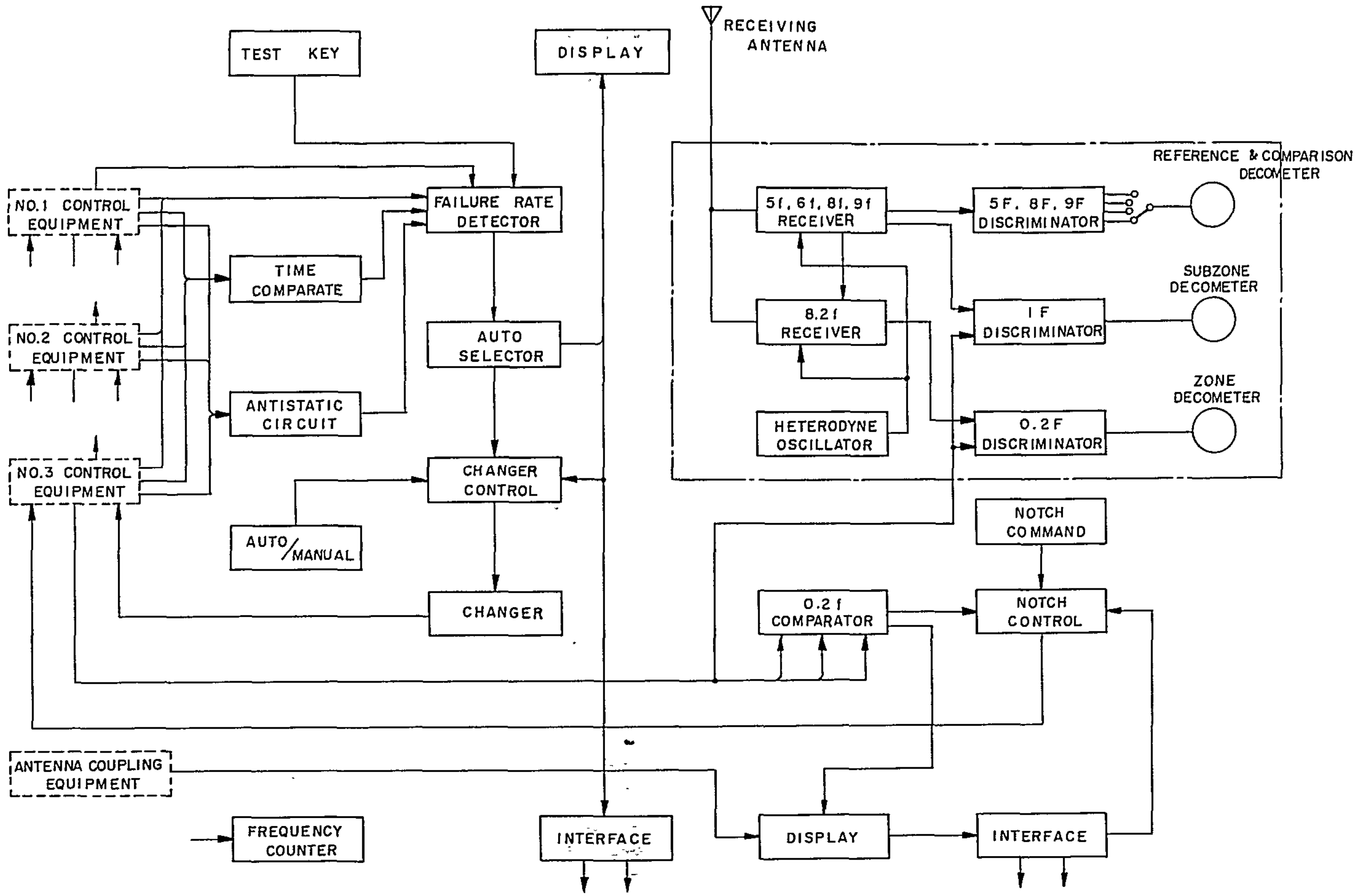


Fig. 5-4-21 MONITORING & SWITCHING EQUIPMENT BLOCK DIAGRAM

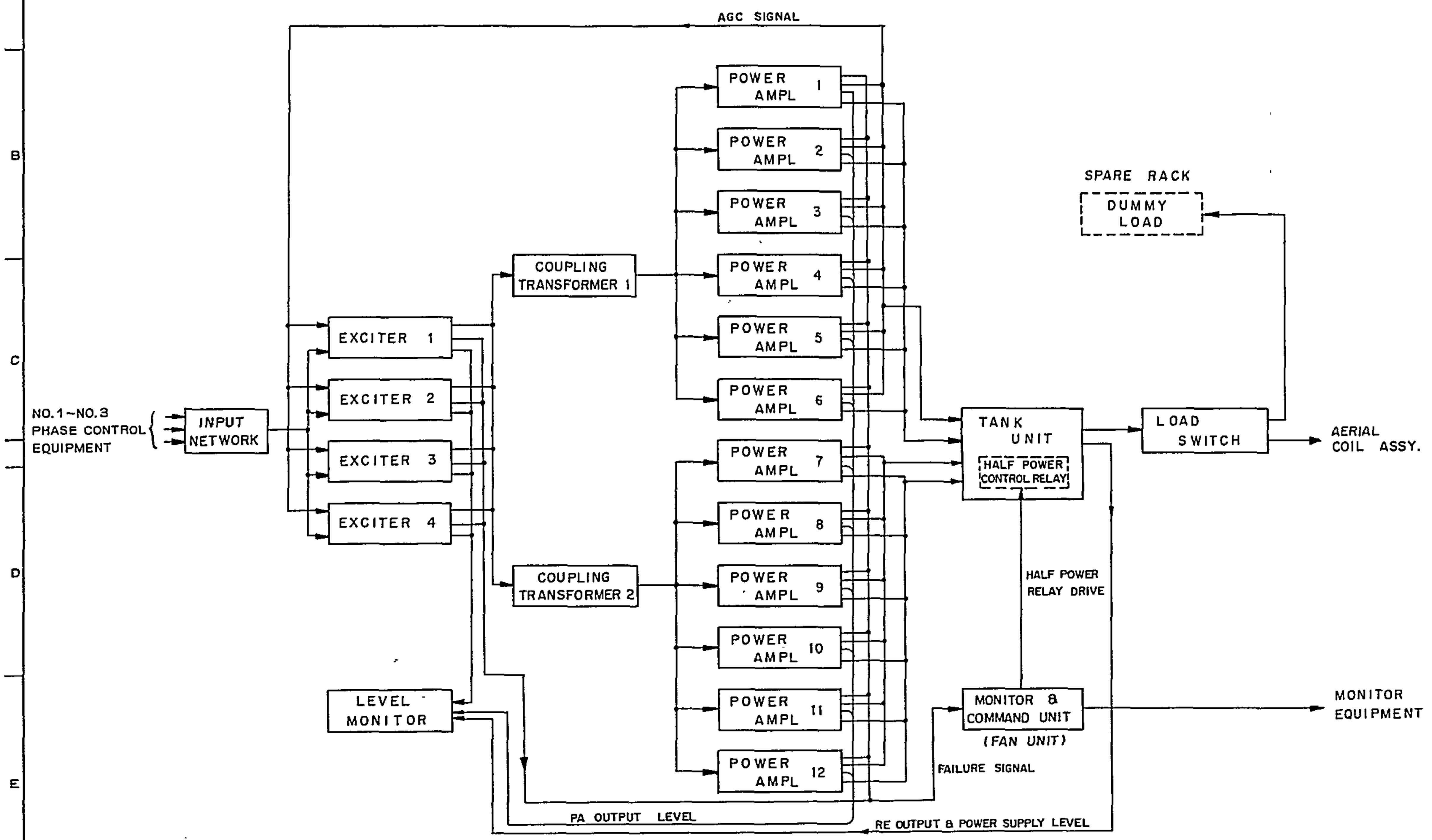


Fig. 5-4-22/1 DECCA TRANSMITTER BLOCK DIAGRAM

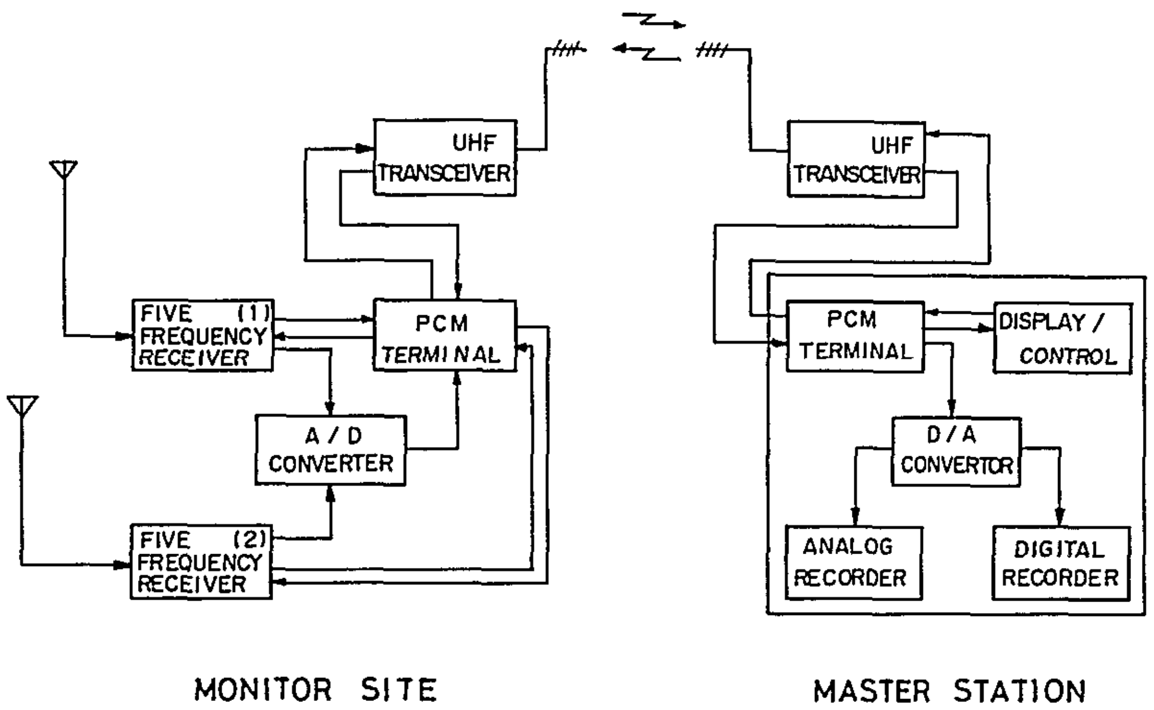


Fig. 5-4-22/2 MONITORING SYSTEM BLOCK DIAGRAM

5-4-2 Power supply equipment for Decca Navigator system

(1) Introduction

1) This power supply equipment is a device to supply power to the transmitting equipment, its ancillaries and other units for use with the Decca Navigator system.

2) It roughly consists of the no-break power supply equipment which supplies uninterrupted power to the Decca transmitting equipment and the general power supply equipment which supplies power to the ancillary equipment.

3) The general power supply equipment is classified into two different systems, depending upon whether commercial power is available in the area where the equipment is installed; Sytem A and System B.

a) System A is used in the area where commercial power is not available. Engine generators are installed to supply power to the load at all times.

b) System B is used in the area where commercial power is available. Engine generators are also installed but for emergency use.

4) The standards to be followed are as follows:

a)	JIS	Japanese Industrial Standards
b)	JEC	Standards of the Japanese Electrotechnical Committee
c)	JEM	Standards of the Japan Electrical Manufacturer Association

5) The environmental conditions are as follows:

a) Ambient temperature 10 ~ 45°C

b) Relative humidity 40 ~ 95%

(2) Composition

1) General power supply equipment

a) In the case of System A

The general power supply equipment in this system comprises the units enumerated below and the connection diagram is shown in Fig. 5-4-23.
The skeleton diagram is as shown in Fig. 5-4-24.
The number of sets given below is for a Decca station.

i) Engine generator 3 sets (Shown in Fig.5-4-34)

A set of engine generator consists of the following units:

AC generator 1

Diesel engine 1

ii) Engine ancillaries 1 set

iii) Engine generator control panel 1 set (Fig. 5-4-24 & 5-4-30)

The control panel is composed of eight panels as follows:

Generator main circuit panel 3

Automatic starter panel 3

Automatic changeover panel (Type A) 1

DC source panel 1

iv) Power distribution panel 1 set (Fig. 5-4-27 & 5-4-30)

b) In the case of system B

The general power supply equipment in this System Comprises the units enumerated below and the connection diagram is shown in Fig. 5-4-23 and the skeleton diagrams are as shown in Figs. 5-4-25 and

5-4-26. The number of sets given below is for a Decca station.

i) Receiving panel 1 set(Fig. 5-4-33)

The receiving panel is composed of three panels as follows:

MOF panel	1
Circuit breaker panel	1
Transformer panel	1

ii) Engine generator 1 set

The same composition as that of System A

iii) Engine ancillaries 1 set

iv) Engine generator control panel 1 set(Fig.5-4-26 & 5-4-30)

The control panel consists of four panels as follows:

Generator main circuit panel	1
Automatic starter panel	1
Automatic changeover panel(Type B)	1
DC source panel	1

v) Power distribution panel 1 set (Fig. 5-4-27 & 5-4-30)

2) No-break power supply equipment

The composition of the no-break power supply equipment is as enumerated below and the skeleton diagram is shown in Fig. 5-4-28.

The specifications of this equipment are the same for both System A and System B.

The number of sets given below is for a Decca station.

i) No-break power supply unit 2 sets (Fig. 5-4-32)

The no-break power supply unit is composed of two panels as listed below. The number of sets given below is for a set of the unit.

Input control panel 1

Output control panel 1

ii) Transmitter power source panel 1 set (Fig.5-4-31)

iii) Spare parts and repair tools 1 set

(3) Functions and ratings

1) Receiving panel

a) Type of panel: Self-stand metal enclosed

b) Functions

It receives commercial power (3ϕ 50 Hz, 6.6 KV) and after stepping down the voltage to 200V by transformer, supplies power to the load through the automatic changeover panel and power distribution panel. The functions of each panel are as follows:

i) MOF panel: Panel to lead in commercial power and monitor the power supply status.

ii) Circuit Breaker(CB) panel: Panel with a circuit breaker unit inside. It also accommodates a single phase transformer.

iii) Transformer panel: Panel with two single phase transformers. These two transformers and the one in the CB panel are connected in delta form.

2) Engine generator rating

a) AC generator

Type of protection:	Protected
Type of excitation:	Brushless
Output power:	125 KVA
Voltage:	200 V
Frequency:	50 Hz
Phases:	3
Revolutions:	1500 rpm
Poles:	4
Power factor:	0.8 (lag)
Rating:	Continuous
Insulation class:	F

b) Diesel engine

Type:	Vertical, single acting, 4-cycle, pre-combution chamber type
Output:	160 ps
Revolutions:	1500 rpm
Number of cylinders:	6
Starter:	Motor
Cooling system:	Water cooling with outside radiator
Fuel:	Diesel or heavy oil
Fuel consumption rate:	200g/ps-h

3) Engine Generator control panel

i) Generator control panel

On and off of output power, automatic regulation of output voltage, monitoring of output.

ii) Automatic starter panel

Automatic starting and stopping of engine generator, and other cntrols.

iii) Automatic changeover panel (Type A)

Automatic changeover of three engine generators.

iv) Automatic changeover panel (Type B)

Automatic changeover between commercial power and engine generator.

v) DC source panel

This panel has two sets of storage battery and two sets of charger for use as control power source for the engine generator.

4) Power distribution panel

a) Type of panel: Self-stand, metal enclosed

b) Functions: It receives the output from the automatic changeover panel and supplies power to each load.

5) No-break power supply unit

a) Type of panel: Enclosed.

b) Functions: It receives AC input power from the power distribution panel and supplies non-break DC power to the transmitter.

i) Input Control Panel

AC power is converted to DC power, which is supplied to the Output control panel, and simultaneously charges the outer battery using the battery charger accommodated in the panel.

In case of AC power cut-off, the output of the outer battery intervenes until the engine generator builds up.

ii) Output control panel

DC power from the Input control panel is re-inverted to the stable DC power of required voltages, which is supplied to the load.

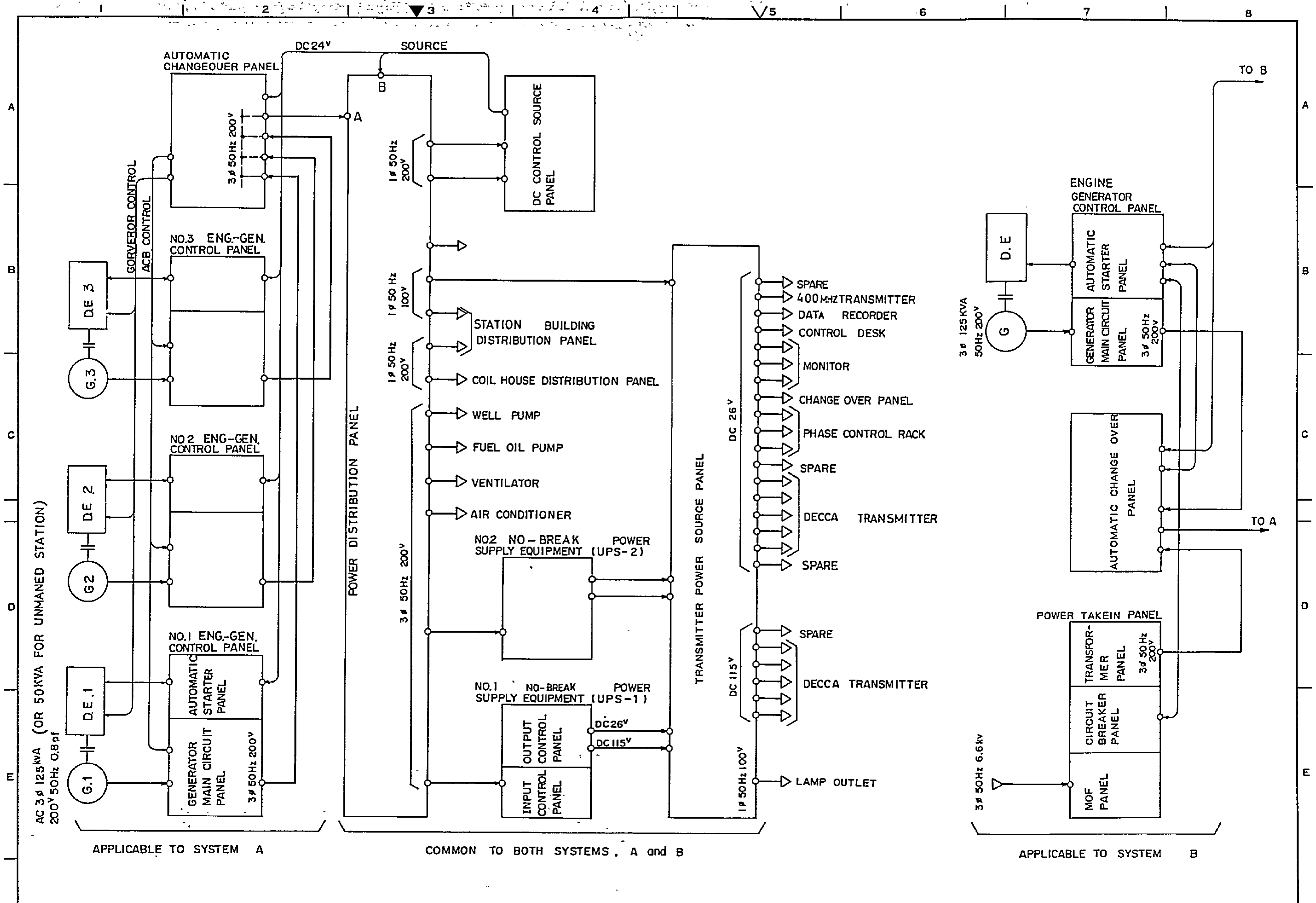


Fig. 5-4-23 CONNECTION DIAGRAM OF POWER SUPPLY SYSTEM FOR DECCA STATION

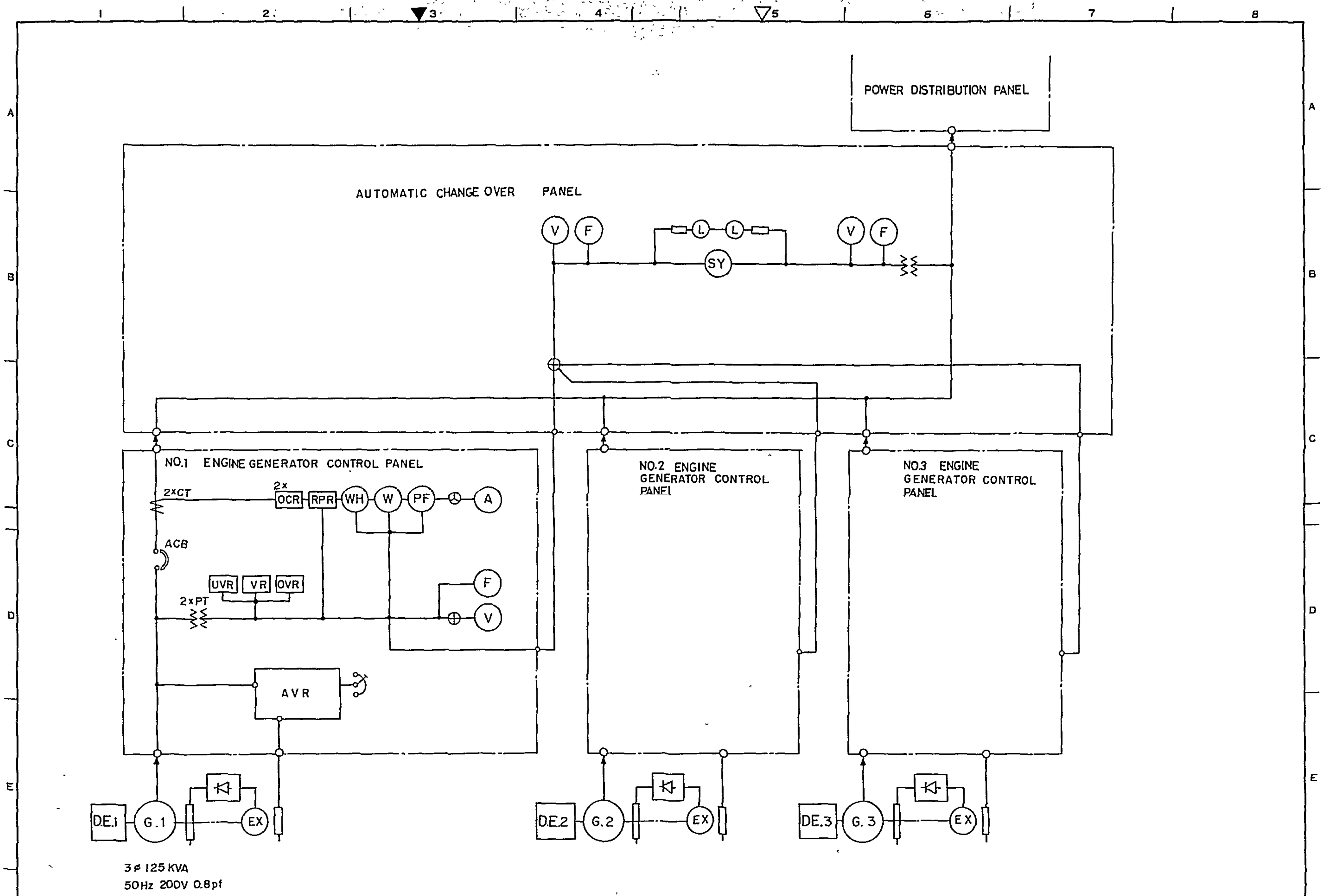


Fig. 5-4-24 SKELETON DIAGRAM OF ENGINE-GENERATOR CONTROL PANEL AND AUTOMATIC SWITCHOVER PANEL

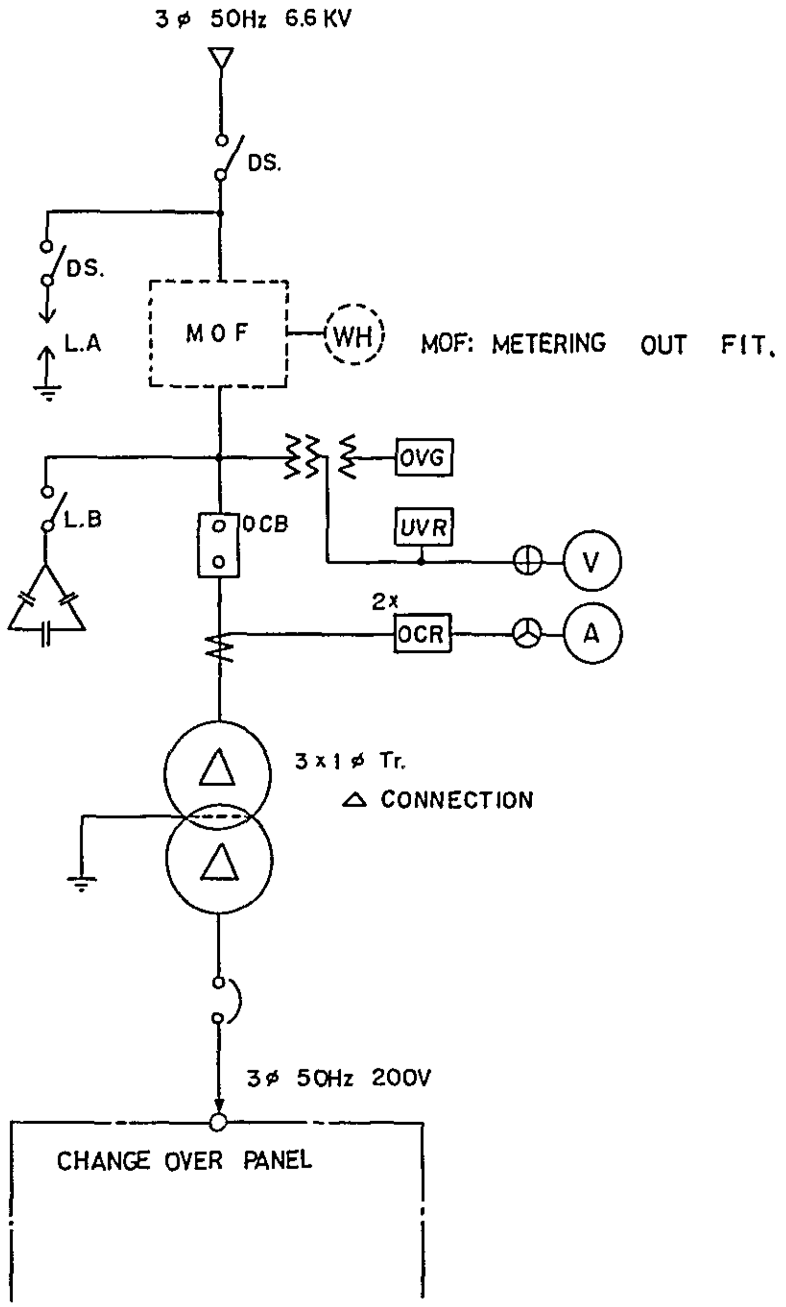


Fig. 5-4-25 SKELETON DIAGRAM OF POWER TAKEIN PANEL

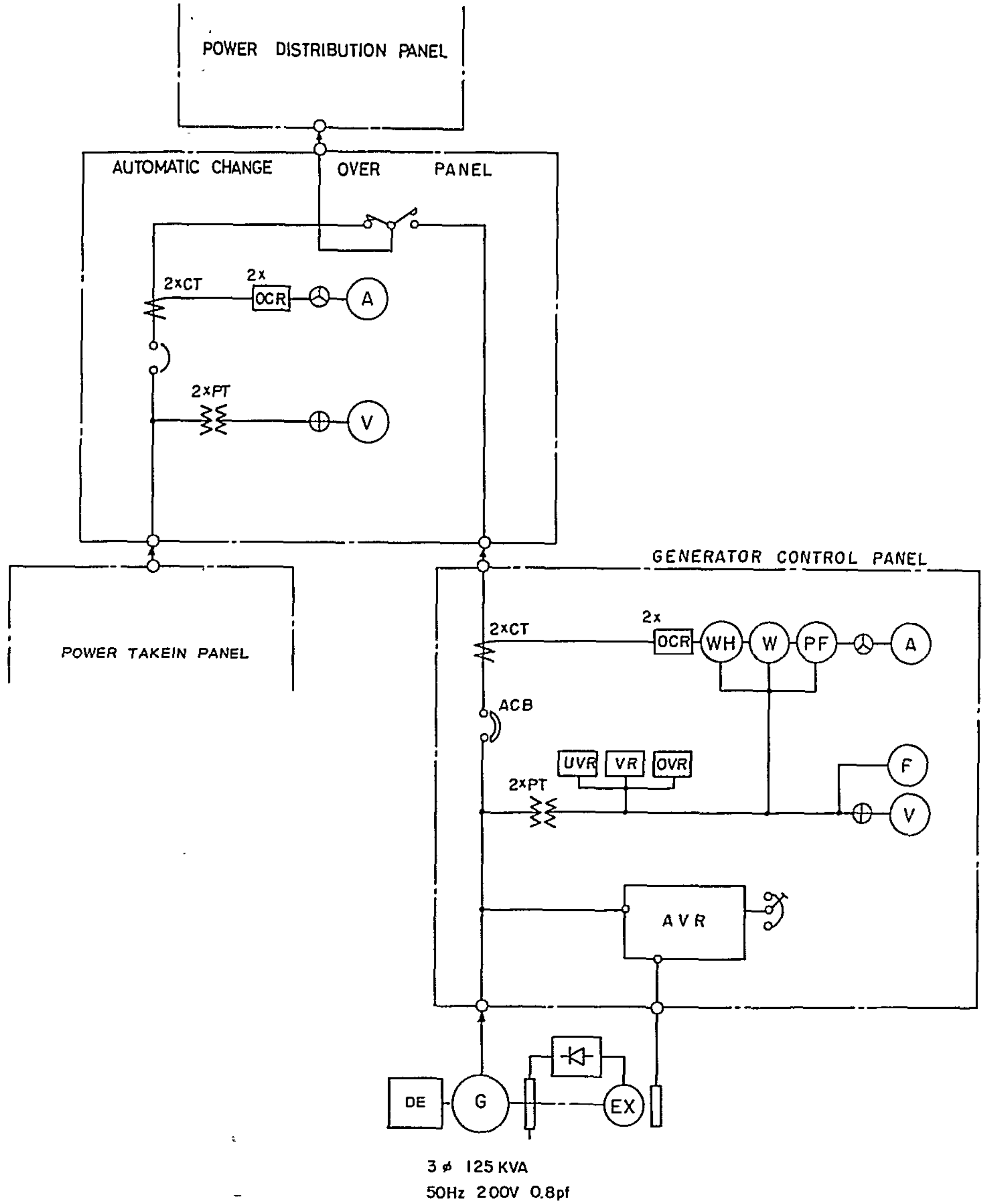


Fig. 5-4-26 SKELETON DIAGRAM OF ENGINE-GENERATOR PANEL

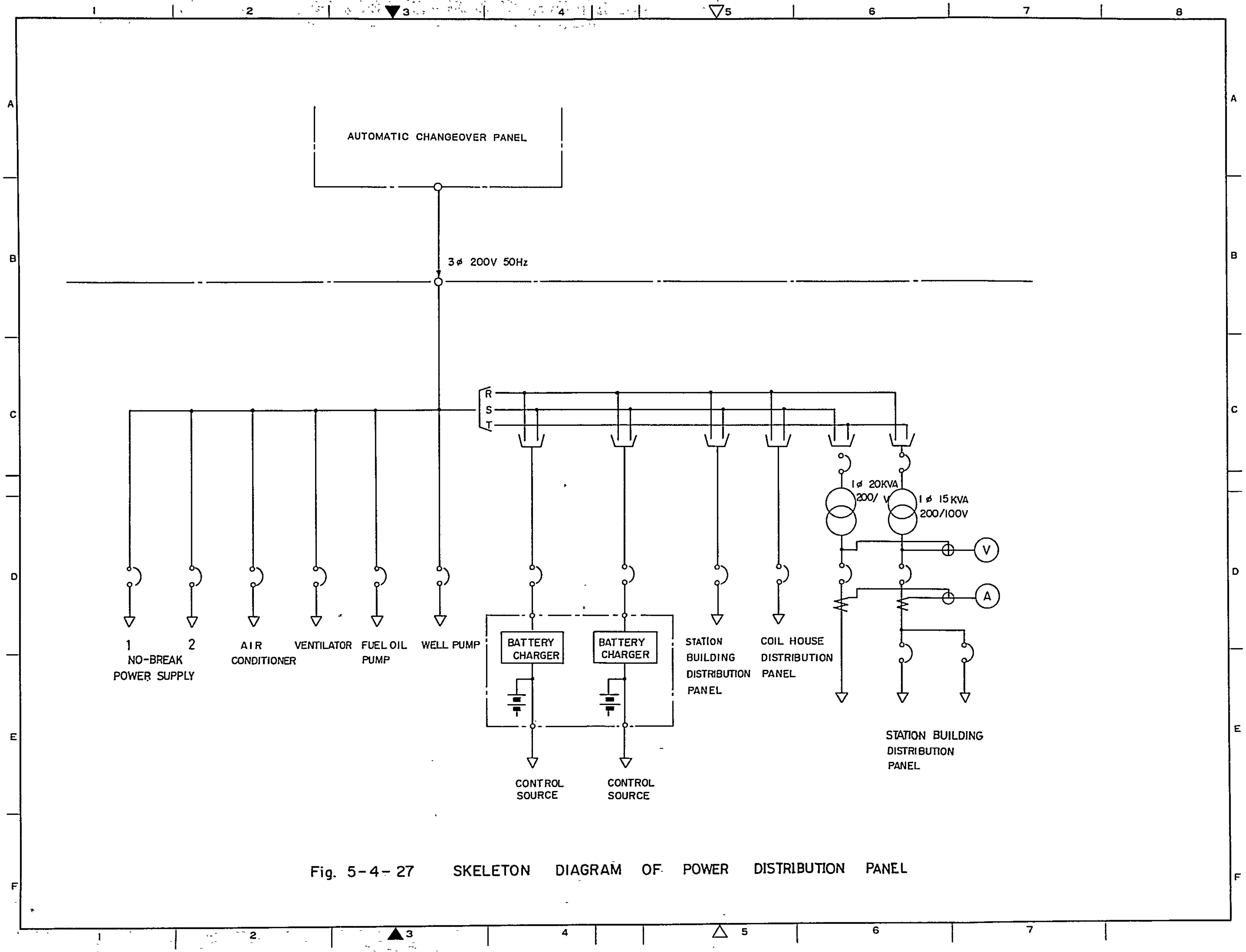


Fig. 5-4-27 SKELETON DIAGRAM OF POWER DISTRIBUTION PANEL

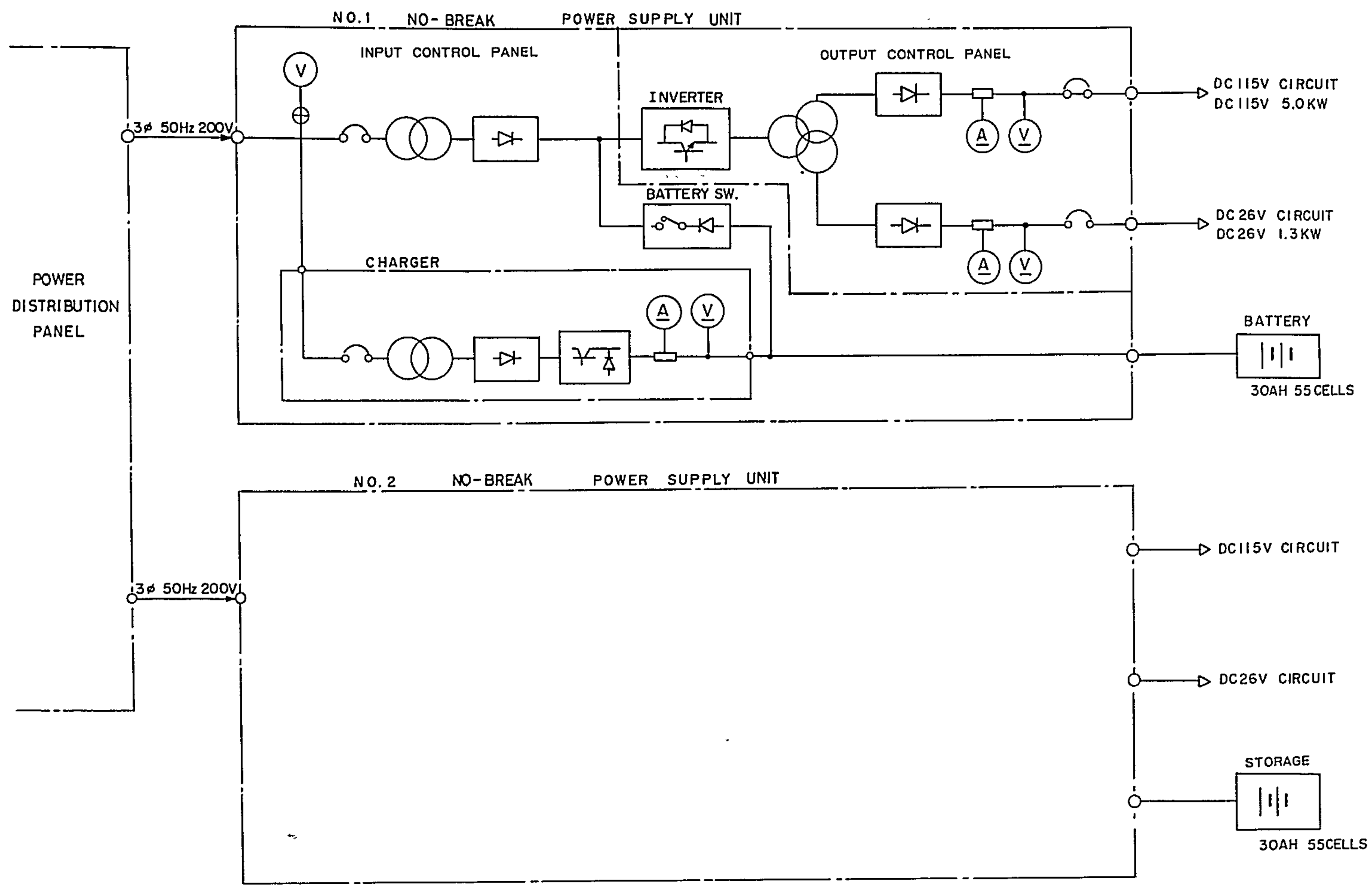


Fig. 5-4-28 SKELETON DIAGRAM OF NO-BREAK POWER SUPPLY EQUIPMENT

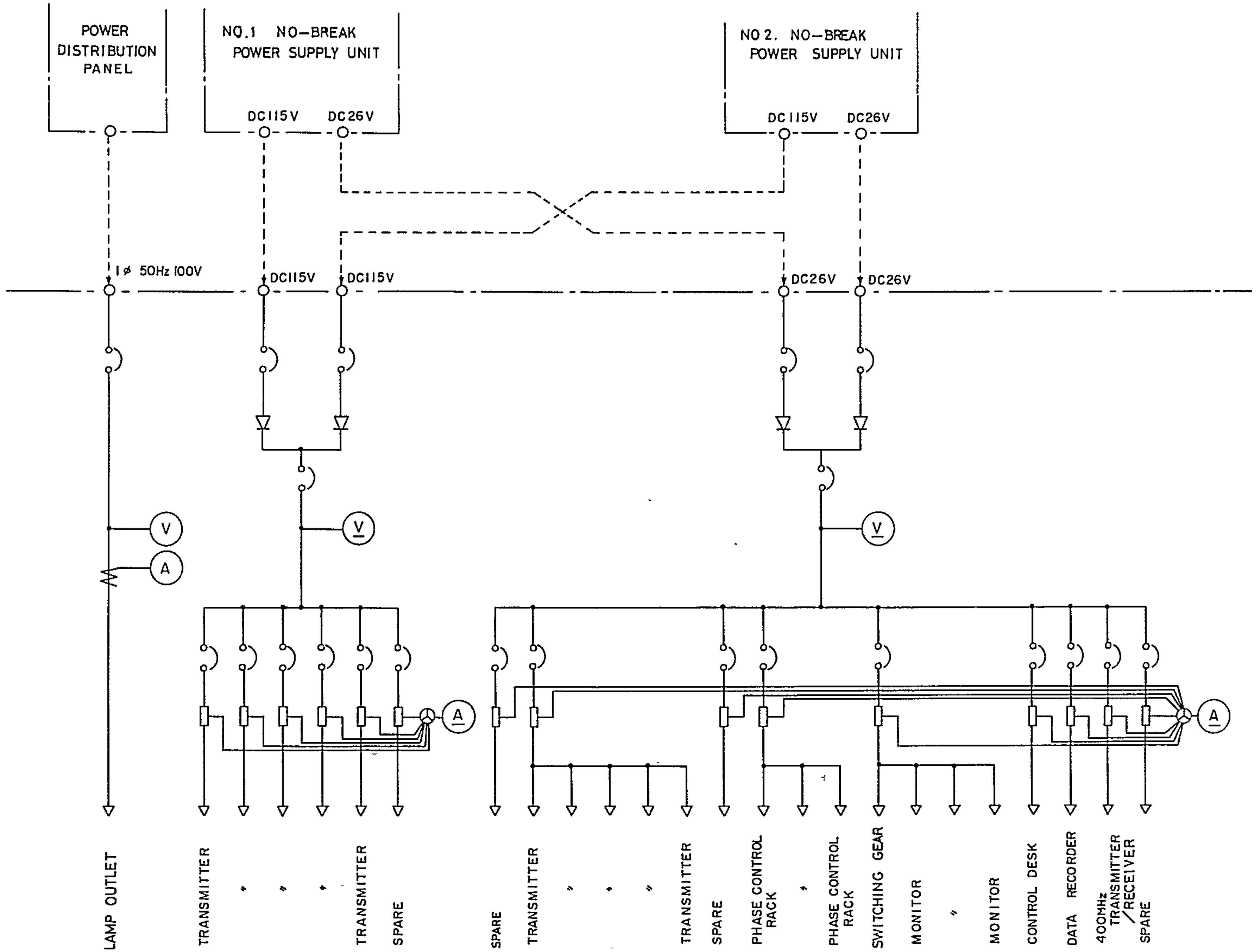


Fig. 5-4-29 SKELETON DIAGRAM OF TRANSMITTER POWER SOURCE PANEL

NO	NAME
1	DC SOURCE PANEL
2	POWER DISTRIBUTION PANEL
3	AUTOMATIC CHANGEOVER PANEL (APPLICABLE TO SYSTEM B) CB PANEL (APPLICABLE TO SYSTEM A)
4	NO.1 GENERATOR MAIN CIRCUIT PANEL
5	NO.1 AUTOMATIC STARTER PANEL
6	NO.2 GENERATOR MAIN CIRCUIT PANEL
7	NO.2 AUTOMATIC STARTER PANEL
8	NO.3 GENERATOR MAIN CIRCUIT PANEL
9	NO.3 AUTOMATIC STARTER PANEL

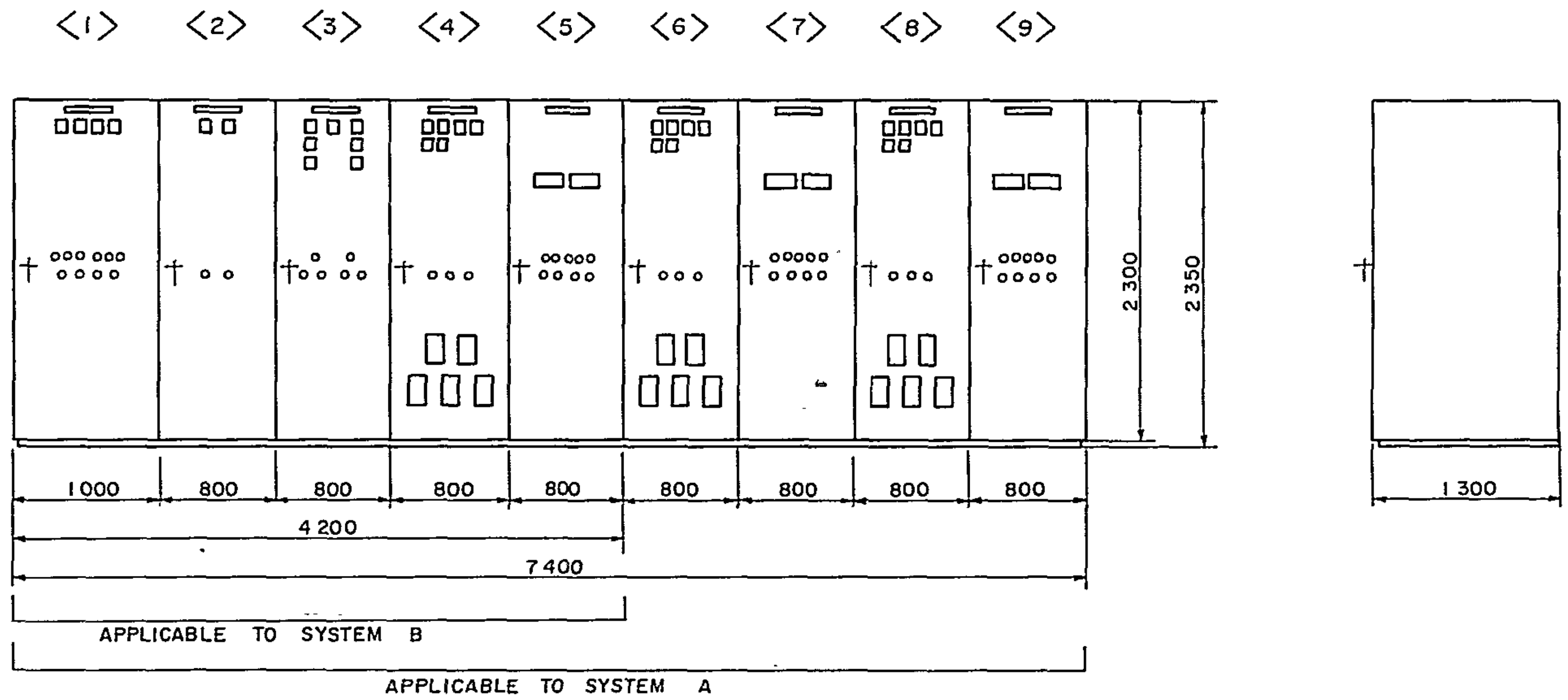
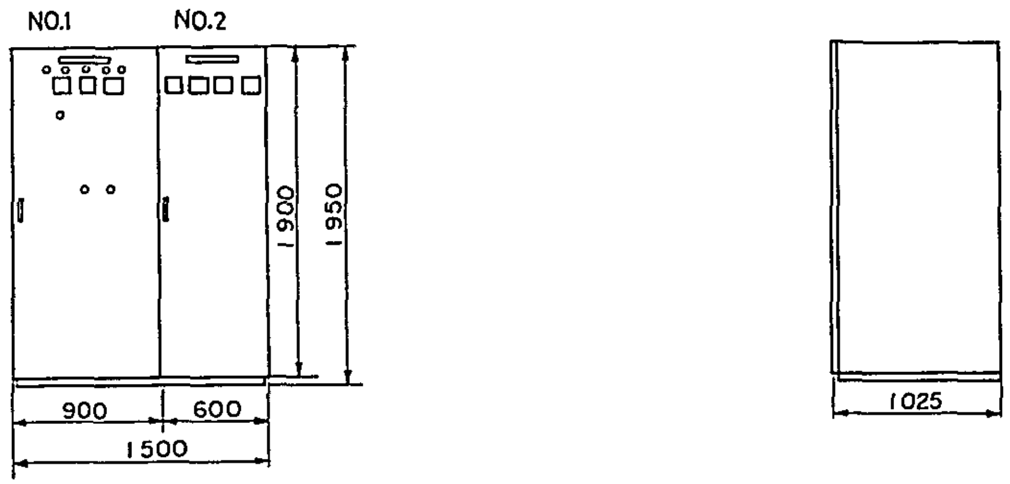


Fig. 5-4-30 GENERAL VIEW OF POWER SUPPLY PANELS

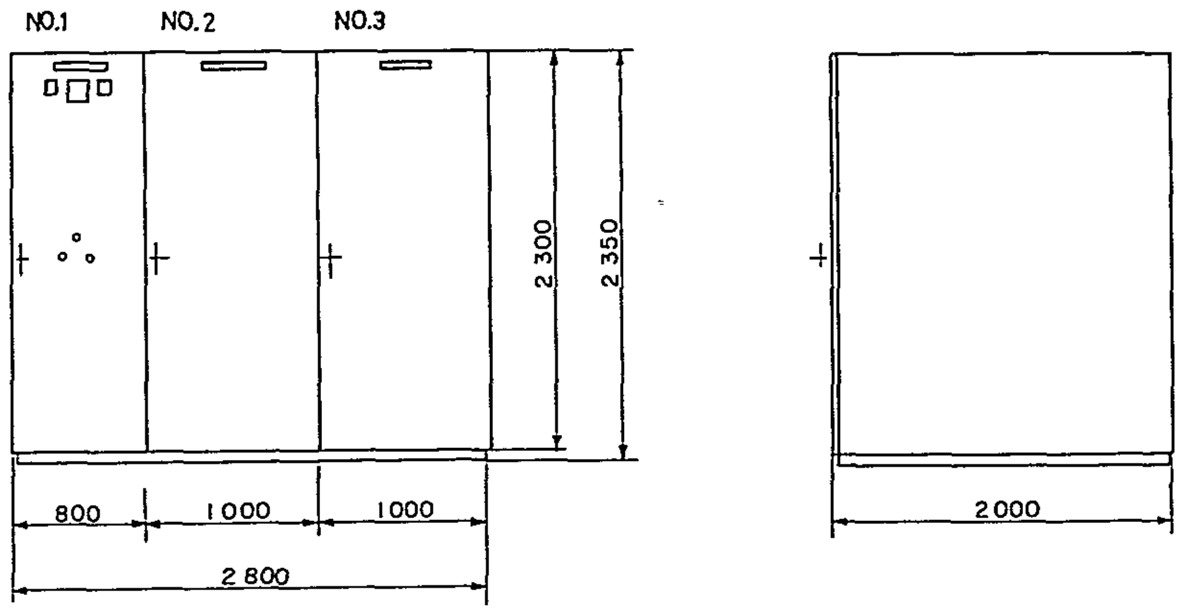
Fig.5–4–31 GENERAL VIEW OF TRANSMITTER POWER SOURCE PANEL

Fig. 5-4-32 GENERAL VIEW OF NO-BREAK POWER SUPPLY EQUIPMENT



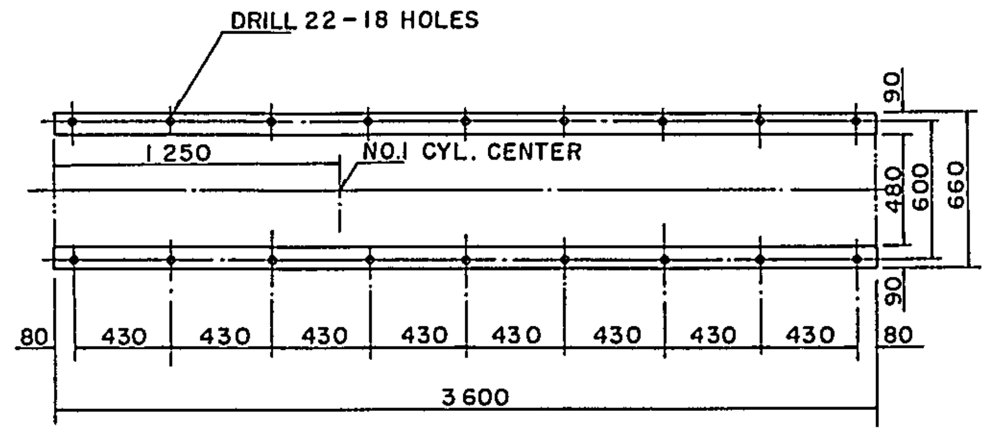
NO.	NAME
1	INPUT CONTROL PANEL
2	OUTPUT CONTROL PANEL

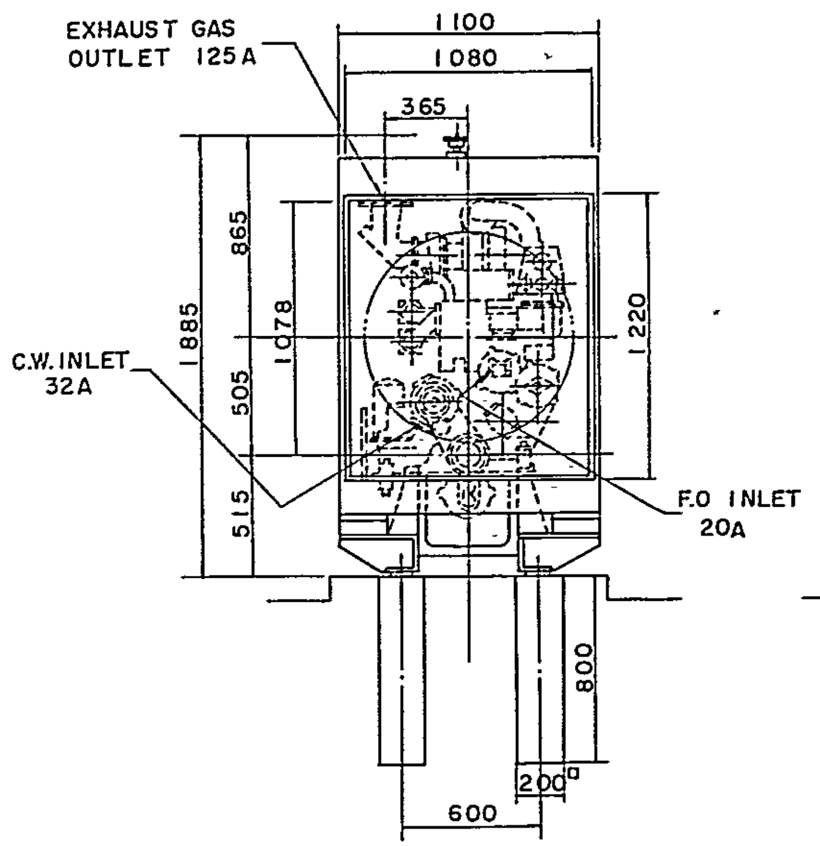
Fig. 5–4–33 GENERAL VIEW OF POWER TAKEIN PANEL



NO.	NAME
1	MOF PANEL
2	CIRCUIT BREAKER PANNEL
3	TRANSFORMER PANEL

DIESEL ENGINE		A.C. GENERATOR	
TYPE	4 – CYCLES	TYPE	SYNCRONOUS
NO. OF CYL	6	PHASE	3 ø
BORE	140 m/m	VOLTAGE	200 V
STROKE	170 m/m	CURRENT	360 A
REVOLUTION	1 500 r.p.m.	REVOLUTION	1 500 r.p.m
B.H.P.	160 P.S.	OUT PUT	125 KVA
B.M.E.P.	6.12 Kg/cm^2	POWER FACTOR.	80 %
MAX. PRESS.	65 Kg/cm^2	CYCLE	50 Hz
PISTON SPEED	8.5 m/s	NO. OF POLES	4
STARTER	MOTOR	EXCITING	BRUSHLESS
COOLING	WATER COOLING	RATING	CONTINUOUS
WEIGHT	1 680 Kg	WEIGHT	1 000Kg





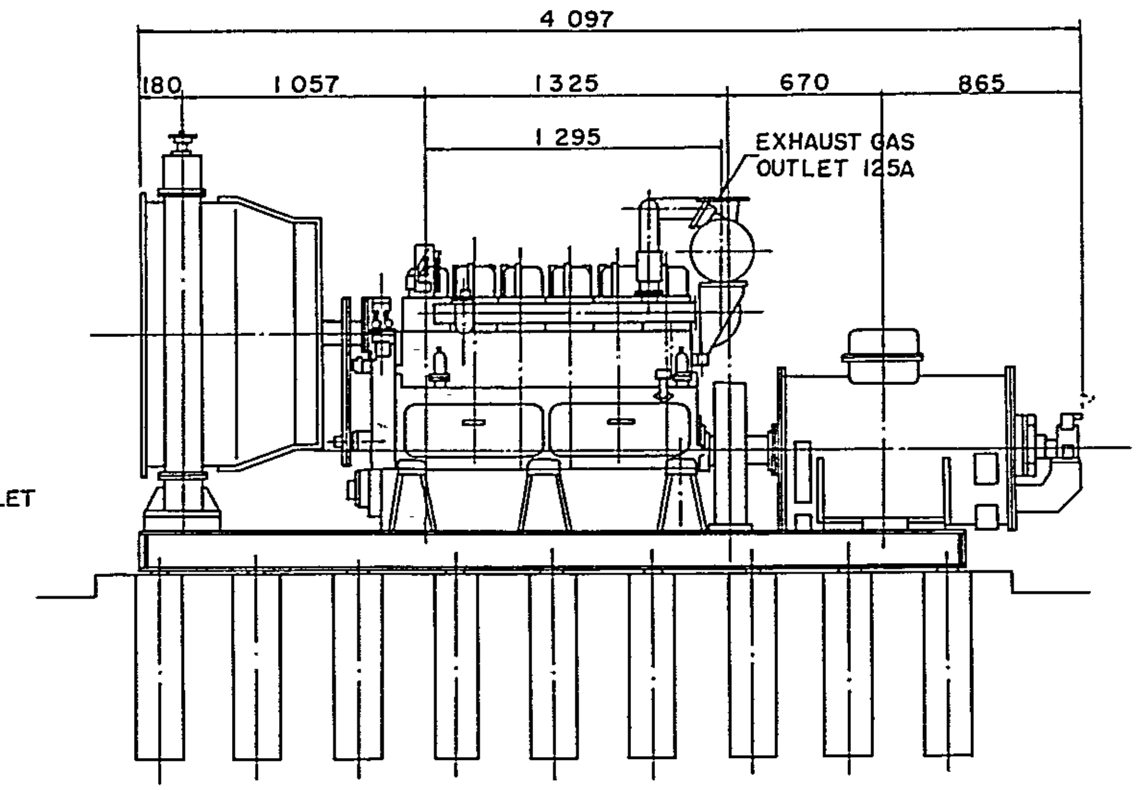


Fig. 5-4-34 OUTER VIEW OF ENGINE - GENERATOR

5-4-3. Communications system

(1) Introduction

The Decca Navigator system can provide the users of the system with highly reliable service only when its master station and three slave stations transmit the synchronised and stabilised radio wave.

The Decca Navigator system is required, because of its being a highly reliable system, to inform the user of any stoppage of service due to "off-air", with promptitude and certainty.

In order to maintain good operation of Decca stations, the mutual communications system between stations and the communication channel to the administrative organ should be eatablished.

To ensure the prompt contact between the stations, an exclusive radio communications network is preferable to a commercial line. However, it is not wise for a Decca station to have a radio operator assigned on exclusive duty of conducting telecommunications. In addition, for better mutual understanding between the parties, a voice communications system should be adopted. As the atomospheric noise level in the tropical zone is very high, single side band (SSB) system would be the most suitable one for these purposes. In some cases, there would be a necessity to record and file the contents of communications, such as important directions or reports. For this purpose, teletypewriter or facsimile system is considered to be adequate. Here in this report, the plan is composed of using teletypewriter system.

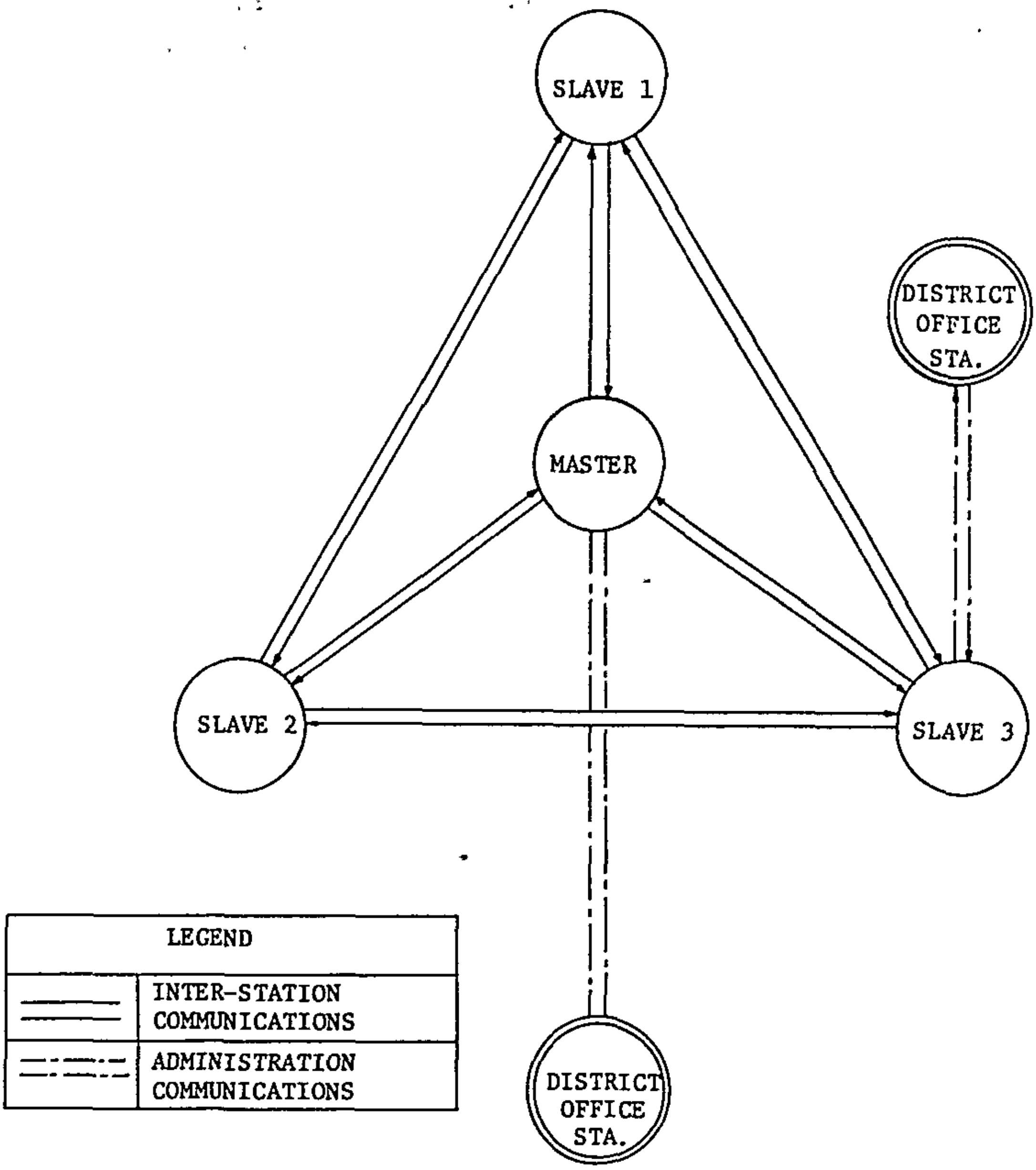
Accordingly, the voice communications and teletypewiter communications will be used properly by the purpose.

(2) Establishment of communications network

As stated in the preceding paragraph, communications required for the operation and maintenance of the Decca Navigator system are roughly divided into the liaison between the stations themselves and the transmission of orders or reports between the stations and their senior organs. The former is called "inter-station communications system" and the latter is referred to as "administration communications system". A typical network is as shown in Fig. 5-4-35.

As shown in Fig. 5-4-35, the inter-station communications system has been contemplated to be composed of the SSB telephone only while the administration communications system, from its purpose, has been so designed to have both SSB telephone and teletypewriter capable of being switched over to each other. Slave station 3 shown in the Figure is assumed to be located in a different country or region from other 3 stations and has a communications channel to its own district office.

Fig. 5-4-35 Standard Communications Network



(3) Channel plan

1) Inter-station communications network

Frequencies to be used should be selected according to the distance between the stations, and then 2 MHz band is recommended for the distance of less than 100 km and

4 MHz band for the distance of more than 100 km.

As a general composition, two frequencies, each chosen from two different frequency bands are planned so that they may be used properly in day and night.

2) Administration communications network

The frequencies to be used in this network are desirable to be commonly used with those of the inter-station network, in view of the effective use of radio frequency, the VHF band is used for the short range communications and 9 MHz band is used additionally for the network whose distance is very long.

3) Propagation mode

The propagation characteristics are largely affected by the ground condition of the propagation path. For the short distance communications, groundwave will be used effectively. For the long distance communications, skywave, mainly 1 Hop F_2 or occasionally 1 Hop Es will be used. Therefore, aerial must be carefully designed to effectively radiate the power at an optimum angle according to the propagation mode. The aerial for skywave communications will be a dipole extended at the height of less than a half wave length in order to obtain the high injection angle. The aerial for ground wave communications will be a vertical aerial.

Fig. 5-4-36A and Fig. 5-4-36B show experimental example of propagation characteristics in Japan and Table 5-4-16 through Table 5-4-20 show usable frequency band by hour.

Fig , 5-4-36A

PROPAGATION CHARACTERISTICS

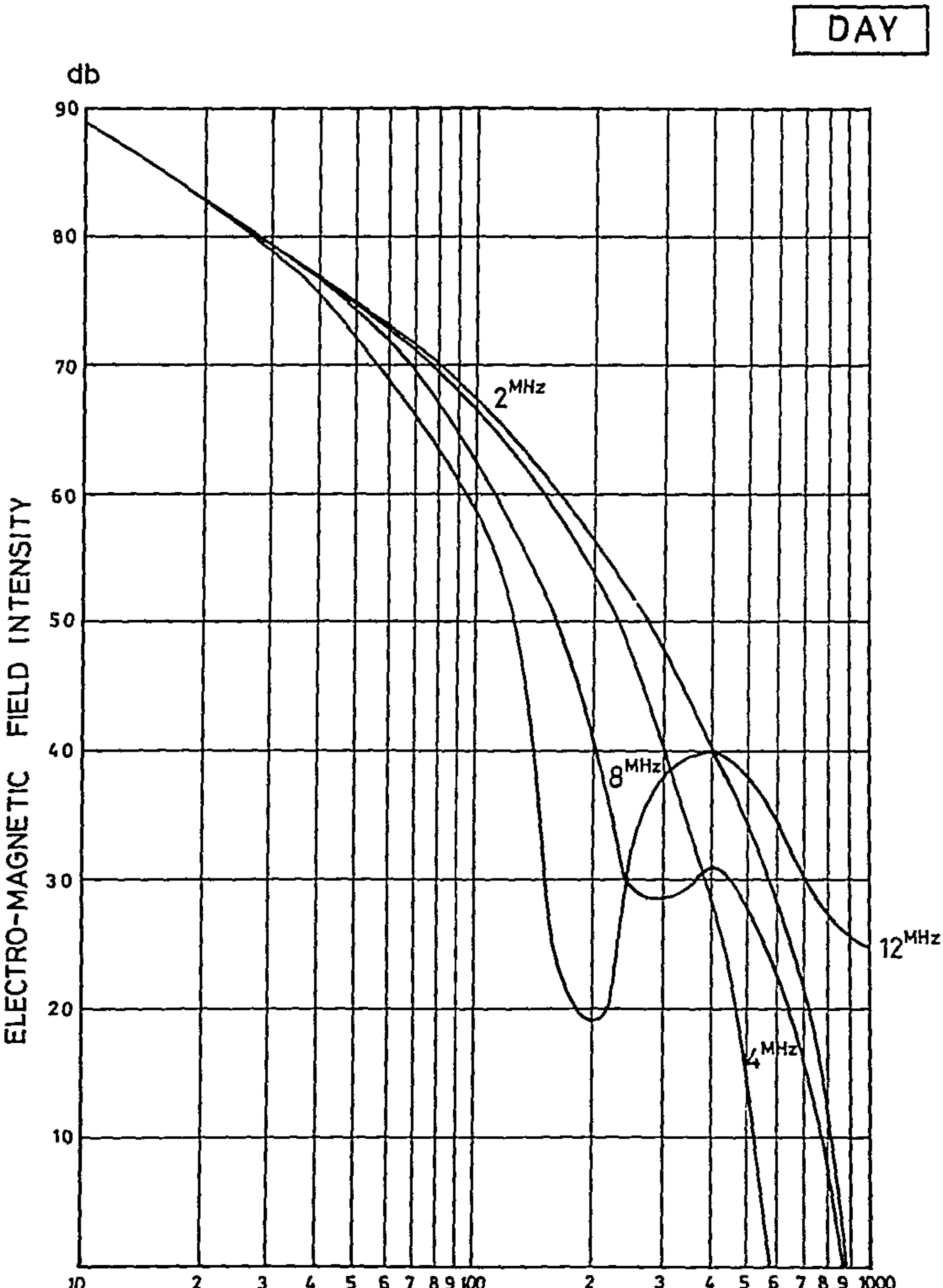
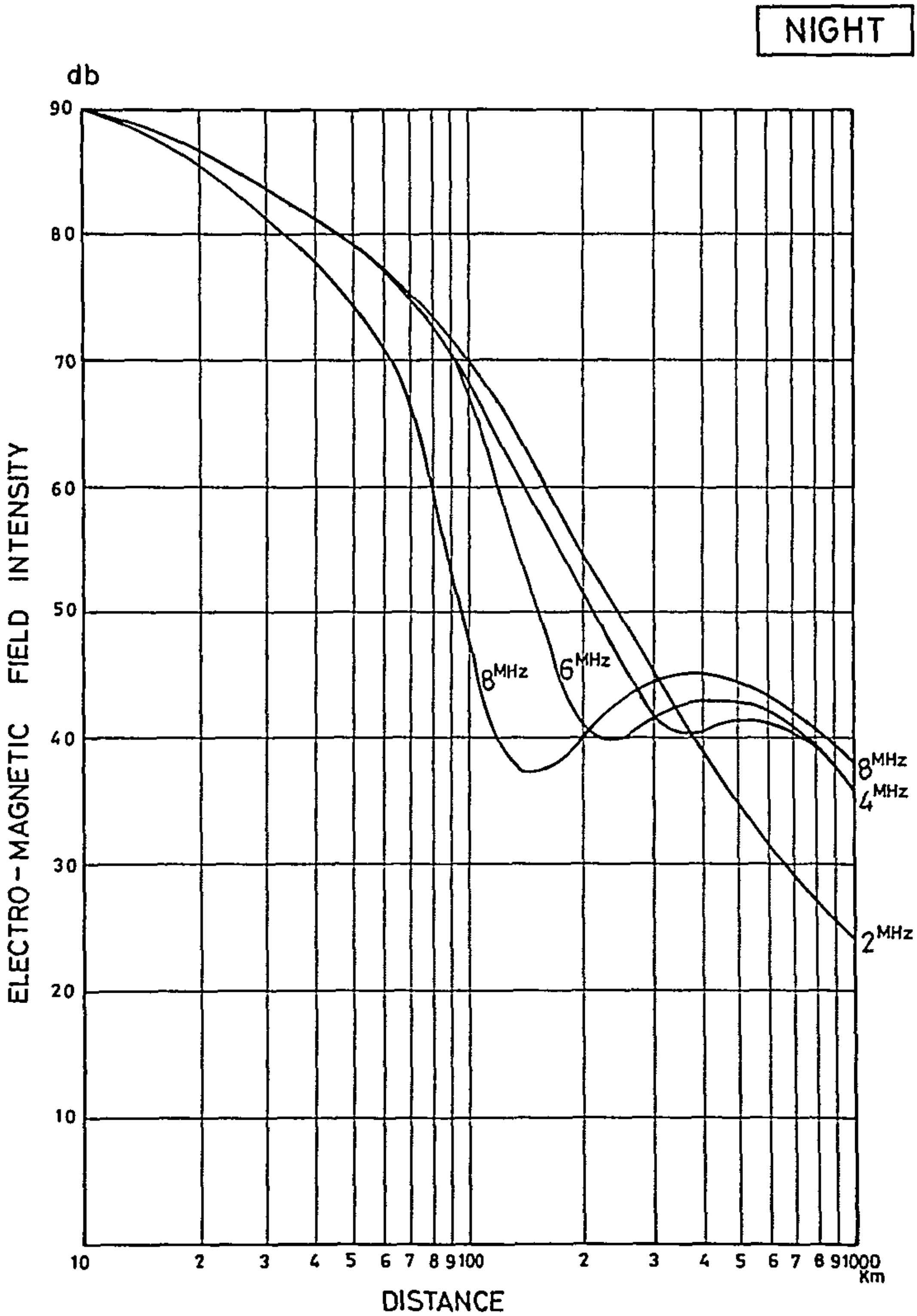


Fig. 5-4-36B

PROPAGATION CHARACTERISTICS



(4) Aerial system

With regard to the design of an aerial, horizontal and vertical directivity of radiated power should be considered in order to meet its purpose.

For example, the aerial for skywave communications should be a dipole extended at the height of less than a half wave length in order to get the high injection angle. In the horizontal directivity, the lobe should be put toward the direction of the partner station.

To obtain ideal directivity, however, would make economical burden big because it would require an additional number of aerials. So, in practice, one aerial should cover as many stations as possible.

A plan has been prepared for the aerial, therefore, taking these into consideration, as shown in Table 5-4-9:

Table 5-4-9 Plan for standard aerial

Communications system	Aerial	Remarks
Inter-station	Dipole or inverted L-type according to the propagation path. The tower should be 20m tall and made of steel mast.	
Administration	Required number of dipole. The tower is 30m tall and stayed truss type.	

Some example of typical configurations of aerial are shown in the following figures:

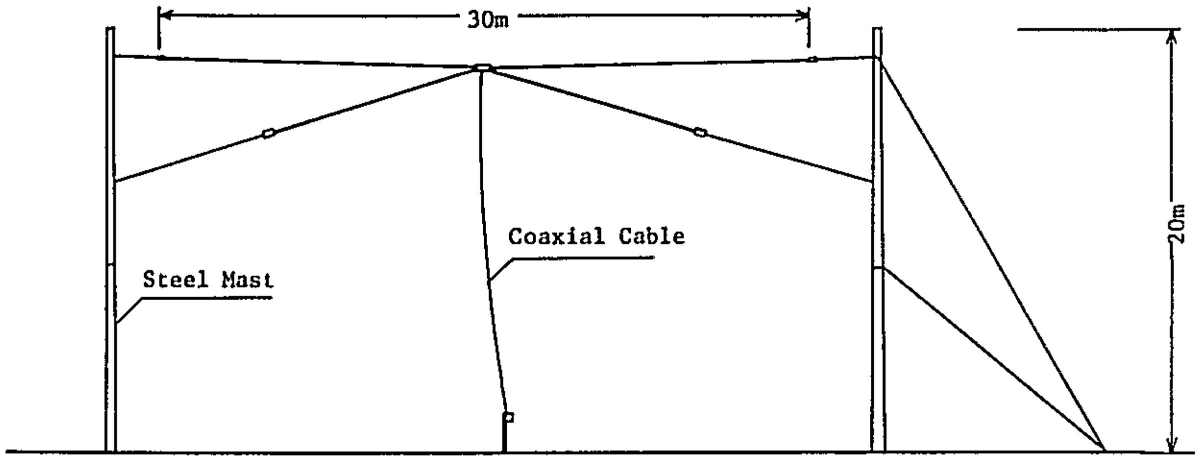


Fig. 5-4-37 Dipole for 4 and 7 MHz

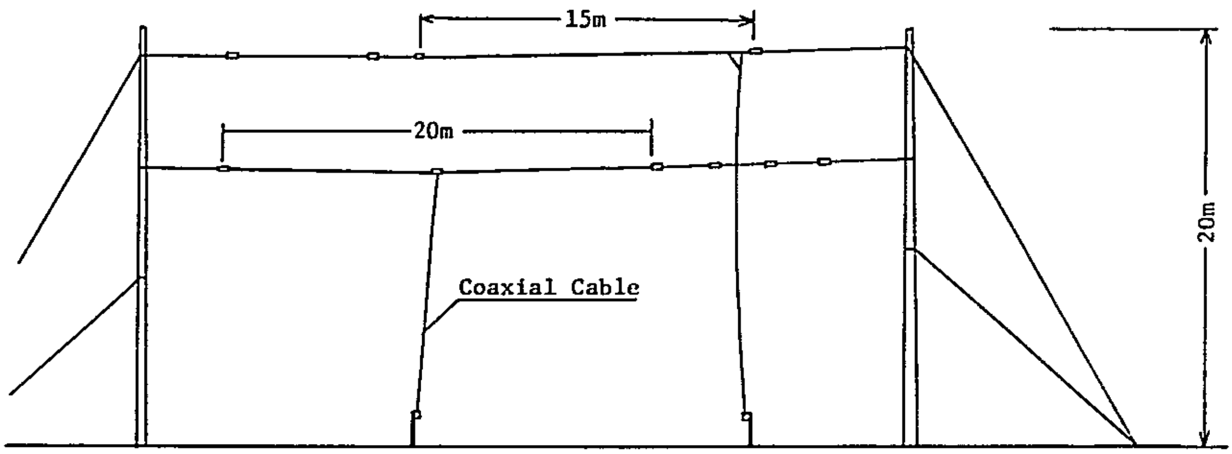


Fig. 5-4-38 Inverted-L Type and Dipole for 2, 4 and 7 MHz

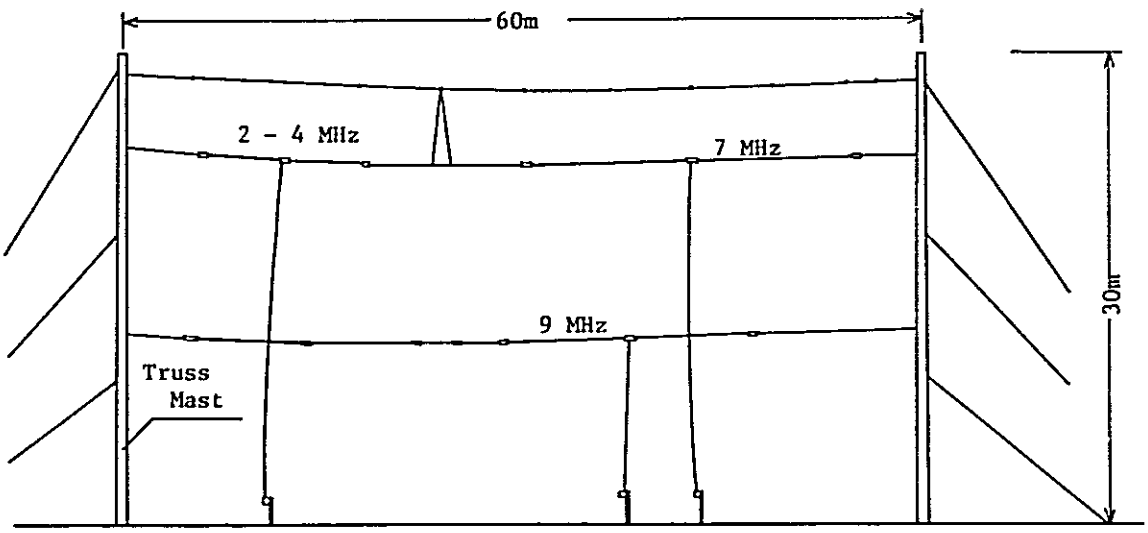


Fig. 5-4-39 Inverted-L Type and Dipole for 2 - 9 MHz

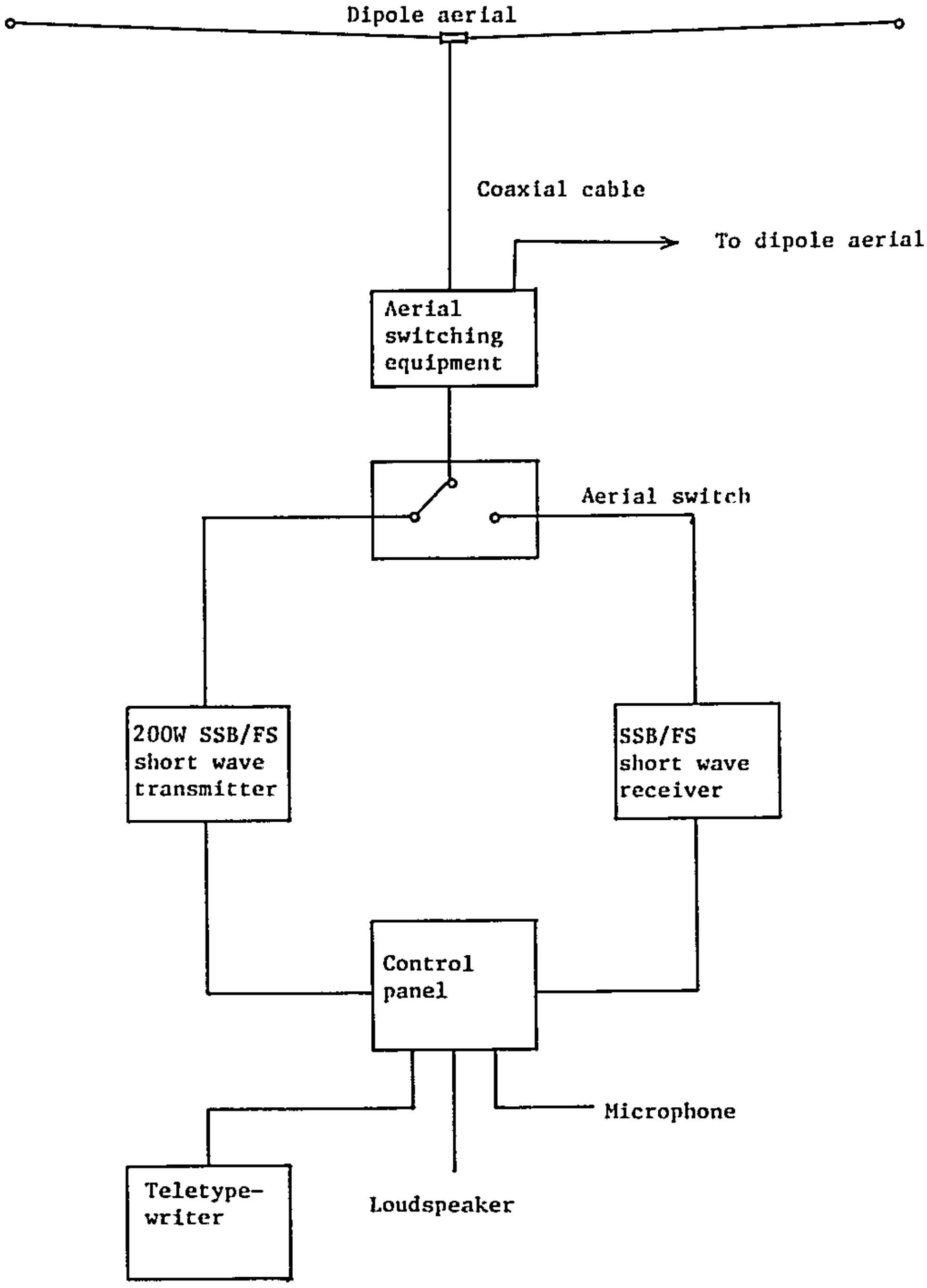
(5) *Channel design*

The longest channel in the administration communications network is approximately 700km between Tj. Mangkalihat and Banjarmasin, Indonesia. In order to maintain satisfactory communications over this distance, it would be required to use three frequencies between 4 to 9 MHz in proper way. The individual design for each Decca chain is as shown in Figs. 5-4-46 through 5-4-48 and Tables 5-4-13 through 5-4-15 also attached hereto.

(6) Communications equipment

In the present channel design, the transmitter output of 100W or 200W will be used in the case of shortwave according to the distance between the stations and that of 25W will be used in the case of VHF. Fig. 5-4-40 through 5-4-42 show the composition of representative euqipment used for channel design.

Fig. 5-4-40 Composition of equipment for long distance circuit



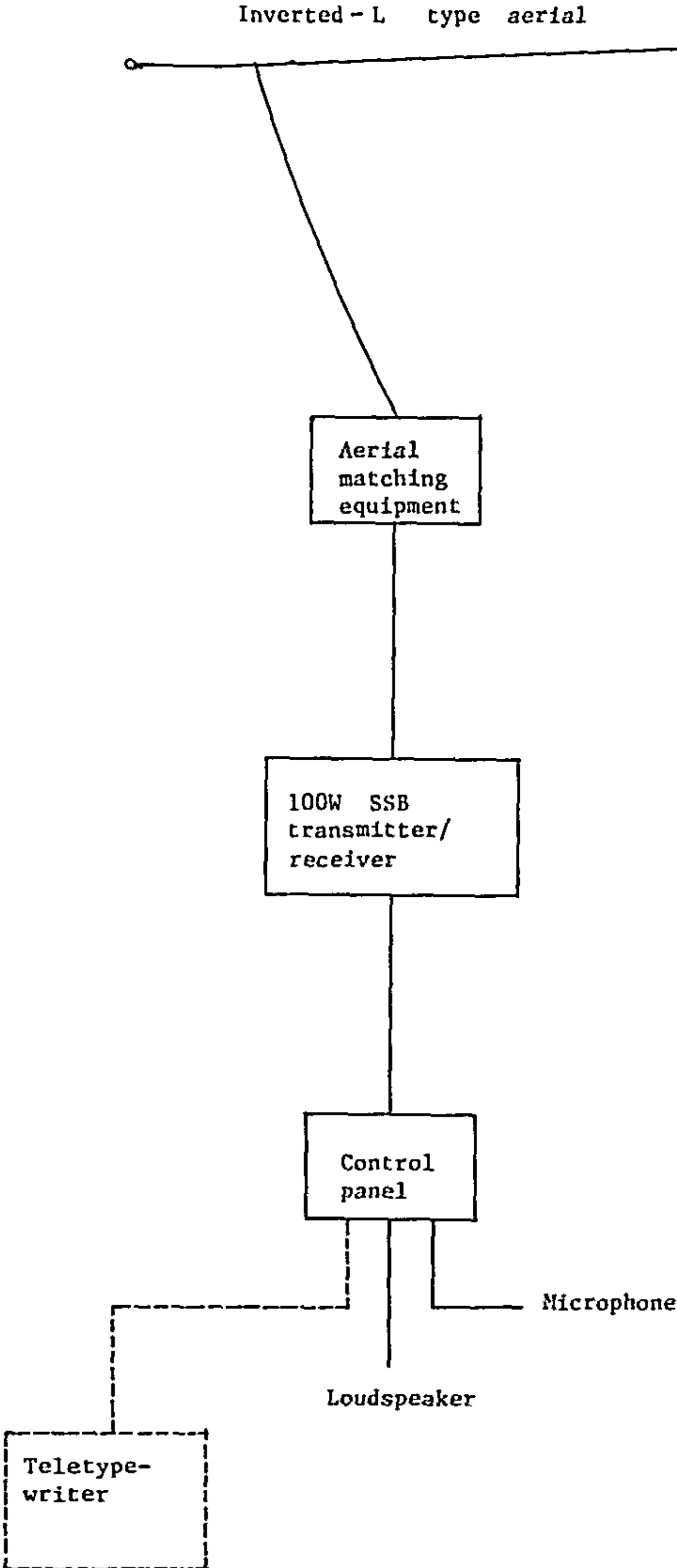


Fig. 5-4-41 Composition of equipment for short distance communications

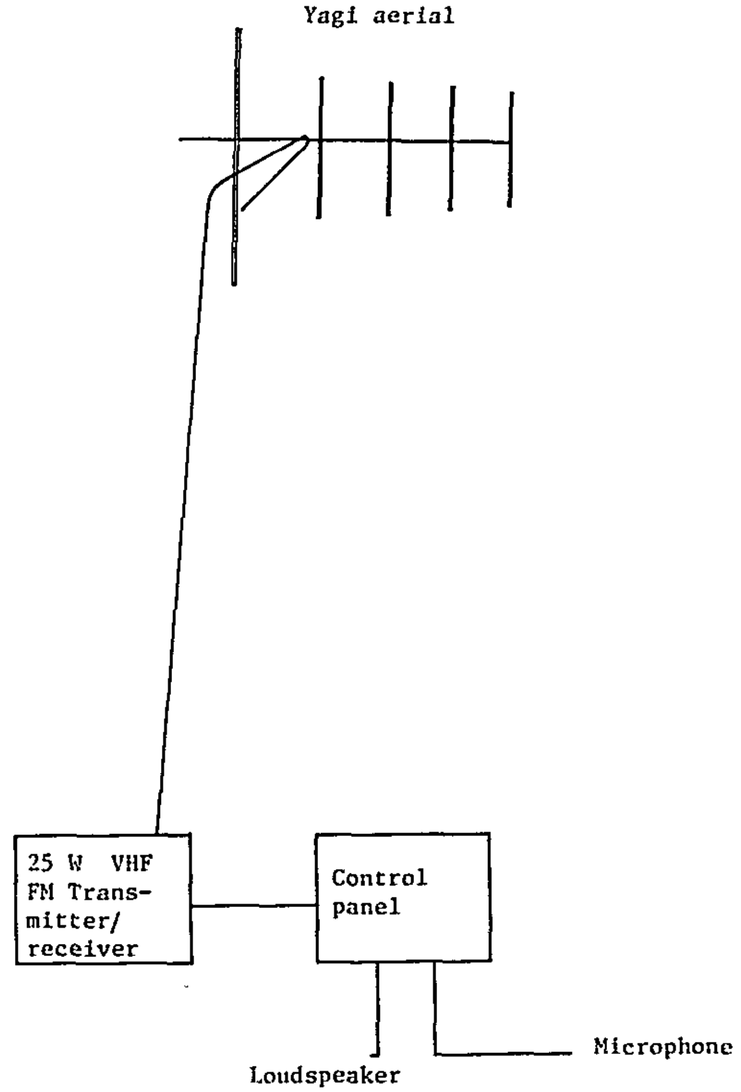


Fig. 5-4-42 Composition of VHF station equipment for short distance communications

Fig. 5-4-46 Communications network
for
Singapore Strait Decca Chain

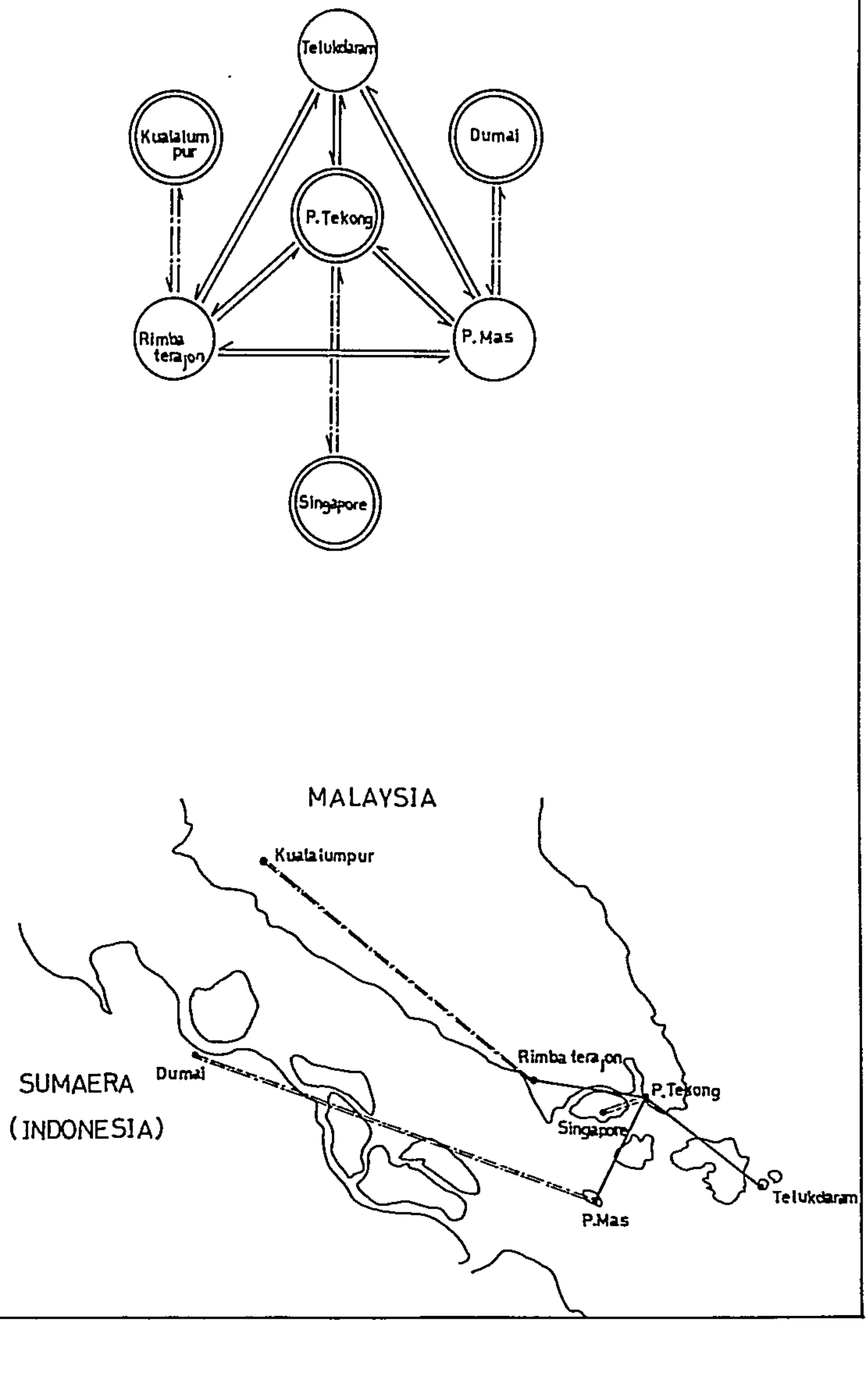


Table 5-4-13 Communications channel design

Name of chain Singapore Decca

Aerial power 100W Station A
200W Station B

MPP: Multi-propagation path (GW and 1 HOP ES)

Name of Station	The other station	Distance between stations (km)	Working frequency (MHz)	Pro-pagation path to be used	Angle of incidence (degree)	h/λ	λ (m)	h (m)	Aerial power	Aerial	Remarks
P.TEKONG	TELUKDARAM	80	2 4	GW GW	- -	- -	150 75	20 20	A	Vert.Ant.	
	P. MAS	80	2 4	GW GW	- -	- -	150 75	20 20	A	Vert.Ant.	
	RIMBA TERAJON	75	2 4	GW GW	- -	- -	150 75	20 20	A	Vert.Ant.	
	SINGAPORE	25	150	GW	-	-	2	-	25W	4 Ele. Yagi	
TELUKDARAM	P.TEKONG	80	2 4	GW GW	- -	- -	150 75	20 20	A	Vert.Ant.	
	P.MAS	100	2 4	GW GW	- -	- -	150 75	20 20	A	Vert.Ant.	
	RIMBA TERAJON	150	2 4	GW GW	- -	- -	150 75	20 20	A	Vert.Ant.	

P.MAS	P.TEKONG	80	2 4	GW GW	- -	- -	150 75	20 20	A	Vert.Ant.	
	TELUKDARAM	100	2 4	GW GW	- -	- -	150 75	20 20	A	Vert.Ant.	
	RIMBA TERAJON	90	2 4	GW GW	- -	- -	150 75	20 20	A	Vert.Ant.	
	DUMAI	275	2 4	GW MPP 1 HOP F_2	- 36 60	- 0.42 0.27	150 75 40	20 31.5(20) 11	A	Vert.Ant. Dipole Dipole	
RIMBA TERAJON	KUALALUMPUR	260	2 4 7	GW MPP 1 HOP F_2	- 38 66	- 0.4 0.3	150 75 40	20 30(20) 12	A	Vert.Ant. Dipole Dipole	
	P.TEKONG	75	2 4	GW GW	- -	- -	150 75	20 20	A	Vert.Ant.	
	P.MAS	90	2 4	GW GW	- -	- -	150 75	20 20	A	Vert.Ant.	
	TELUKDARAM	150	2 4	GW GW	- -	- -	150 75	20 20	A	Vert.Ant.	
DUMAI	P.MAS	275	2 4 7	GW MPP 1 HOP F_2	- 36 60	- 0.42 0.27	150 75 40	20 31.5 11	A	Vert.Ant. Dipole Dipole	
KUALALUMPUR	RIMBA TERAJON	260	2 4 7	GW MPP 1 HOP F_2	- 38 66	- 0.4 0.3	150 75 40	20 30 12	A	Vert Ant. Dipole Dipole	
SINGAPORE	P.TEKONG	25	150	GW	-	-	2	15	25W	4 Ele. Yagi	

Fig. 5-4-47 Communications network for South Malacca Decca Chain

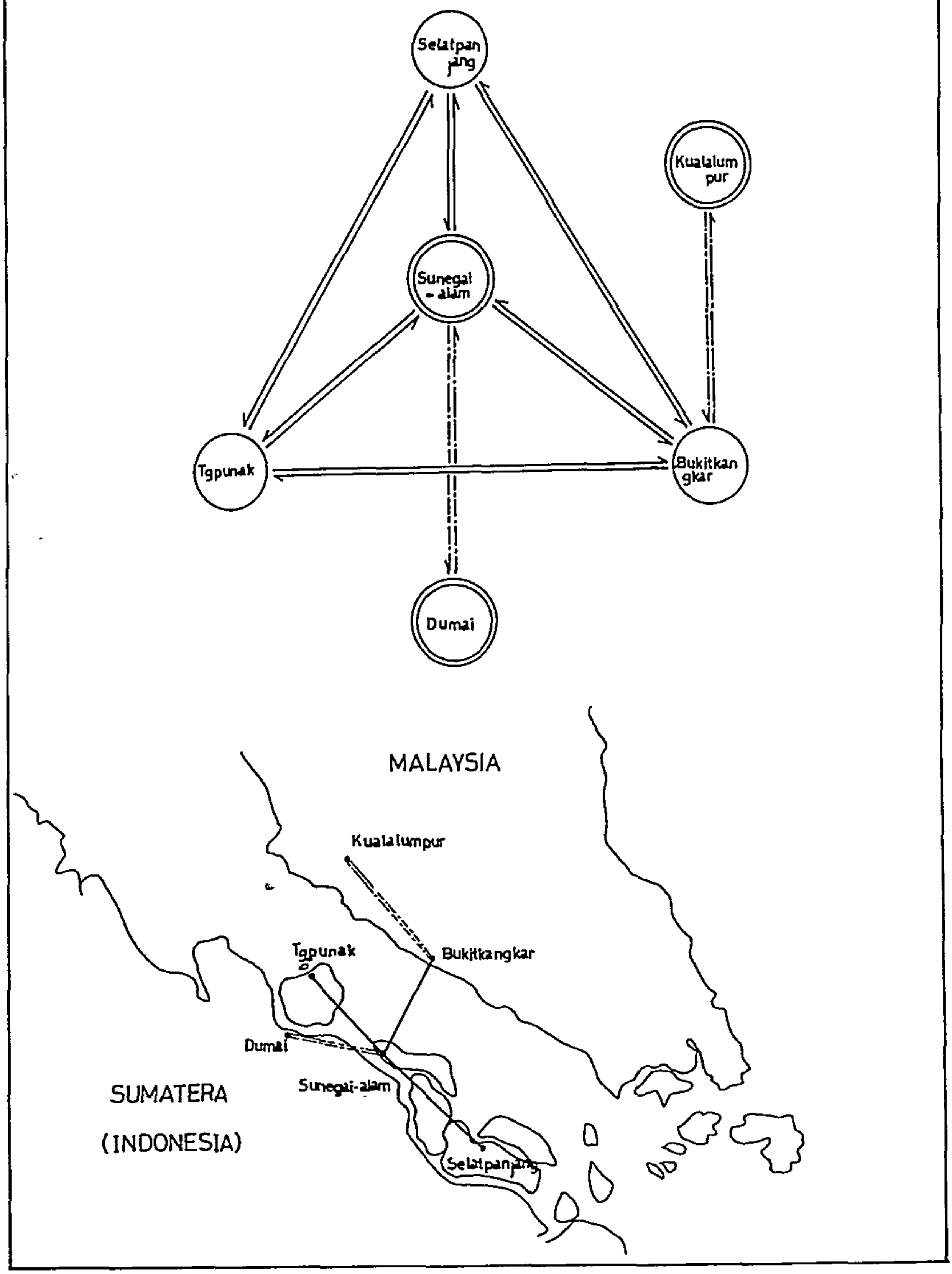


Table 5-4-14 Communications circuit design

Name of chain South Malacca Decca

Aerial power 100W Station A

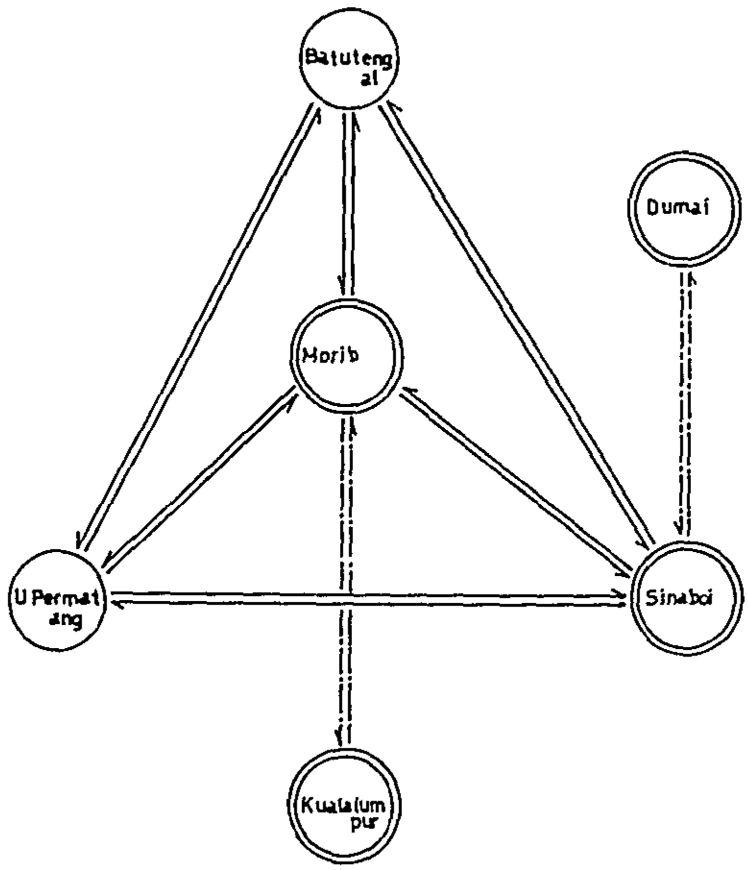
200W Station B

MPP: Multi-propagation path (GW and 1 HOP ES)

Name of station	The other station	Distance between stations (km)	Working fre-quency (MHz)	Pro-pagation path to be used	Angle of incidence (degree)	h/λ	λ (m)	h (m)	Aerial power	Aerial	Remarks
SUNGAI -AIAM	TG.PUNAK	95	2 4	GW GW	- -	- -	150 75	20 20	A	Vert. Ant.	
	SELAT PANJANG	90	"	"	-	-	"	20 20	A	"	
	BUKIT KANGKAR	80	"	"	- -	- -	"	20 20	A	"	
	DUMAI	80	"	"	- -	- -	"	20 20	A	"	
TG.PLUMK	SUNGAI -AIAM	95	2 4	GW GW	- -	- -	150 75	20 20	A	Vert. Ant.	
	SELAT PANJANG	175	"	GW MPP	- 48	- 0.34	"	20 26(20)	A	"	
	BUKIT KANGKAR	105	"	GW GW	- -	- -	"	20 20	A	"	
SELAT PANJANG	SUNGAI -AIAM	90	2 4	GW GW	- -	- -	150 75	20 20	A	Vert. Ant.	

	TG. PUNAK	175	2 4	GW MPP	- 48	- 0.34	150 75	20 26(20)	A	Vert. Ant.	
	BUKIT KANGKAR	120	"	GW GW	- -	- -	"	20 20	A	"	
BUKIT KANGKAR	KUALA-LUMPUR	140	2 4	GW MPP	- 56	- 0.3	150 75	20 23(20)	A	Vert. Ant. Dipole	
	SUNGAI -AIAM	80	"	GW GW	- -	- -	"	20 20	A	Vert. Ant.	
	TG.PUNAK	105	"	"	- -	- -	"	20 20	A	"	
	SELAT PANJANG	120	"	"	- -	- -	"	20 20	A	"	
DUMAI	SUNGAI -AIAM	80	2 4	GW GW	- -	- -	150 75	20 20	A	Vert. Ant.	
KUALA-LUMPUR	BUKIT KANGKAR	140	2 4	GW MPP	- 56	- 0.3	150 75	20 23(20)	A	Vert. Ant. Dipole	

Fig. 5-4-48 Communications network for Malacca Strait North Decca Chain



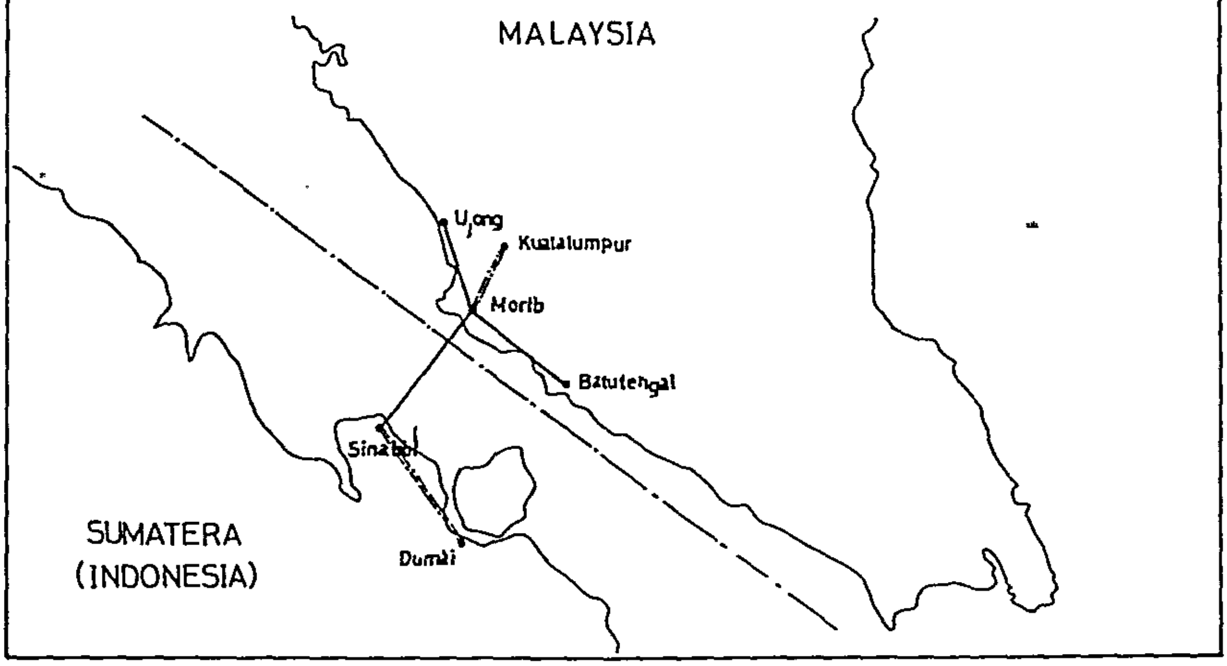


Table 5-4-15 Communications channel design

Name of chain: Malacca Decca

Aerial power: 100W Station A
200W Station B

Name of Station	The other station	Distance between stations (km)	Working frequency (MHz)	Propagation path to be used	Angle of incidence (degree)	h/λ	λ (m)	h (m)	Aerial power	Aerial	Remarks
MORIB	U.PERMATANG	65	2 4	GW GW	- -	- -	150 75	20 20	A	Vert.Ant.	
	BATUTENGAH	85	2 4	GW GW	- -	- -	150 75	20 20	A	Vert.Ant.	
	SINABOI	75	2 4	GW GW	- -	- -	150 75	20 20	A	Vert.Ant.	
	KUALALUMPUR	50	2 4	GW GW	- -	- -	150 75	20 20	A	Vert.Ant.	
UJ.PERMATANG	MORIB	65	2 4	GW GW	- -	- -	150 75	20 20	A	Vert.Ant.	
	BATUTENGAH	145	2 4	GW GW	- -	- -	150 75	20 20	A	Vert.Ant.	
	SINABOI	130	2 4	GW GW	- -	- -	150 75	20 20	A	Vert.Ant.	

BATUTENGAH	MORIB	85	2 4	GW GW	- -	- -	150 75	20 20	A	Vert.Ant.	
	U.RERMATANG	145	2 4	GW GW	- -	- -	150 75	20 20	A	Vert.Ant.	
	SINABOI	105	2 4	GW GW	- -	- -	150 75	20 20	A	Vert.Ant.	
SINABOI	MORIB	75	2 4	GW GW	- -	- -	150 75	20 20	A	Vert.Ant.	
	U.RERMATANG	130	2 4	GW GW	- -	- -	150 75	20 20	A	Vert.Ant.	
	BATUTENGAH	105	2 4	GW GW	- -	- -	150 75	20 20	A	Vert.Ant.	
	DUMAI	70	2 4	GW GW	- -	- -	150 75	20 20	A	Vert.Ant.	
KUALALUMPUR	MORIB	50	2 4	GW GW	- -	- -	150 75	20 20	A	Vert.Ant.	
DUMAI	SINABOI	70	2 4	GW GW	- -	- -	150 75	20 20	A	Vert.Ant.	

Table 5-4-16 Usable frequency band by hour

Distance = 100 km

Equinox day

Sunspot number R = 25

1 HOP F_2

Δ = 80°

Ant = Dipole

local time	00~04	04~07	07~10	10~12	12~14	14~16	16~18	18~24
Frequency band MHz	4	4	(4)					4
			7	7	7	7	7	
Absorption loss -dB	0	0~8	(8~29)				(18~35)	35~0
			4~13	13~16	16~14	14~8	8~1.5	
Path loss -dB	101	101						
			105	105	105	105	105	101
Aerial gain +dB	4 x 2	4 x 2	4 x 2	4 x 2	4 x 2	4 x 2	4 x 2	4 x 2
System loss -dB	93	93~101						96.5~93
			101~110	110~113	113~111	111~105	105~98.5	
Noise power -dB(W)	95~98	98~108						103~95
			113~118	118	118~115	115~113	113~111	
Required S/N dB	20	20	20	20	20	20	20	20
Required receiving power -dB(W)	75~78	78~88	93~98	98	98~95	95~93	93~81	83~75
Required transmitting power dB(W)	18~15	15~13	8~12	12~15	15~16	16~12	12~17.5	17.5~18
Remarks	System loss is the total of Absorption loss, Path loss and Aerial gain.							

Table 5-4-17 Usable frequency band by hour

Distance = 200 km
Equinox Day
Sunspot number R=25
1 HOP F2
$\Delta = 72°$
Ant = Dipole

Local time	00~04	04~07	07~10	10~12	12~14	14~16	16~18	18~24
Frequency band	4	4						4
MHz			7	7	7	7	7	
Adsorpotion loss	0	0 ~ 9						4 ~ 0
-dB			4 ~ 13	13~17	17~15	15 ~ 9	9 ~ 2	
Path loss	102	102						102
-dB			106	106	106	106	106	
Aerial gain +dB	8	8	8	8	8	8	8	8
System loss	94	94~103						98~94
-dB			102~111	111~115	115~113	113~107	107~100	
Noise power -dB(W)	95~98	98~108	113~118	118	118~115	115~113	113~111	103~95
Required S/N dB	20	20	20	20	20	20	20	20
Required reci-ving power -dB(W)	75~78	78~88	93~98	98	98~95	95~93	93~91	83~75
Required trans-mitting power dB(W)	19~16	16~15	9~13	13~17	17~18	18~14	14 ~ 9	15~19
Remarks	Sytem loss is the total of Absorption loss, Path loss and Aerial gain.							

Table 5-4-18 Usable frequency band by hour

Distance = 100 km

Equinox day

Sunspot number R = 25

1 HOP F_2

Δ = 63°

Ant = Dipole

local time	00~04	04~07	07~10	10~12	12~14	14~16	16~18	18~24
Frequency band MHz	4	4						4
			7	7	7	7	7	
Absorption loss -dB	0	0~9						4~0
			4~13	13~17	17~15	15~9	9~2	
Path loss -dB	102	102						102
			107	107	107	107	107	
Aerial gain +dB	8	8	8	8	8	8	8	8
System loss -dB	94	94~103						103~95
			113~118	118	118~115	115~113	113~111	
Noise power -dB(W)	95~98	98~108	113~118	118	118~115	115~113	113~111	103~95
Required S/N dB	20	20	20	20	20	20	20	20
Required receiving power -dB(W)	75~78	78~88	93~98	98	98~95	95~93	93~91	83~75
Required transmitting power dB(W)	19~16	16~15	10~14	14~18	18~19	19~15	15~10	15~19
Remarks	System loss is the total of Absorption loss, Path loss and Aerial gain.							

Table 5-4-19 Usable frequency band by hour

Distance = 500 km
Equinox day
Sunspot number R = 25
1 HOP F_2
$\Delta = 50°$
Ant = Dipole

Local time	00~04	04~07	07~10	10~12	12~14	14~16	16~18	18~24
Frequency band MHz	4	4						
			7					7
				9	9	9	9	
Absorption loss -dB	0	0 ~ 6						
			3 ~15		12~11	11 ~ 6	6 ~ 2	3 ~ 0
				9 ~ 12				
Path loss -dB	103	103						
			108					108
				110	110	110	110	
Aerial gain +dB	8	8	8	8	8	8	8	8
System loss -dB	95	95~101	103~115	110~114	114~113	113~108	108~104	103~100
Noise power -dB(W)	95~98	98~108	113~118	121	121~118	118~116	116~115	111~106
Required S/N dB	20	20	20	20	20	20	20	20
Required receiving power -dB(W)	75~78	78~88	93~98	101	101~98	98~96	96~95	91~86
Required transmitting power dB(W)	20~17	17~13	10~17	10~13	13~15	15~12	12~ 9	12~14
Remarks	System loss is the total of Absorption loss, Path loss and Aerial gain.							

Table 5-4-20 Usable frequency band by hour

Distance = 700 km
Equinox day
Sunspot number R = 25
1 HOP F2
Δ = 40°
Ant = Dipole

Local time	00~04	04~07	07~10	10~12	12~14	14~16	16~18	18~24
Frequency band MHz	4	4						
			7					7
				9	9	9	9	
Absorption loss -dB	0	0~7						
			3~17					3~0
				10~13	13~12	12~7	7~2	
Path loss -dB	105	105						
			109					109
				111	111	111	111	
Aerial gain + dB	8	8	8	8	8	8	8	8
System loss -dB	97	97~104	104~118	113~116	116~115	115~110	110~105	104~101
Noise power -dB(W)	95~98	98~108	113~118	121	121~118	118~116	116~115	111~106
Required S/N dB	20	20	20	20	20	20	20	20
Required receiving power -dB(W)	75~78	78~88	93~98	101	101~98	98~96	96~95	91~86
Required transmitting power dB(W)	22~19	17~16	11~20	12~15	15~17	17~14	14~10	13~15
Remarks	System loss is the total of Absorption loss, Path loss and Aerial gain.							

5-4-4 Lightning protector of Decca transmitting equipment

(1) Introduction

The aerial coil of Decca transmitting equipment comprises total of 5 coils of A,B,C,D and E which are ritz wires honeycomb-wound on the wooden frame to increase the efficience of the coils. Normally, the lightning arrester of transmitting system in a radio station is to incorporate an arrester in parallel with the transmitter at the base of an aerial. In the case of Decca transmitting equipment, it is difficult to protect the coils against lightning only with usual arrester because of small endurance in the thermal and mechanical aspects due to the afore-said structure. The lightning may give the coils burning damage or mechanical damage according to its scale. The lightning protector as shown in Fig. 5-4-49 has been developed and put in practical use for the Decca stations in Japan, which is much effective to protect the lightning impact. The principle of this lightning protector is so as to protect the coils as follows: the fuse will be cut at the initial stage (before a critical point where the coils can endure in the thermal and mecanical aspects) by selecting a proper fusing point of the fuse inserted between the coils and the aerial corresponding to the lightning stroke current in dotted line shown in Fig. 5-4-50, and thereby the circuit will be cut and all of the lightning current will be led to the earth through the arrester.

(2) Selection of fuse in the lightning protector

Selection of fuse in this lightning protection circuit has a significant mean, in other words:

1. it fuses at about t= 10 μs against the lightning stroke current.

2. it does not explode by the thermal energy when the lightning current passes.

3. it has a large fusing capacity to cut fully the circuit when fusing.

The fuse satisfying following specifications is used.

1. Type: Wide range fuse.

2. Nominal Voltage: 36 kV

3. Nominal Current: 40 A

4. Fusing capacity: 250 MVA

5. Structure: As shown in Fig. 5-4-51.

Fig. 5-4-49 Schematic diagram of Lightning protector

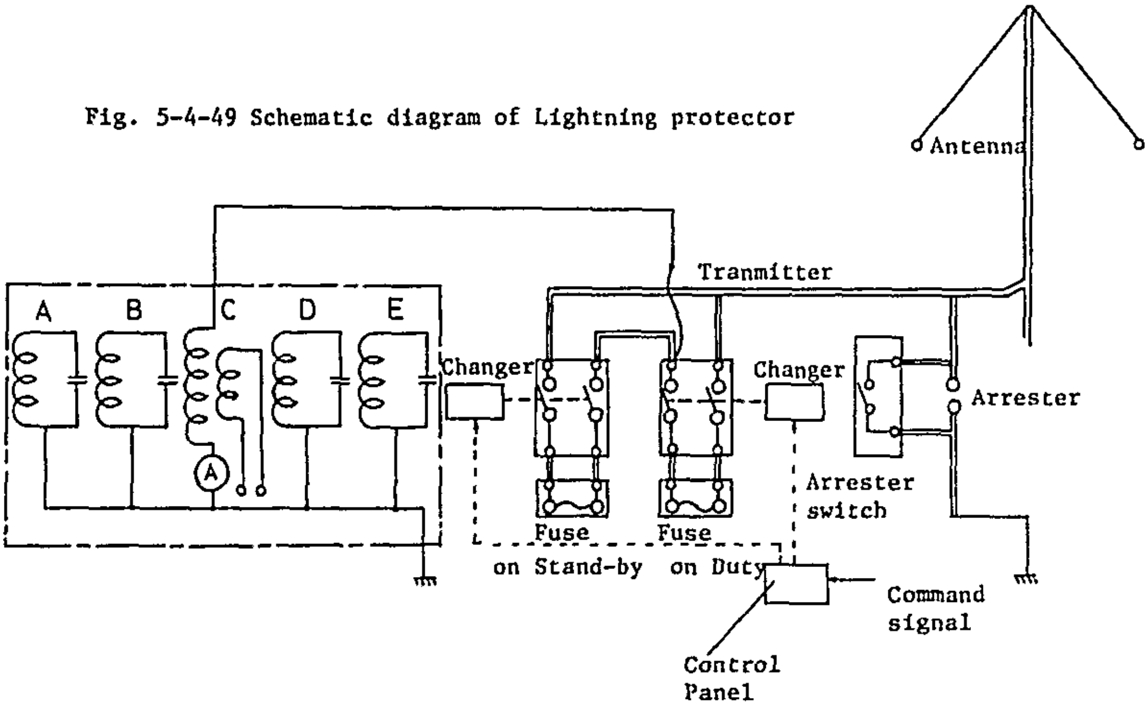
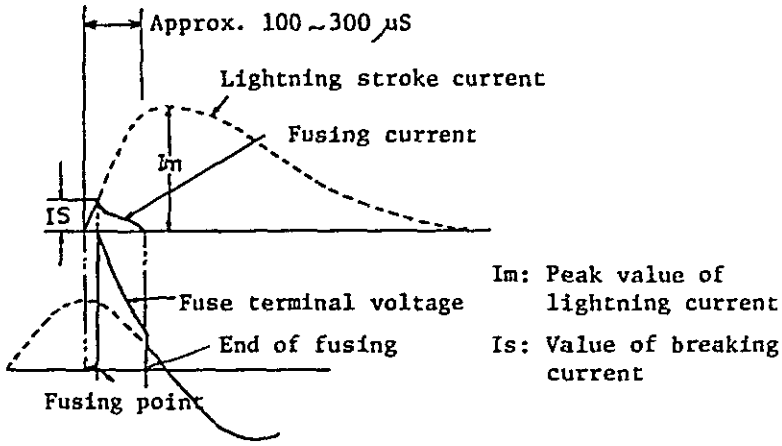


Fig. 5-4-50 Timing of fusing



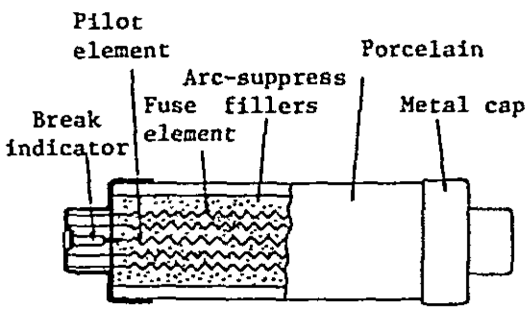


Fig. 5-4-51 Section of fuse

5-5 Unmanned Decca system

5-5-1 Introduction

A Decca transmitting chain can be unmanned by adding to it a monitor site, a control centre and by incorporating monitor and control functions into each station. There are two cases in the unmanned system; one is a system which comprises an unmanned master and slave stations and a station established in a different site which incorporates the monitor site and the control centre, the other is a system which comprises the control centre annexed to the unmanned master station and the monitor site. It is desirable to man the master station because a failure in the master station might cause the off air of the whole chain. It would, therefore, be advisable to have the latter system. This system is also adopted to the unmanned chain in Japan. Periodical go-around inspection and maintenance are carried out at three unmanned slave stations. The interval of 15 days will be enough. In case the unmanned Decca system was employed, it may be able to reduce the number of engineers for operation and maintenance and to cut down construction and maintenance expenses thereby. On the other hand, however, there would be a serious question in taking a measure to the trouble as compared with the manned system. That is, in the event that the man power would be required to recover the system, it takes some time for the engineer to get in the station and consequently it will deteriorate the servicing quality. Therefore, when the unmanned system is adopted, full consideration should be taken into the administration organisation ensuring more able engineers them those in the manned system and better accessibility.

5-5-2 Explanation of the system

In the unmanned system, as shown in Fig.5-5-1, the navigational frequencies radiated from each station are received at the remote monitor site and are transfered to the control centre via UHF radio link. The overall system monitor is carried out at the control centre. The operating states of equipment are monitored at the control centre using the coded 8.2f signal from each slave station.

The control of each slave station is carried out, as necessary, by the control centre using the coded 8.2f signal of the master station. The monitor and control of equipment in the master station are carried out as same as the slave station through the line connected between the control centre and the master station. The 8.2f frequency can only be used for data transmission when it is not required for "pattern" or "guard" functions. The remaining period of the 20 second cycle is divided between the three slave stations as shown in the transmission timing diagram of Fig. 5-5-2. The time of 8.2f frequency to be used for monitoring and contiolling slave stations is asigned on the basis of zero time (the end of the master 8.2f guard transmission) as follows:

Report message time from the red slave is from 8.4 to 10.92 seconds (in the case of command message to the red slave, it starts at 8.28 seconds). Report message time from the green slave is from 11.16 to 13.68 seconds (in the case of command message to the green slave, it starts at 11.04 seconds). Report message time from the purple slave is from 13.92 to 16.44 seconds (in the case of command message to the purple slave, it starts at 13.8 seconds). As- for monitoring and controlling the master station, report message time is from 3.36 to 5.88 seconds (in the case of command message to the master, the signal starts at 3.24 seconds).

Normally each station is sending information on the equipment operation states to the control centre. When the control centre sends an intervene signal to a station, the corresponding station stops sending report message and changes to automatically the receiving mode of command message and then is controlled by the command message. The bit capacity of a command message is 22 bits and the first bit is for the intervene signal. The bit capacity of a report message is 21 bits and the duration of a bit is 120 mS respectively. The data transmission reliability is improved by parity check or repetition check and a specific bit for noise detection.

5-5-3 Functions of the control centre

1) Overall monitoring of the system

The normal pattern and mutipulse pattern received at the remote monitor site are displayed on the LI metre and decometre each for red, green and purple assembled in the monitor console and at the same time they are recorded on the monitor recorder. Thus the deviation from the normal value is at all times monitored. Provision is made on the monitor recorder to provide an alarm in the event of any pattern changing in phase by more than a predetermined amount. The amplitude and timing of received signal are also at all times monitored at the monitor console.

2) Monitoring of operation states of each station equipment

The operating states of equipments of each station are transmitted by 21 bit report message signal to the control centre. 16 bits are used dor transmitting 22 items of monitoring information and one bit for noise check, four bits for parity check. These 22 item are displayed on the remote control and display unit at the control centre. The remote control and display unit carries four control panels, one for each of the four stations. These indications are listed below;

(1) Phase control equipment No.1 on duty
(2) " " " No.2 " "
(3) " " " No.3 " "
(4) Normal pattern indicator 1st stage
(5) Multipulse pattern 1st stage
(6) Power supply indicator 1st stage
(7) Main power supply off alarm
(8) Phase control alarm, 1st stage (1 unit locked out)
(9) Normal pattern alarm 2nd stage
(10) Low aerial current alarm
(11) Multipulse pattern alarm 2nd stage
(12) Power supply alarm 2nd stage

(13) Phase control alarm 2nd stage

(14) Standby power supply alarm (for example, diesel not started)

(15) Remote control channel A or B in use

(16) Final M.P. fault

(17) A.T.A.M. fault

(18) Loss of zero time

(19) Coil protect fuse No.1 on duty

(20) " No.2 "

(21) " No.3 "

(22) " No.4 "

The first stage information (4) and (5) indicate a module failure causing not more than a 30% power loss on the normal pattern power amplifier or on any one of the four Multipulse channel power amplifiers respectively. The second stage alarms (9), (11), cater for any further loss of power amplifier capacity. To guard against the possibility of failure in one channel masking a further fault in any of the remaining three channels of the Multipulse L.I. system, such an alarm circuit (11), is provided in this instance.

The primary phase control equipment (8) operates in the event of a failure of any sort on one phase control equipment which causes this equipment to be locked out of the automatic switching system. To permit a degree of monitor over the remaining two equipments after such an occurrence, the 2nd stage alarm (13) is provided to indicate that a discrepancy has occurred between these units. The alarm(16) covers any subsequent fault condition in the pultipulse signal when the final phase control equipment is in operation.

The 1st and 2nd stage power supply alarms indicate respectively a fault of no immediate urgency in the power system and an urgent fault in this system requiring prompt action.

By inclusion of an indicator channel (15) ot show which of the two remote control channels (A,B) is in use at each station, a check can be maintained on the serviceability of both channels, as these are automatically switched into service alternately on a predetermined schedule. Further, an intermittent fault indication can be identified as a remote control system fault if it is transmitted on one of the two channels only. A further alarm condition is obtained if a fault occurs in the overall transmission channel ("loss of message"): this is augmented by indication (18) when such loss of message is due to a synchronization failure. In order to prevent damage to the aerial couls at the time of lightning strike, four protective fuses are provided in the aerial system. The operating states of protective fuses are indicated by (19), (20), (21), (22).

3) Control of equipment of each station and maintenance of system functions

According to the data obtained by overall monitoring of the system and by monitoring the operating states of equipment of each station, the control centre carries out control as necessary for maintaining at all times the normal functions of the whole system. For this purpose, a message containing 21 bits is transmitted from the control centre to the four stations. 20 bits are used for transmitting 10 item signal and the remaining one bit for noise detection.

The remote control facilities are nine in number and one is spair:

(1) Change duty phase control rack

(2) System reset

(3) Reset 'notch' (i.e. phasing of Multipulse transmissions)

(4) Suppress lock-out system

(5) Switch off Multipulse transmission

(6) Switch off all transmissions

(7) Start diesel

(8) Initiate half-power signalling

(9) Change duty coil protect fuse

Operation (1) permits the operator to bring into duty any one of the three phase control racks at will in order to check its performance by reference to the monitor receiver.

Operation (2) overrides the lock-out system, resets standby phase control rack synchronising and resets the transmitter switching (5) and (6) if either of these operations have been performed and unless the appropriate control switch is still set to 'off'. If a Multipulse phasing error exists, the duty rack can be readjusted by operation (3). It should be noted that, due to the need to rephase, if required, at the zone pattern frequency of 0.2f, which could demand up to 29 cycles or 'notches' at 6f, 3 of the available 8 bits in the control transmissions are used to minimize the number of operations necessary for this purpose.

Operation (4) is necessary as oterwise a failure, for example, of one of the Multipulse amplifier channels could cause a complete lock-out of the phase control equipment switching when no phase control equipment fault exists. Operation (7) provides back-up protection for the automatic diesel-generator control system. Operation (8) is provided, if required, to operate an engineer call system in which field engineers are equipped with a special receiver which gives an alarm signal in response to periodic changes to half power of the normal pattern transmission. In the protective fuse on duty is defective, operation (9) changes to the spair protective fuse.

4) Data collection for analysing failures

In order to recover the failures of equipments at the earliest time, it is important to detect the failure location and to seize correctly the conditions. For this purpose, it is required to obtain information on the operation states of equipment until such failure has come to happen and the phenomenon occurred.

In the case of manned station, the operator confirms the operation states of equipment as routine work and can easily specify the failure location when a fault occurs. However, in the case of unmanned station, the special functions should be provided in place of the above function, that is; at the control centre and unmanned stations, functions to record conitinuously the necessary data and to analyze the failure comparing between both recordings. At the control centre, facilities are provided to record periodically in usual condition the normal and multipulse pattern signals received at the monitor site, the operating states of equipments of each slave station sent via 8.2f transmission signal, the operating states of equipment at the master station sent via line and any failure or changing in performance. At each unmanned station, facility is provided to make a continuous record of detailed operation states of each equipment other than those to be sent to the control centre.

The earliest recovery of the system is made possible by mutually comparing and analysing these data and specifying the failure location.

5-5-4 Equipments to be required for the unmanned system

In the unmanned Decca chain, the following equipments other than those of the manned Decca chain:

Table 5-5-1

Item of equipment	Quantity			Remarks
	M	S	CC	
Line terminal equipment	1	0	1	
Data recorder	1	1	1	
Interface unit	1	1	1	in register rack
Sending/receiving register				
Timer				
Interface				
Monitoring and control console			1	
Monitor receiver display				
Control panel				

The whole composition of these equipments is as shown in Fig. 5-5-3 and the control centre equipment composition is as shown in Fig. 5-5-4.

5-5-5 Unmanned Decca station equipment

(1) Composition

In the unmanned Decca system, the control centre annexed to the master station monitors the whole system and the operating states of each station equipment and controls the equipments as necessary. For this purpose, the equipments stated in paragraph 5-4-4 are required, composition of those equipments in the unmanned' station is as shown in Table 5-5-2 and composition of the manned station equipments are also included thereto for the comparison purpose. Functions of these equipments are as follows:

(2) Monitoring and switching equipment

This equipment is provided to monitor the operating states of the phase control equipment in the same way as the manned Decca system, and select and switch to an optimum rack automatically when a fault exists in duty rack. In addition to these functions, this equipment sends out the status information on the phase control racks to the control centre and selects and switches to the rack according to the command signal from the control centre.
The outer view of the equipment is similar to that of the manned system shown in Fig. 5-4-12 and Fig. 5-4-13.
The 8.2f coding/decoding circuits to send/receive signals to/from the control centre is incoporated in the interface unit shown in the same Figures.

1) Functions

a) Detection of abnormality of the phase control equipment and of itself.

b) Automatic switching of the phase control equipment (Automatic or manual)

c) Indication of the abnormality

Table 5-5-2 Manned/Unmanned Station Equipment Components

Item	Unmanned				Manned			Remarks
	M	S(for each)	C.C	R.M.S	M	S(for each)	R.M.S.	
Phase control equipment	3	3			3	3		
Receiving aerial		4				4		Wire or whip for phase control rack and station monitor
Monitoring Switching equipment	2	2			2	2		In unmanned station It needs interfacer for monitoring and command signals
Transmitter	5	5			5	5		5f, 6f, 8f, 8.2f, 9f .
Spare rack	1	1			1	1		PA, EX Spare unit and Dummy Load
Aerial coil assembly	1	1			1	1		Multiple feeding for an aerial
ATAM unit	1	1			1	1		5 frequencies simultaneously
Monitor receiving equipment				1			1	Including receiving aerial
UHF Transmitter/Receiver				1			1	Data transmission
Line terminal equipment					1			
Operation console								
Monitoring & control console			1					
Sending/receiving Register Rack			1					

Data Recorder Rack for control center			1					
Data Recorder Rack for station	1	1						

d) Monitoring of station operation

e) Sending/receiving of the report/command message to/from the monitoring & control console at the control centre.

2) Composition

As shown in Table 5-5-3.

(3) Data recorder rack of each station

This equipment is provided to record automatically the operating states of each equipment at a station. The outer view of the equipment is as shown in Fig. 5-5-5.

1) Functions

a) Recording the transmitting aerial current on the analogue recorder.

b) Recording the report/command to or from the control centre on the digital recorder.

c) Recording all the alarm conditions.

2) Composition

As shown in Table 5-5-4.

Table 5-5-3 Monitoring and switching equipment components

Name of Rack	Name of Unit	Quantity		Remarks
		M	S	
Changer	Indicator Unit	1	1	
	Switching Unit	1	1	
	Auto selector unit (1)	1	1	for phase control equipment
	Auto selector unit (2)	3	3	
	Frequency counter unit	1	1	
	Interface unit (1)	1	1	including Sending/Receiving Register, Timer, etc. for 8.2f cording/adecoding
	Power unit	1	1	
Monitor	Indicator & control unit	1	-	
	Monitoring unit	1	1	comparison units of 0.2f & 6f, osc 4, MK-10, Identification unit (Master station) Station monitor receiver, MK-10 Identification unit (Slave station)
	Monitoring Receiver unit	-	1	
	Antenna current meter unit	1	1	
	Interface unit (2)	1	1	
	Power unit	1	1	

Table 5-5-4 Data recorder components

Name of rack	Quantity	Remarks
Aerial current recorder	1	
Digital printer	1	For record of equipment states
Timer	1	For control of Digital printer
Power supply	1	

(4) Line terminal equipment

This equipment will be required in case that the control centre is established in a different place from the master station and is an impedance conversion unit to prevent deterioration of the signal to noise ratio on the line.

(5) Monitoring and control console

This console is provided at the control centre to receive the monitoring signals from the monitor site and to carry out the phase comparison, etc. and to display the results of the comparison and AGC levels, etc. This console is also provided to make remote control of equipments of each station in order to monitor the operating states of the whole chain and to maintain the chain functions. Fig.5-5-6 shows the outer view of this console.

1) Functions

a) Display of the operating states of the phase control equipment

b) Indication of the abnormality

c) Indication of normal pattern, multipulse pattern and AGC levels

d) Switching of phase control equipment and sending/receiving report/command message

2) Composition

As shown in Table 5-5-5.

Table 5-5-5 Monitoring and control console components

Name of unit	Quantity	Remarks
Display unit (1)	1	
Display unit (2)	1	
Reception data unit	1	including D/A convertor
Master station control unit	1	
Red station control unit	1	
Green station control unit	1	
Purple station control unit	1	
Timer	1	Digital printer (1) (Record of Zone & LI)
Interface unit (1)	1	
Interface unit (2)	1	
Power unit (1)	1	
Power unit (2)	1	

(6) Register rack

This rack is provided to send and receive the remote monitor control signals between the control cetnre and the four stations and consists of the sending/receiving register and the timer controlling them. The outer view of the rack is shown in Fig. 5-5-7.

1) Functions

a) Recoding the report signals from each station

b) Coding the command signals

2) Composition

As shown in Table 5-5-6.

(7) Data recorder rack for the control centre

This rack is provide a record of the operating states of a chain and to provide an alarm when a fault occurs. The outer view of this rack is shown in Fig. 5-5-8.

1) Functions

a) Recording normal pattern on the analogue recorder

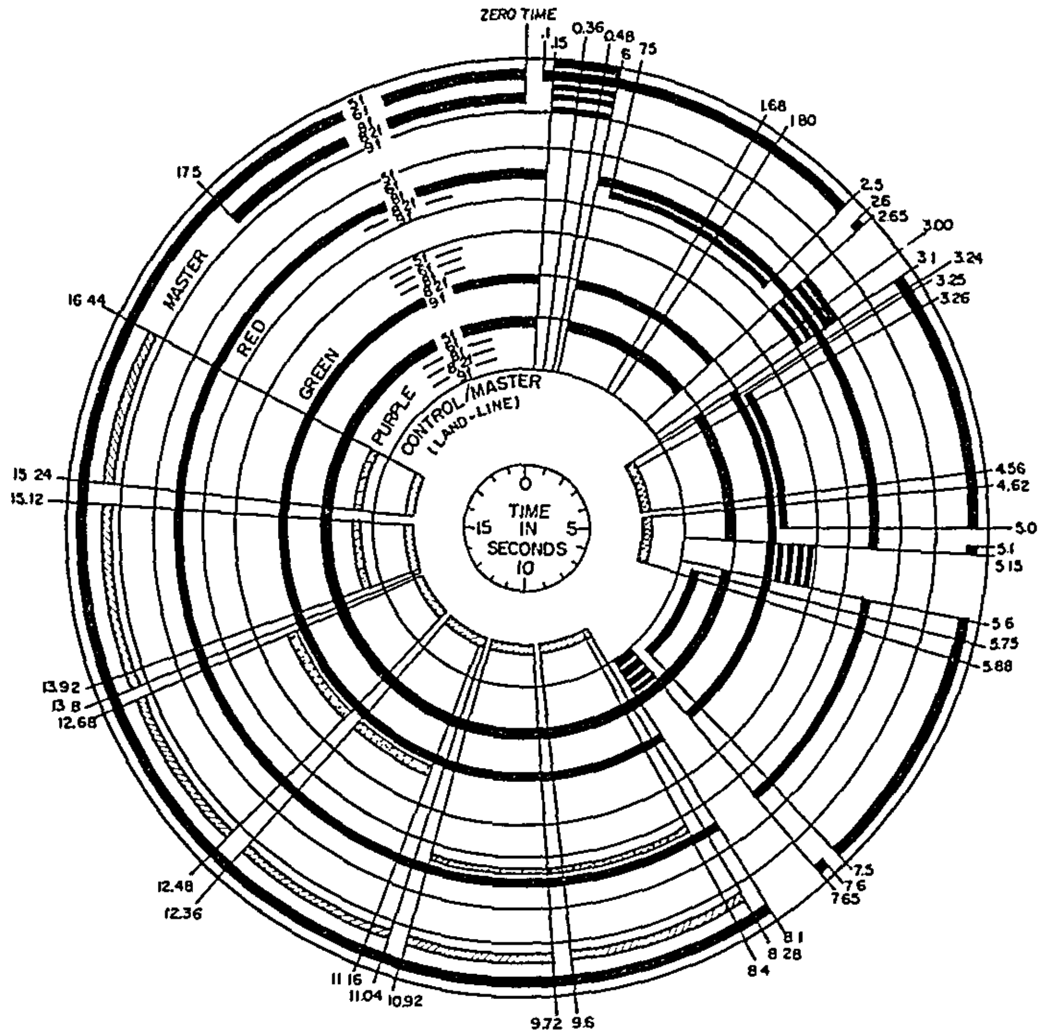
b) Recording LI patterns (Zone and LI) on the degital recorder

c) In the event of any pattern changing in phase by more than a predetermined amount, an alarm is provided

d) Recording report/command messages on the digital recorder

2) Composition

As shown in Table 5-5-7.



control/report
report
control

} coded sequences (120mS bits)

Note:- Timing shown for chain with control centre-master land-line link.

Fig. 5-5-2 Transmission timing for 4-station chain with control centre

Table 5-5-6 Register Rack components

Name of unit	Quantity	Remarks
Register channel A unit	1	for each station
Register channel B unit	1	"
Timer unit (1)	1	for register channel A unit
" (2)	1	" B "
Power unit	1	

Table 5-5-7 Data recorder rack components

Name of unit	Quantity	Remarks
Alarm unit	1	
Normal pattern recorder	1	
Digital printer (1)	1	L.I. & Zone readings
Digital printer (2)	1	report & command message
Timer unit	1	for digital printers
Power unit	1	

5-5-6 Power supply equipment of unmanned Decca station

The power supply equipment of unmanned Decca station is almost identical to that of manned Decca station except in the capacity of engine-generator in a slave station. The power supply capacity will be enough with 50 kVA due to the reduction of power consumption in unmanned station.

A comparison between unmanned and manned stations is shown in Table 5-5-8.

The outer view of 50 kVA engine-generator is shown in Fig. 5-5-9A and Fig. 5-5-9B.

Table 5-5-8

	Unmanned station		Manned station		Remarks
	Capacity	Quantity	Capacity	Quantity	
Engine-generator	50 kVA	3	125 kVA	3	Slave station

5-5-7 Building of unmanned Decca station

Building of unmanned Decca station has only a change in the slave station, in other words, there is a reduction in the area required for the transmitting building and in the personnel quarters.

A comparison between unmanned and manned transmitting buildings is shown in Table 5-5-9. The design drawing of unmanned transmitting building is incorporated in the attached drawings.

Table 5-5-9 Comparison between unmanned and manned transmitting buildings.

		Area (m^2)		Remarks
		Unmanned station (Slave only)	Manned station	
Transmitting building		202	386	Power supply building included in the case of manned station
break-down of major part	Power supply room	90	96	
	Transmitter room	40	54	
	Battery room	11	8	
	Storage	18	18	
	Living space and others	43	210	Area of veranda excluded in the case of manned station

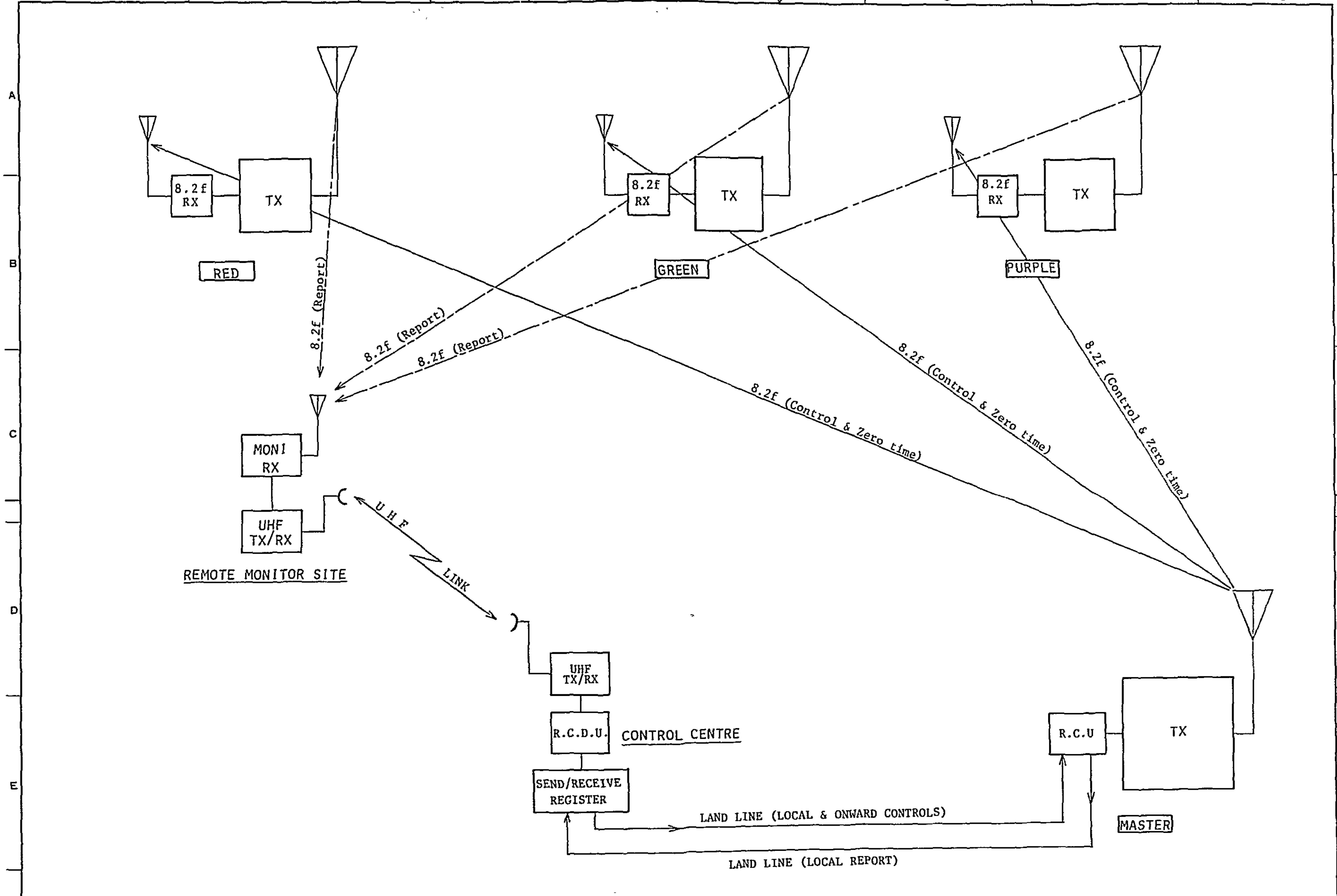
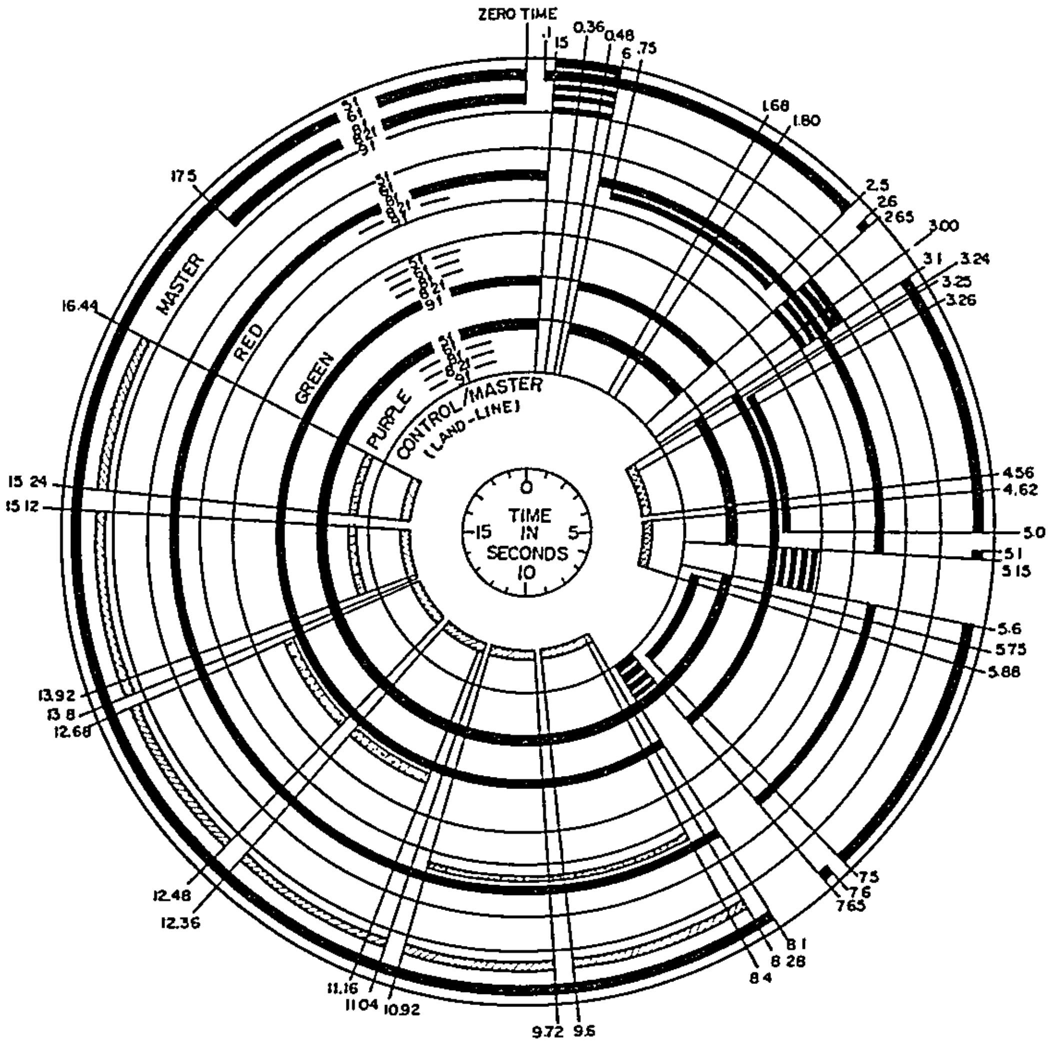


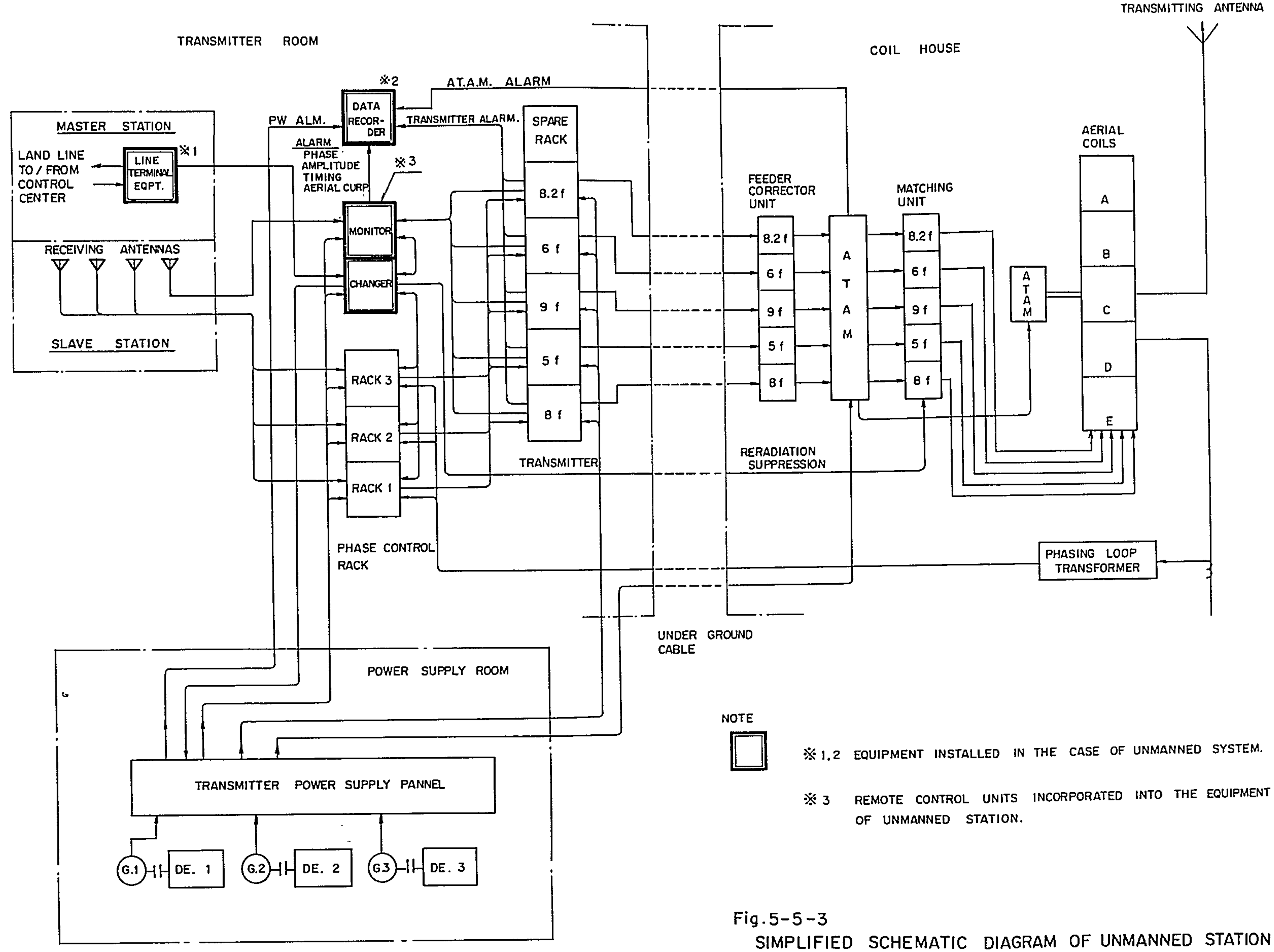
Fig. 5-5-1 Transmission Signals for Remote Monitoring & Control SysteM



▒	control/report	coded sequences (120mS bits)
▭	report	
▨	control	

Note:- Timing shown for chain with control centre-master land-line link.

Fig. 5-5-2 Transmission timing for 4-station chain with control centre



NOTE

※1, 2 EQUIPMENT INSTALLED IN THE CASE OF UNMANNED SYSTEM.

※3 REMOTE CONTROL UNITS INCORPORATED INTO THE EQUIPMENT OF UNMANNED STATION.

Fig.5-5-3
SIMPLIFIED SCHEMATIC DIAGRAM OF UNMANNED STATION

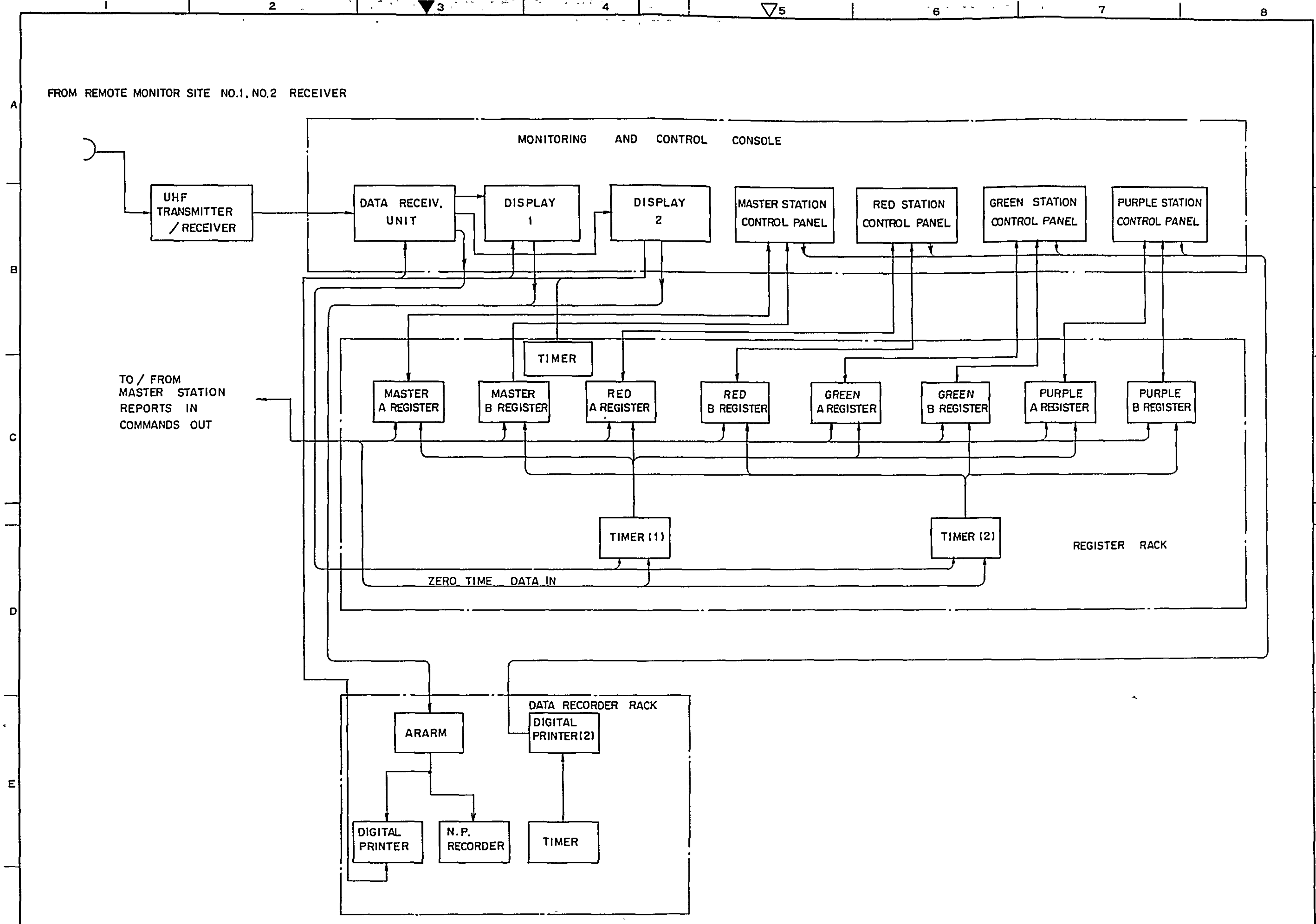


Fig. 5-5-4 SIMPLIFIED SCHEMATIC DIAGRAM OF CONTROL CENTRE

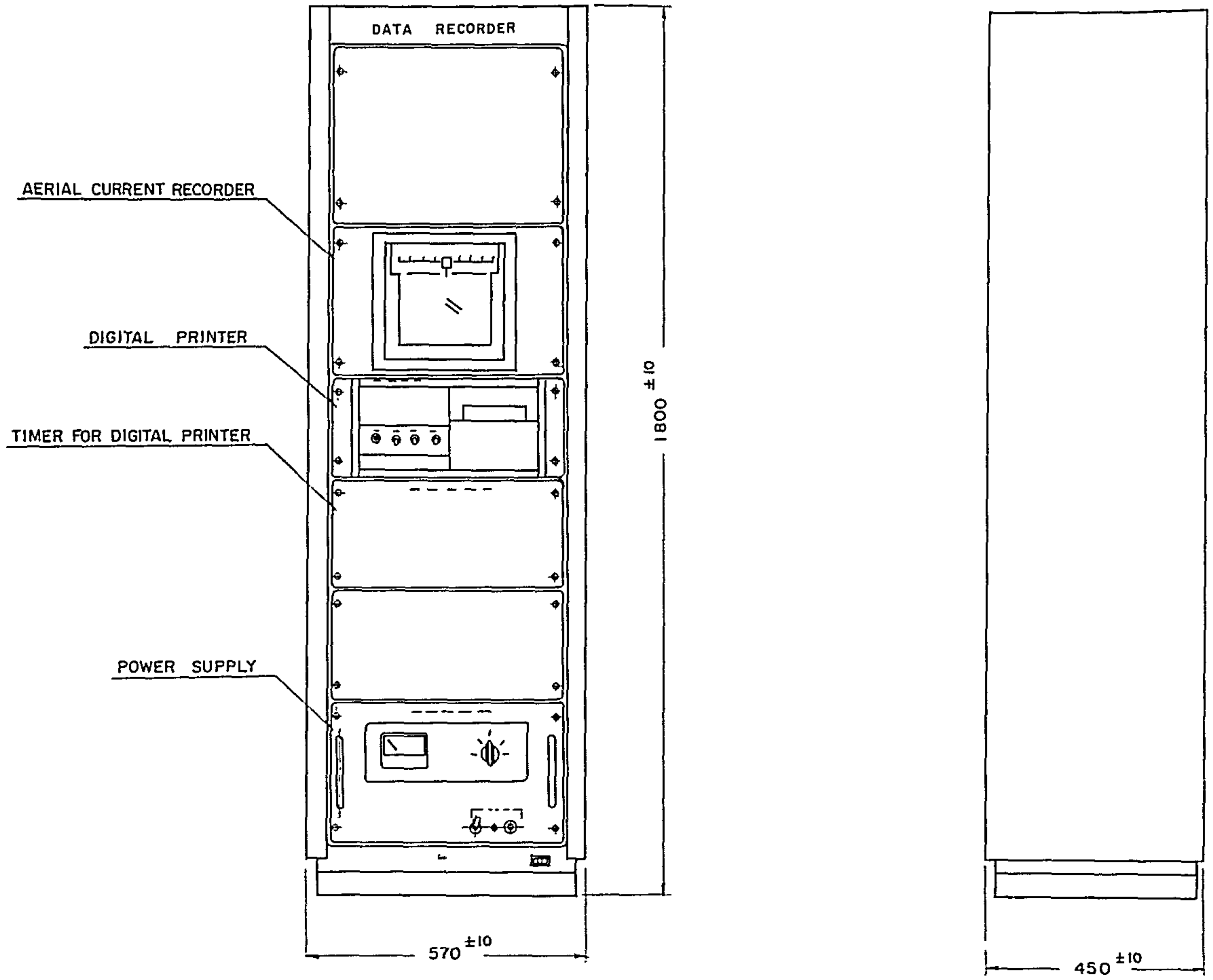


Fig. 5-5-5 DATA RECORDER RACK FOR STATION OUTER VIEW

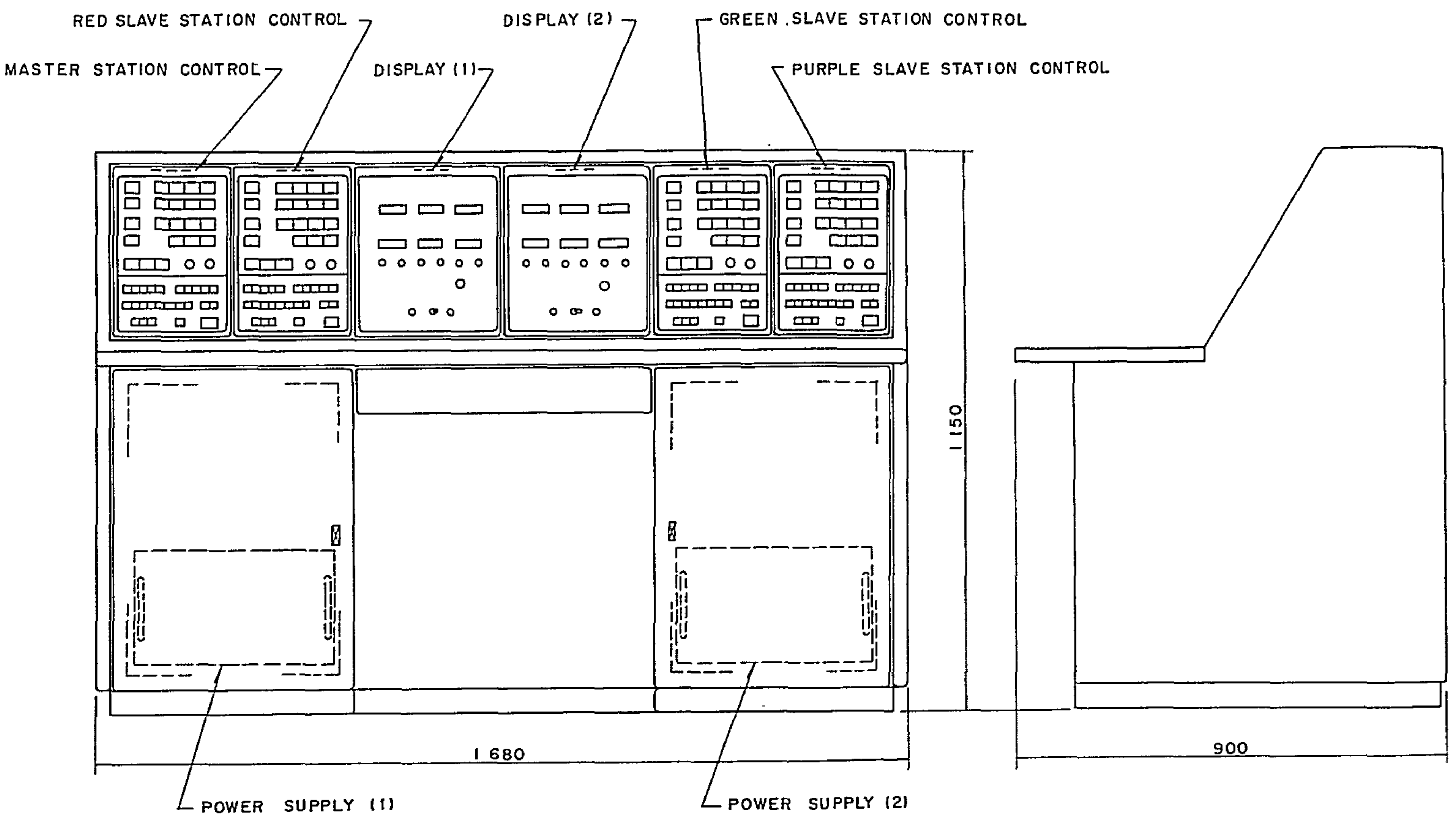


Fig. 5-5-6 MONITOR AND CONTROL CONSOLE OUTER VIEW

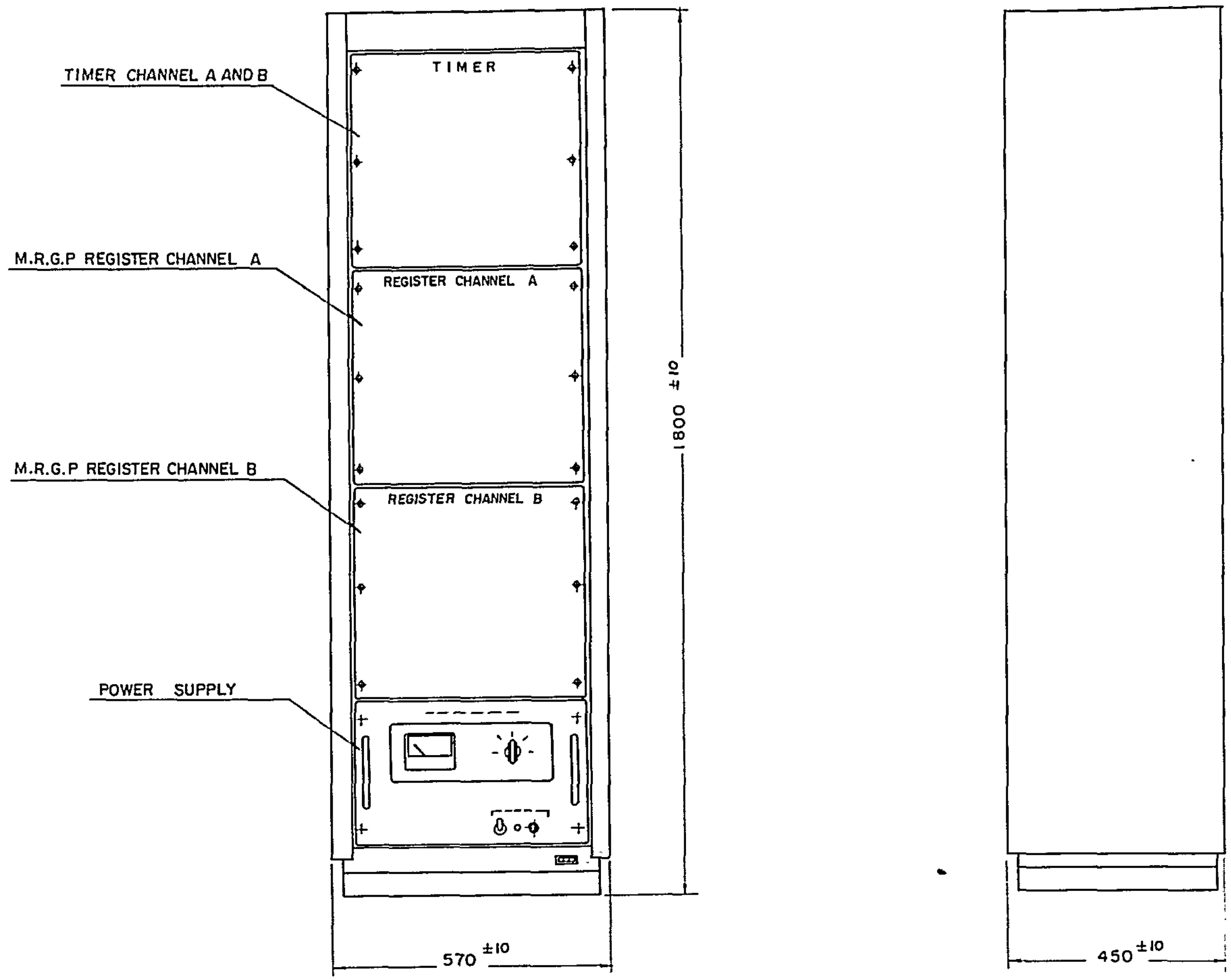


Fig. 5-5-7 REGISTER RACK OUTER VIEW

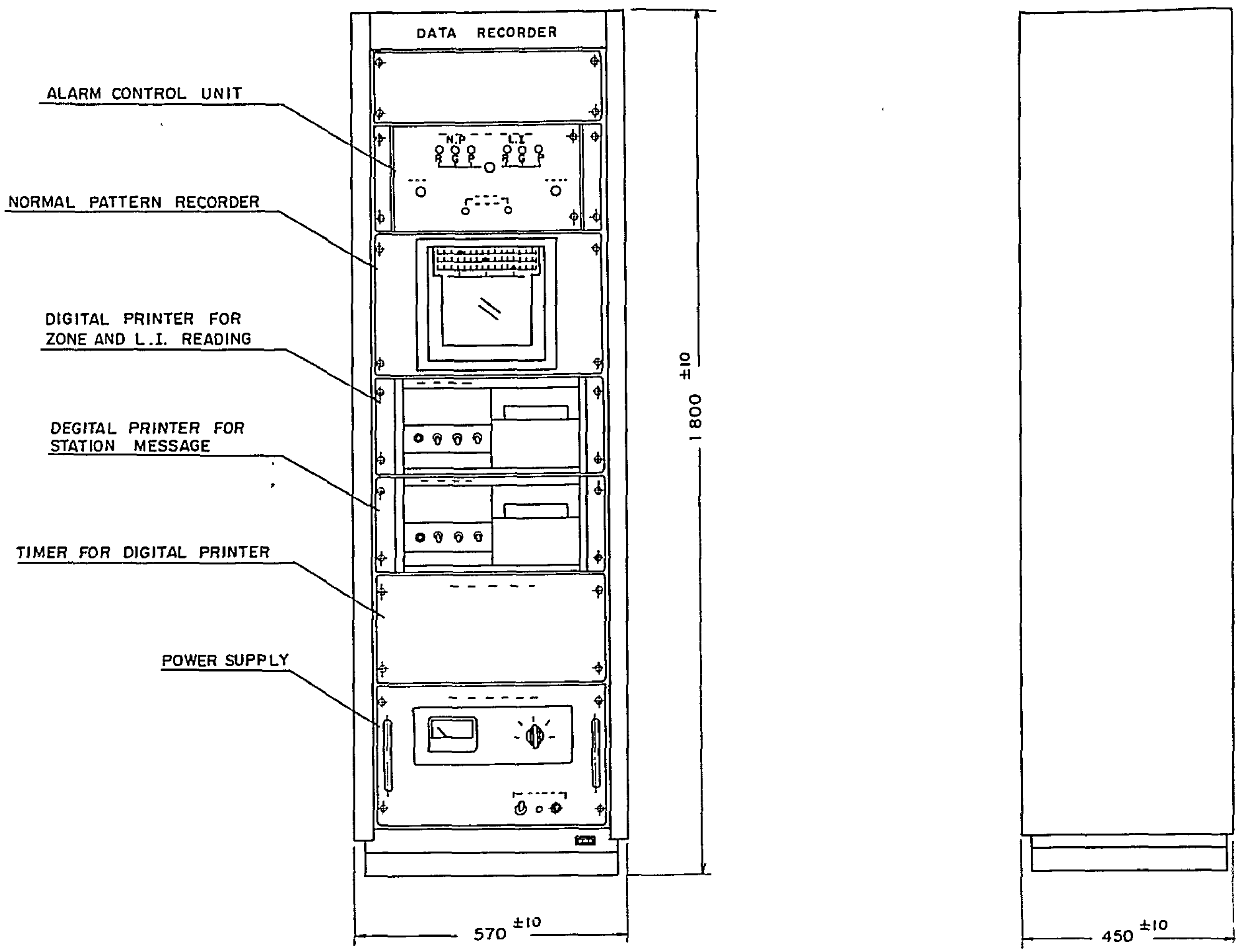
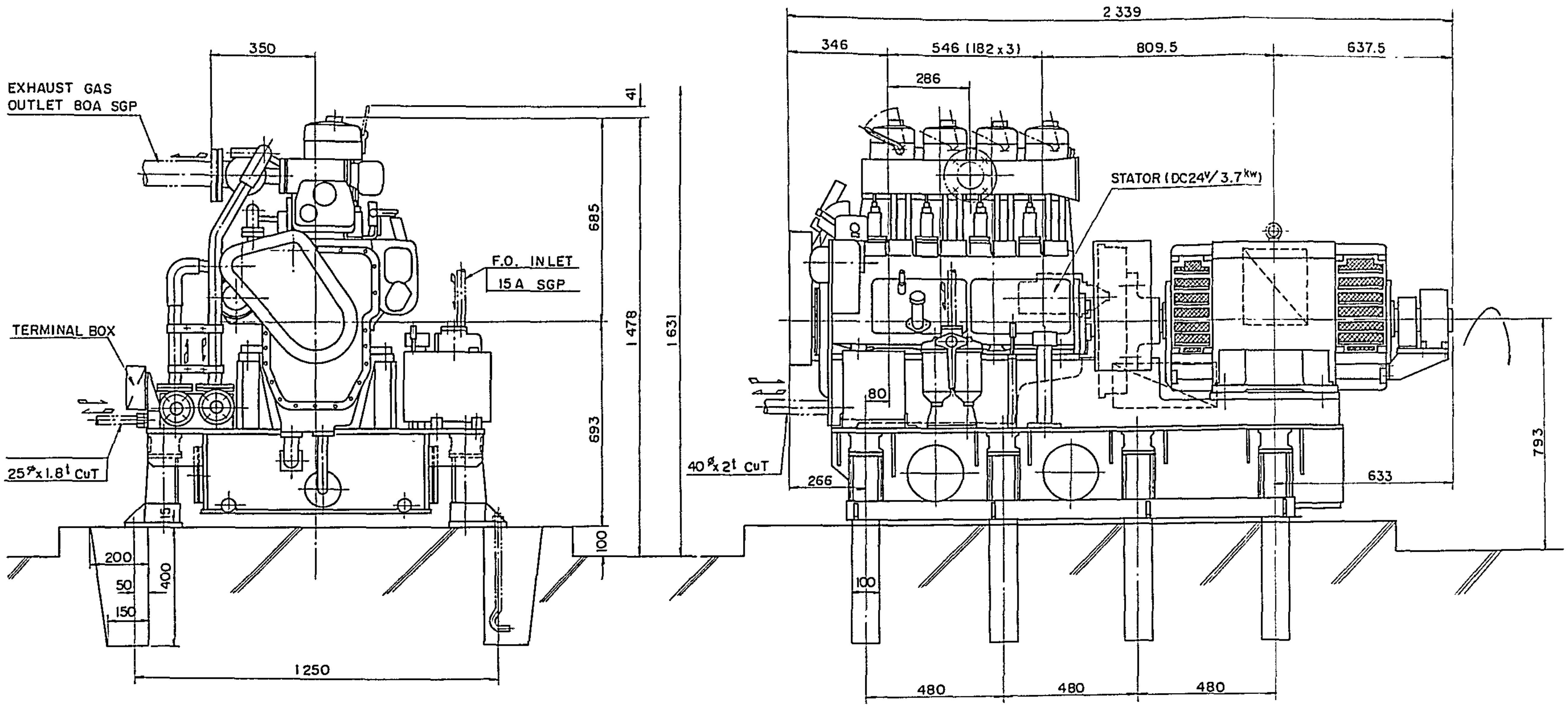
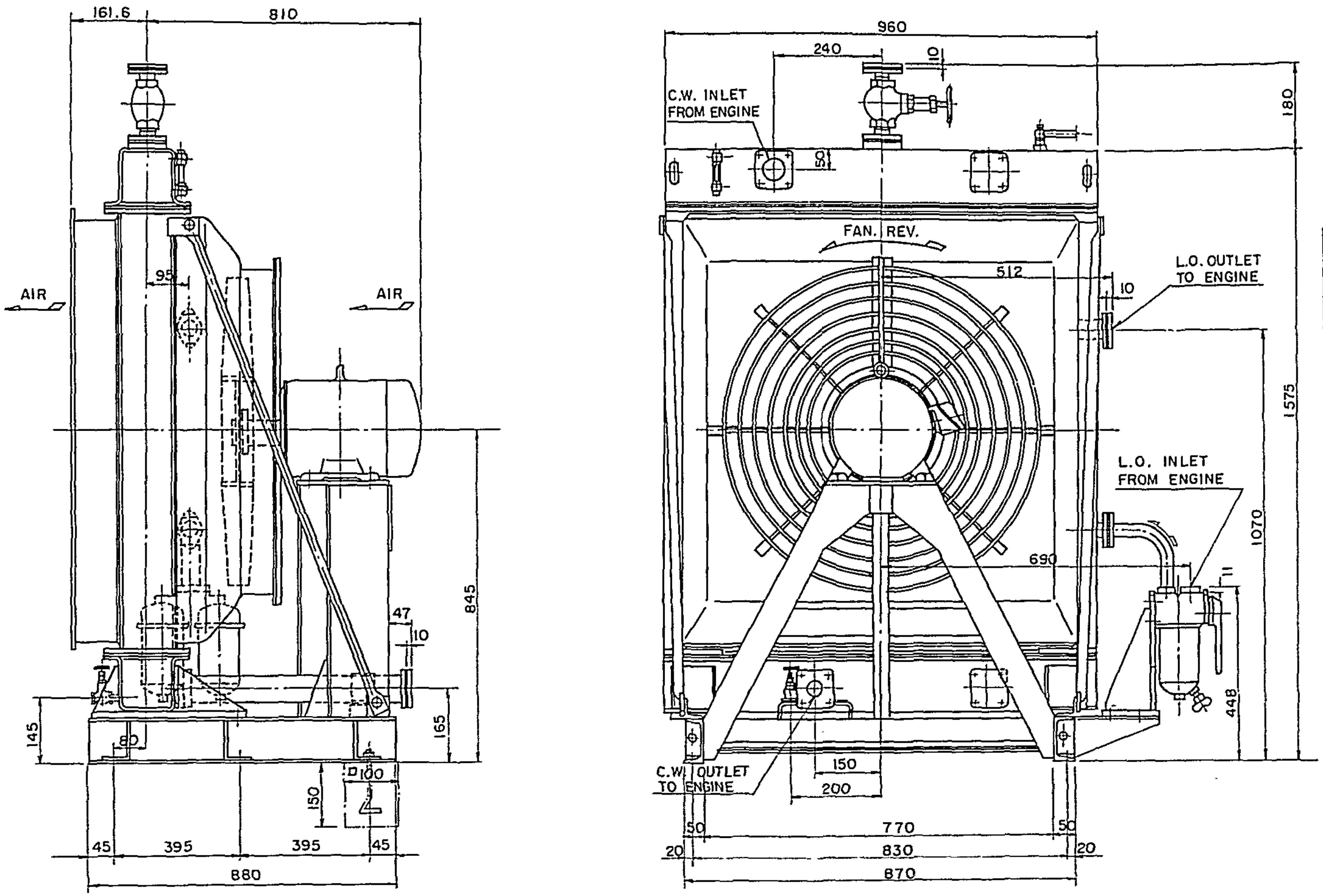


Fig. 5-5-8 DATA RECORDER RACK FOR CONTROL CENTRE OUTER VIEW



DIESEL ENGINE		A.C. GENERATOR	
TYPE	4 – CYCLES	TYPE	SYNCRONUS
NO. OF CYL	4	PHASE	3 ø
BORE	130 m/m	VOLTAGE	200 V
STROKE	140 m/m	CURRENT	144 A
REVOLUTION	1 500 r.p.m.	REVOLUTION	1 500 r.p.m.
B.H.P.	72 P.S.	OUT PUT	50 KVA
B.M.E.P.		POWER FACTOR	85 %
MAX. PRESS		CYCLE	50 Hz
PISTON SPEED		NO. OF POLE	4
STARTING	MOTOR	EXCITING	
COOLING	WATER	RATING	CONTINUITY
WEIGHT	850 kg	WEIGHT	470 kg

Fig. 5–5–9A
OUTER VIEW OF ENGINE-GENERATOR FOR UNMANNED DECCA STATION



FAN & MOTOR	
OUTER DIA.	750 ø mm
AIR FLOW RATE	250 m^3/min
REVOLUTION	1 420 RPM.
MOTOR OUT PUT	3.7 KW

Fig. 5-5-9B

RADIATOR FOR 50KVA ENGINE-GENERATOR
USING UNMANED DECCA STATION

5-6 Construction schedule

5-6-1 Introduction

According to the configuration programme shown in Table 5-1, Decca chains will be constructed in consecutive order. A schedule for constructing a Decca chain will be described in the following section 5-6-2 and the whole schedule will be explained in 5-6-3.

5-6-2 Construction schedule for a Decca chain

Table 5-6-1 attached herewith shows a typical schedule for constructing a Decca chain which consists of a master station, three slave stations and a monitor station annexed to the master station. It normally takes two years to complete the construction of a Decca chain, assuming that road construction is completed in 3 months, and its service will be provided in the third year.

Before the construction of the first Decca chain preparation period for execution design, propagation survey and position surrey of the whole chain will be required. Following is an explanation of the important items appearing in the attached table of schedule.

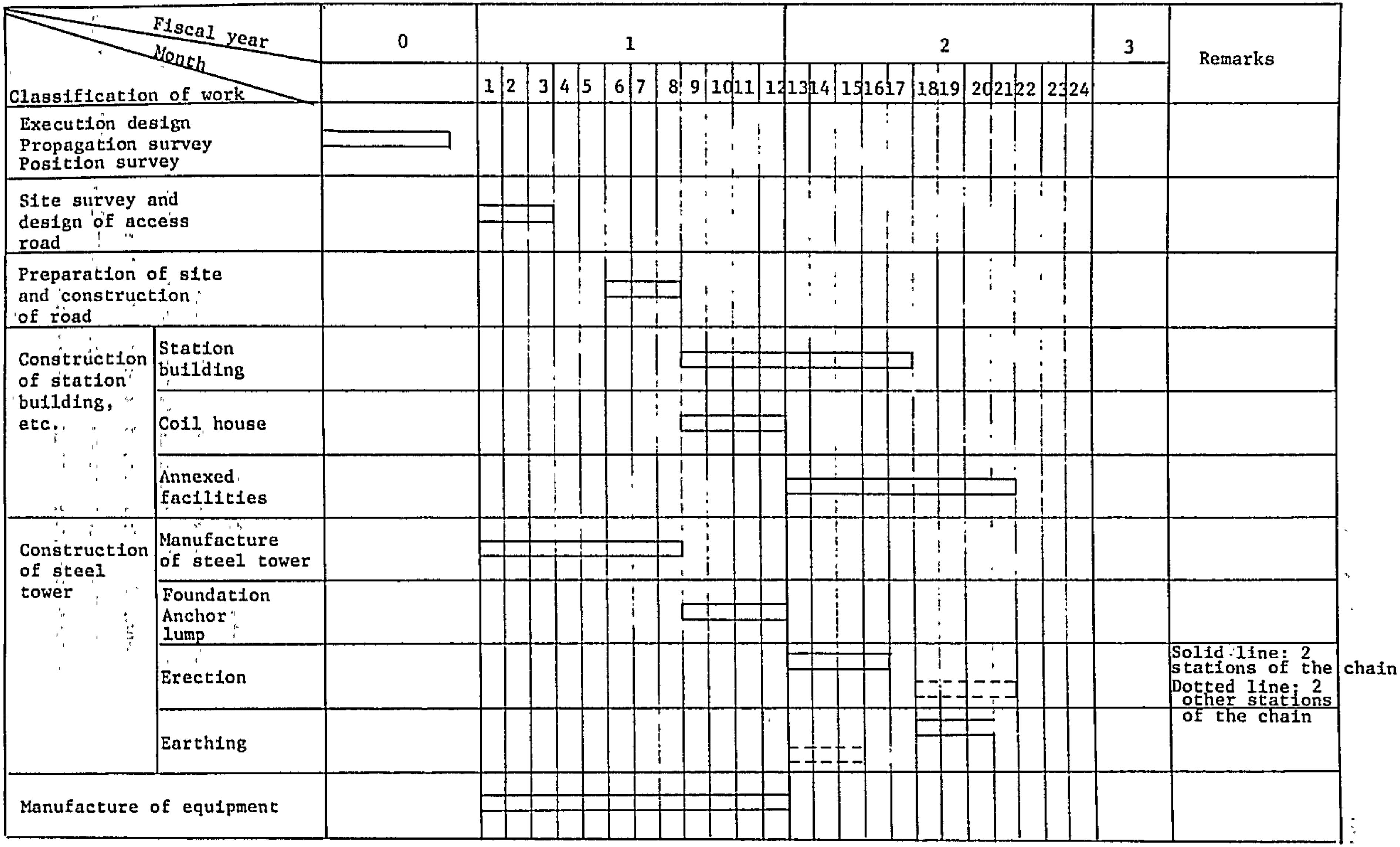
(1) Execution design

Prior to the construction of a Decca station, it is essential to prepare detailed design needed for the execution of construction work for the station building, steel tower and other facilities, and contract preparations on the basis of such design. The design is made common to all the stations of a chain.

(2) Site survey and design of access road

Survey of each station site and for the construction of a road (and in some cases a pier also) should be carried out and execution drawings for the construction work should be prepared. The period required for this work varies with local conditions of each site, but normally it takes three months including field and desk work.

Table 5-6-1 Typical schedule for construction of Decca chains



Installation and adjustment				Solid line: 2 stations of the chain Dotted line: 2 other stations of the chain
Training				
Preparation of charts				
Commissioning			→	

The nature of ground of each site should also be examined and, if necessary, detailed soil investigation should be carried out. During the two months following such survey all sorts of contract for construction should be prepared.

(3) Preparation of site and construction of road

According to the results of the previous survey, levelling of the ground is easy at each site. However, there is a big difference in the situation of the sites in regard to an approach to them from the arterial road or the sea. At some sites the existing road is available for immediate use by vehicle traffic while at other sites a pier should be newly built for unloading equipment and materials for construction work. This situation is described in detail in the results of survey by each site. (5-2-2)

In the typical construction schedule appended hereto, the period required for completing the preparations of sites and roads is shown as three months. However, at a site where it is expected to take more than three months for such preparations, work should be commenced well ahead so that the preparations may be completed within the scheduled period.

(4) Construction of station building, etc.

The construction of the station building and coil house should follow the completion of the access road and is estimated to be completed in nine months, i.e. they will be completed before the 18th month of the schedule when the installation of transmitting equipment is commenced. The construction of the coil house must not be carried out at the time of erection of the aerial tower. The annexed facilities such as oil tanks, outside drain, etc. which are not related directly to the equipment installations, may be completed by the end of the 21st month of the schedule.

(5) Construction of aerial system

In constructing a Decca transmitting aerial, the following points should be borne in mind:

1) Manufacturing of steel tower and accessory materials

The steel tower materials are the tower elements, wire ropes for guys, insulators and metal fittings and anchor metal fixtures. It will take eight months in total to prepare manufacturing design, to procure materials, to manufacture and to conduct inspection.

2) Construction of foundation and anchor lumps

Four months are required for this constrction including piling work. This period could be reduced by about 20 days at a site where the soil conditions are good.

3) Earthing

A period of three months is estimated for earthing work, though it depends on man-power and soil condition. The earthing system is 120 radial wires of 120 metres in length and buried 30 cm under the ground. The work should not concur the timing of the tower erection.

4) Erection of steel tower

Four months of field work are required for the erection of the tower and the extension of the umbrella-type radial and cage wires. It would be best to organise two groups of the workers, each to take care of two of the four stations in consideration of constrction schedule and the effective use of the construction workers and equipment, since the scale of the transmitting tower is big as compared with that of others such as receiving aerials.

(6) Manufacture of equipment

A total of twelve months is required in completing the manufacture of electronic equipment; the three months are for designing, five months for procuring necessary materials and parts, three months for assembling and another month for adjusting and inspection. The power supply equipments can be completed in eight months, but one set of the power supply equipments must be completed in time for the adjustment of Decca transmitting equipment at the factory.

(7) Installation and adjustment

A total of three months is required for the installation and adjustment, which include the power supply equipment, Decca transmitting equipment and communications equipment. After the completion of installation and adjustment of each station, the overall adjustment of the system should be performed simultaneously for the four stations.

(8) Preparation of charts

A period of approximately a year is required in the preparation of Decca charts, assuming that the position of transmitting aerials are already fixed.

In the area where geodetic nets are well furnished, it would be sufficient to fix the position of a Decca station by the triangular survey, but in the area where such nets are not well furnished or in the case where stations are situated in the area of different Datum, survey using satellites should be necessary.

5-6-3 Whole schedule for Decca chains

Table 5-6-2 appended hereto lists the whole schedule for Decca chains. Chains should be constructed in the order of priority, taking into consideration the amount of fund and the number of engineers available.

Table 5-6-2 Whole schedule for Decca chains

Area	Name of chain \ Fiscal year	0	1	2	3	4	Remarks
Malacca/ Singapore	Singapore						
	Malacca St. North						
	Malacca St. South						

5-7 Construction costs

5-7-1 General

(1) Introduction

The total costs of construction required for this project is 6,831 (million yen) (or thousand US$24,395), which are broken down as shown in Table 5-7-1.

Table 5-7-1 Total costs of construction

Classification		Total	Fund: Foreign fund	Fund: Local fund
Hyperbolic electronic navigation system (Decca system)	A*	Million yen 5,886	Mil.yen 4,482	Mil.yen 1,404
		Thousand US$ 21,021	Th.US$ 16,007	Th.US$ 5,014
	B	600	0	600
		2,142	0	2,142
	Total	6,486	4,482	2,004
		23,163	16,007	7,156
Other electronic navigation systems		345	259	86
		1,232	925	307
Total		Mil.yen 6,831	4,741	2,090
		Th.US$ 24,395	16,932	7,463

* Note A: Expenses required for the construction of facilities (such as transmitter room, engine generator room

and coil house of the station building and various types of aerial) and for the equipments (such as Decca transmitting equipment, communications and power supply equipment), needed directly for operating Decca stations.

B: Expenses required for the construction of facilities and for the equipments (such as office room, hall, etc.) other than those mentioned in A above.

A tentative plan for the personnel billets is shown in the annexed drawing. An estimated cost of construction of billets per station is ¥84,000,000 ($299,000) or ¥113,000,000 ($464,000) in the case of 7 or 10 personnel respectively. The amount required for billets is not included in the total costs of construction as shown in Table 5-7-1.

(2) Terms of calculation of construction cost

1) Calculation has been done as of June 1977.

The calculated sum may be required to be modified depending upon possible delay in the time of commencement of work or extension of the period of the whole project. The sum may also be modified in the event of big fluctuations in the movements of international market.

2) The exchange rates of currencies used in this report are as follows:

US$ 1 = ¥280
RP 1 = ¥0.7
M$ 1 = ¥120
S$ 1 = ¥120

5-7-2 Construction costs of Decca chain

(1) Costs related to whole chain

The costs related to the whole chain are as shown in Table 5-7-2 below.

Table 5-7-2 Costs related to whole chain

	Class	Total	Fund	
			Foreign fund	Local fund
Costs related to whole chain	A	Mil.yen 190	Mil.yen 190	Mil.yen 0
		Th.US$ 680	Th.US$ 680	Th.US$ 0

This is a total sum of the costs related to the fields of work common to all chains or work considered economically advantageous if carried out simultaneously.

1) Radio wave propagation survey

The radio wave propagation survey is conducted to investigate in detail the peculiarity of radio wave propagation and atmospheric noise in the tropical zone, ensure the accuracy in the design and thereby make the Decca system fulfill its function under such conditions.

This survey is conducted at a representative area. An outline of the method of survey is this: Measurement is conducted at the possible sites of slave stations and various points within the coverage of the chain, of the electric field intensity of radio wave transmitted by the transmitting equipment on an experimental scale (consisting of 60m tall umbrella type aerial and 600W output transmitter) installed at the possible site of the master station. The measured field intensity is then analysed to confirm the accuracy of the system, effective area of thd chain, etc.

2) Survey of position

The proposed Decca chains are situated either spreading over the area of different geodetic Datum or in the area where triangular net is not fully furnished, and therefore the position of the aerial is surveyed by utilising satellites. It would be more economical and effective to conduct this survey at one time at all possible sites of the present project.

3) Detailed design cost

This is a cost for consultation relating to the system design such as detailed design of the aerial tower and building, etc., common to all stations.

(2) Construction costs of each chain

The detailed items of construction costs of the Decca Navigator system by each chain are as shown in Table 5-7-3.

(3) Construction costs by each country

The detailed items of constrction costs by each country are as shown in Table 5-7-4.

(4) Constrction costs by each station

The detailed items of construction costs by each station are as shown in Table 5-7-5 from (1) through (4).

Table 5-7-5 (1) and (2) are as for Local fund,
Table 5-7-5 (3) and (4) are as for Foreign fund.

Table 5-7-3 Construction costs of each chain

Name of chain		Total sum	Fund	
			Foreign fund	Local fund
Singapore Strait	A	Mil.yen 1,981	Mil.yen 1,518	Mil.yen 463
		Th.US$ 7,074	Th.US$ 5,421	Th.US$ 1,653
	B	200	0	200
		713	0	713
	Total	2,181	1,518	663
		7,787	5,421	2,366
Malacca Strait South	A	1,990	1,516	474
		7,108	5,415	1,693
	B	200	0	200
		713	0	713
	Total	2,190	1,516	674
		7,821	5,415	2,406
Malacca Strait North	A	1,915	1,447	468
		6,838	5,167	1,671
	B	200	0	200
		713	0	713
	Total	2,115	1,447	668
		7,551	5,167	2,384

Table 5-7-4 Construction costs by each country

Name of country			Total sum	Fund	
				Foreign fund	Local fund
Republic of Indonesia	Singapore Strait	A	Mil.yen 2,989	Mil.yen 2,302	Mil.yen 687
			Mil.RP 4,270	Mil.RP 3,288	Mil.RP 982
	Malacca St.South	B	300	0	300
			428	0	428
	Malacca St.North	Total	Mil.yen 3,289	Mil.yen 2,302	Mil.yen 987
			Mil.RP 4,698	Mil.RP 3,288	Mil.RP 1,410
Malaysia		A	Mil.yen 2,364	Mil.yen 1,766	Mil.yen 598
			Th.M$ 19,702	Th.M$ 14,714	Th.M$ 4,988
		B	250	0	250
			2,081	0	2,081
		Total	Mil.yen 2,614	Mil.yen 1,766	Mil.yen 848
			Th.M$ 21,783	Th.M$ 14,714	Th.M$ 7,069
Republic of Singapore		A	Mil.yen 533	Mil.yen 414	Mil.yen 119
			Th.S$ 4,443	3,449	994
		B	50	0	50
			416	0	416
		Total	583	414	169
			4,859	3,449	1,410

(5) Classification of construction costs

The construction costs are roughly divided into two parts: foreign fund part and local fund part, "foreign fund" refers to fund for the purchase of equipment outside the country and "local fund" refers to the provision of works, buildings, tower construction, etc., which could be conducted within the country siting the project. They are further divided into several sub-parts as follows:

1) Foreign fund part

a) Consulting service

Cost for consulting service required for implementing the present project. This service covers system design including basic design for civil engineering and architecture, preparation of specifications, review of bidding documents, management for the progress of work.

b) Radio wave propagation survey

Cost required for the work described in 5-7-2 (1) 1).

c) Survey of position

Cost required for the work described in 5-7-2 (1) 2).

d) Electronic equipment

Cost required for purchasing Decca transmitting equipment, communications equipment and special installation materials.

e) Power supply equipment

Cost for purchasing no-break power supply equipment, engine generator, etc.

f) Adjustment

Cost for instruction of installation of electronic and power supply equipment and for adjustment for those.

g) Steel tower

Cost for manufacturing steel tower elements and accessory materials for transmitting aerial and costs required for guidance in the erection work.

2) Local fund part

a) Civil engineering and construction

Execution design of civil engineering and architecture in connection with sites and roads, including survey and boring, and construction works.

b) Tower construction

Cost for construction of foundation structure and anchor lamps and erection of transmitting tower and cost for manufacturing and constructing all steel poles.

c) Installation

Cost for installation of electronic equipment and power supply equipment.

d) Commercial power leading-in

Cost for installation of power line for area where commercial power is available.

e) Transport and custody

Cost for domestic transport and storage of all equipment (costs required for transporting equipment to the desired position within the site).

f) Charts

Cost for preparing charts is not estimated.

5-7-3 Contents of construction costs

(1) Table of budget

The table of budget by each station and chain is as shown in Table 5-7-5 (1)～(4)

(2) Calculation is based on following items

1) Costs for manufacturing equipment

The manufacturing costs of the equipment and tower materials in the foreign fund part are calculated on the basis of CIF port in the capital city (or port nearest to the capital city).

2) Costs for civil engineering work

Civil engineering works such as construction of roads and piers and construction of station buildings are carried out by local fund.

3) Installation and adjustment

a) Installation of electronic equipment and power supply equipment is carried out under the guidance of engineers from the manufactures of such equipment with local fund. The expenses for the adjustment of the equipment which follows the installation are covered by foreign fund.

b) The expenses required for the erection of the transmitting steel tower are covered by local fund, but in order to solve possible problems in the erecting work, the estimates include guidance by engineers with foreign fund.

4) Cost for purchasing lots of land

Costs required for purchase of lots for site and roads (local fund) are not included in the present estimates.

5) Extra costs

Extra costs to cover increase in construction costs due to modifications of original plan or rise in commodity prices are not included in the estimates.

6) Other costs

a) Monthly pays and other expenses for travelling, communications, consumption goods for Government personnel exclusively engaged in planning and administration of this project are not included in the estimates.

b) It has been estimated that the existing building would be available for use as monitor station, but the costs for the equipment and aerial of the monitor station are included in the estimates.

Construction cost by station (Local fund) (Unit: Thousand yen)

Name of chain	Name of station	Pier and road	Station work	Station admin	Steel tower	Instal-lation	Power lead-in	Transport or custody	Site survey and design	Station total	Chain total
Singapore Strait	P. Tekong	3,420	56,656	49,949	31,651	19,432	0	3,167	5,000	169,275	
	Rimba Terjan	6,813	55,536	49,949	28,651	15,111	11,000	2,111	5,000	174,171	
	P. Mas	2,836	56,656	49,949	31,651	16,130	0	2,111	5,000	164,333	
	Teluk Dalam	0	56,656	49,949	28,651	12,699	0	2,111	5,000	155,066	
	Total	13,069	225,504	199,796	120,604	63,372	11,000	9,500	20,000		662,845
Malacca St. South	Sungai Aiam	5,840	56,656	49,949	28,651	19,509	0	3,167	5,000	168,772	
	Selat Panjang	5,686	56,656	49,949	31,651	12,699	0	2,111	5,000	163,752	
	Bukit Kangkan	8,759	55,536	49,949	28,651	15,111	10,000	2,111	5,000	175,117	
	Tg. Punak	8,190	56,656	49,949	31,651	12,699	0	2,111	5,000	166,256	
	Total	28,475	225,504	199,796	120,604	60,018	10,000	9,500	20,000		673,897
Malacca St. North	Morib	0	55,536	49,949	28,651	18,490	1,500	3,167	5,000	162,293	
	Ujong Parmatang	0	55,536	49,949	28,651	11,680	15,000	2,111	5,000	167,927	
	Sinaboi	7,216	56,656	49,949	31,651	16,130	0	2,111	5,000	168,713	
	Batu Tengah	3,406	55,536	49,949	28,651	11,680	12,500	2,111	5,000	168,833	
	Total	10,627	223,264	199,796	117,604	57,980	29,000	9,500	20,000		667,766
	Total by each item	142,229	1,297,488	1,148,827	710,973	346,417	50,000	54,889	115,000	Grand total	3,865,823

5-7-5 (2)

Construction cost by station (Local fund) (Unit: Thousand US dollars)

Name of chain	Name of station	Pier and road	Station work	Station admin	Steel tower	Instal-lation	Power lead-in	Transport or custody	Site survey and design	Station total	Chain total
Singapore Strait	P. Tekong	12.2	202.3	178.3	113.0	69.4	0	11.3	17.9	604.4	
	Rimba Terjan	24.3	198.3	178.3	102.3	53.9	39.2	7.5	17.9	621.7	
	P. Mas	10.1	202.3	178.3	113.0	57.6	0	7.5	17.9	586.7	
	Teluk Dalam	0	202.3	178.3	102.3	45.3	0	7.5	17.9	553.6	
	Total	46.6	805.2	713.2	430.6	226.2	39.2	33.8	71.6		2,366.4
Malacca St. South	Sungai Aiam	20.8	202.3	178.3	102.3	69.6	0	11.3	17.9	602.5	
	Selat Panjang	20.3	202.3	178.3	113.0	45.3	0	7.5	17.9	584.6	
	Bukit Kangkan	31.3	198.3	178.3	102.3	53.9	35.7	7.5	17.9	625.2	
	Tg. Punak	29.2	202.3	178.3	113.0	45.3	0	7.5	17.9	593.5	
	Total	101.6	805.2	713.2	430.6	214.1	35.7	33.8	71.6		2,405.8
Malacca St. North	Morib	0	198.3	178.3	102.3	66.0	5.4	11.3	17.9	579.5	
	Ujong Parmatang	0	198.3	178.3	102.3	41.7	54.0	7.5	17.9	600.0	
	Sinaboi	25.7	202.3	178.3	113.0	57.6	0	7.5	17.9	602.3	
	Batu Tengah	12.1	198.3	178.3	102.3	41.7	44.6	7.5	17.9	602.7	
	Total	37.8	797.2	713.2	419.9	207.0	104.0	33.8	71.6		2,384.5
	Total by each item	507.4	4,632.9	4,100.9	2,538.4	1,222.3	178.9	195.3	411.7	Grand total	13,787.8

Construction cost by station (Foreign fund) (Unit: Thousand yen)

Name of chain	Name of station	Electronic equipment	Power supply equipment	Adjust-ment	Steel tower	Consultant service	Interim total	Interim total of chains	Spare parts	Measurement equipment	Total for station	Total for chain
Singapore Strait	P. Tekong	236,531	73,100	23,418	37,455	8,000	378,504		27,163	8,245	413,912	
	Rimba Terjan	207,503	46,700	20,882	37,455	8,000	320,540		22,020	4,118	346,678	
	P. Mas	209,503	73,100	23,257	37,455	8,000	351,315		24,660	4,101	380,076	
	Teluk Dalam	206,826	73,100	23,179	37,455	8,000	348,560		24,692	4,094	377,346	
	Total	860,363	266,000	90,736	149,820	32,000		1,398,919	98,535	20,558		1,518,012
Malacca St. South	Sungai Aiam	232,971	73,100	23,257	37,455	8,000	374,783		26,807	8,181	409,771	
	Selat Panjang	206,826	73,100	23,179	37,455	8,000	348,560		24,492	4,094	377,146	
	Bukit Kangkan	210,503	46,700	20,822	37,455	8,000	323,480		24,660	4,101	352,241	
	Tg. Punak	206,826	73,100	23,179	37,455	8,000	348,560		24,492	4,094	377,146	
	Total	857,126	266,000	90,437	149,820	32,000		1,395,383	100,451	20,470		1,516,304
Malacca St. North	Morib	229,971	46,700	20,882	37,455	8,000	343,008		24,167	8,181	375,356	
	Ujong Permatang	206,826	46,700	20,804	37,455	8,000	319,785		21,852	4,094	345,731	
	Sinaboi	209,503	73,100	23,257	37,455	8,000	351,315		24,660	4,101	380,076	
	Batu Tengah	206,826	46,700	20,804	37,455	8,000	319,785		21,852	4,094	345,731	
	Total	853,126	213,200	85,747	149,820	32,000		1,333,893	92,531	20,470		1,446,894
	Total	4,944,387	1,549,300	526,473	861,465	184,000		8,065,625	569,698	118,878		8,753,201

5-7-5 (4)

Construction cost by station (Foreign fund) (Unit: Thousand US dollars)

Name of chain	Name of station	Electronic equipment	Power supply equipment	Adjust-ment	Steel tower	Consultant serivce	Interim total	Interim total of chains	Spare parts	Measurement equipment	Total for station	Total for chain
Singapore Strait	P. Tekong	844.7	261.0	83.6	133.7	28,5	1,351,5		97.1	29.4	1,478.0	
	Rimba Terjan	741.0	166.7	74.5	133.7	28.5	1,144.4		78.6	14.7	1,237.7	
	P. Mas	748.2	261.0	83.0	133.7	28.5	1,254.4		88.0	14.6	1,357.0	
	Teluk Dalam	738.6	261.0	82.7	133.7	28.5	1,244.5		88.1	14.6	1,347.2	
	Total	3,072.5	949.7	323.8	534.8	114.0		4,994.8	351.8	73.3		5,419.9
Malacca St. South	Sungai Aiam	832.0	261.0	84.0	133.7	28.5	1,339.2		95.7	29.2	1,464.1	
	Selat Panjang	738.6	261.0	82.7	133.7	28.5	1,244.5		87.4	14.6	1,346.5	
	Bukit Kangkan	751.7	166.7	74.3	133.7	28.5	1,154.9		88.7	14.6	1,258.2	
	Tg. Punak	738.6	261.0	82.7	133.7	28.5	1,244.5		87.4	14.6	1,346.5	
	Total	3,060.9	949.7	323.7	534.8	114.0		4,983.1	359.2	73.0		5,415.3
Malacca St. North	Marib	821.3	166.7	74.5	133.7	28.5	1,224.7		86.3	29.2	1,340.2	
	Ujong Permatang	738.6	166.7	74.3	133.7	28.5	1,141.8		78.0	14.6	1,234.4	
	Sinaboi	748.2	261.0	83.0	133.7	28.5	1,254.4		88.0	14.6	1,357.0	
	Batu Tengah	738.6	166.7	74.3	133.7	28.5	1,141.8		78.0	14.6	1,234.4	
	Total	3,046.7	761.1	306.1	534.8	114.0		4,762.7	330.3	73.0		5,166.0
	Total	17,653.7	5,531.5	1,879.9	3,075.1	655.5		28,795.7	2,034.2	424.0		31,253.9

5-7-4. Construction costs of unmanned Decca chain

Construction costs of unmanned Decca chain containes as increase required for unmanned Decca equipments as stated in 5-5, on the other hand, however, due to reduction of slave station building and thereby decrease in power supply capacity, the balance per standard chain compared with a manned Decca chain is as follows:

Reduction: 155 million yen (2,968 thousand US$)

Comparisons of construction costs between manned and unmanned systems are shown in Table 5-7-6 and Table 5-7-7 by station and chain respectively. In addition, due to decrease of 12 in number of personnel per chain in the case of unmanned Decca system, reduction of approximately 180 million yen (642 thousand US$) will be estimated.

Table 5-7-6 Comparison of construction costs per station between manned and unmanned systems

		Manned station A	Unmanned station B	Balance B-A	Remarks
1. Local Fund		Th.yen	Th.yen	Th.yen	
1) Transmitting Building	Master	106,605	106,605	0	
	Slave (3 stations)	319,815 (106,605)	131,733 (43,911)	-188,082	Number in blankets is for a station
	Subtotal	426,420	238,338	-188,082	
Total		426,420	238,338	-188,082	
2. Foreign Fund					
1) Electronic Equipment	Master	236,495	256,995	20,500	Inclusive equipment of Moniter Site and Control Center in case of the unmanned system.
	Slave (3 stations)	620,478 (206,826)	641,778 (213,926)	21,300	
	Subtotal	856,973	898,773	41,800	
2) Power Supply Equipment	Master	73,100	73,100	0	
	Slave (3 stations)	219,300 (73,100)	210,300 (70,100)	-9,000	
	Subtotal	292,400	283,400	-9,000	

Total		1,149,373	1,182,173	32,800	
Grand Total		1,575,793	1,420,511	-155,282	

Note: Costs common to manned and unmanned stations are excluded.

Table 5-7-7 Comparison of construction costs per chain between manned and unmanned systems

Name of chain	Manned station	Unmanned station	Balance
Singapore Straits	Mil.yen 2,181	Mil.yen 2,026	Mil.yen 155
	Th.US$ 7,787	Th.US$ 7,235	Th.US$ 552
Malacca Straits North	2,190	2,035	155
	7,821	7,269	552
Malacca Straits South	2,115	1,960	155
	7,551	6,999	552
Total	Mil.yen 6,486	Mil.yen 6,021	Mil.yen 465
	Th.US$ 23,159	Th.US$ 21,503	Th.US$ 1,656

5-8 Plan to furnish medium wave radio beacons and other systems

5-8-1 Plan to furnish medium wave radio beacons (MWB)

Type of aid	Place	1st. year	2nd. year	Total
		Th.yen	Th.yen	Th.yen
MWB	Pu.Mankai		42,000	42,000
	Total		42,000	42,000

5-8-2 Plan to furnish Ramark

Type of aid	Place	1st.year	2nd.year	Total
		Th.yen	Th.yen	Th.yen
Ramark	One Fathom Bank	41,500		41,500
"	Segenting	55,000		55,000
"	Horsburgh	57,000		57,000
"	Rob Roy Bank		50,100	50,100
"	Medang		57,000	57,000
	Total	153,500	107,100	260,600

5-8-3 Plan to furnish radarbeacons

Type of aid	Place	1st.year	2nd.year	Total
		Th.yen	Th.yen	Th.yen
Radarbeacon	Takong	42,200		42,200

Chapter 6

Visual Aids to Navigation

Chapter 6 Visual Aids to Navigation

6-1 Roles of Visual Aids

Visual aids to navigation are marks or signals artificially set up to ensure the safety of navigation and promote the operational efficiency of vessels, along with charts and sailing directions.

Roughly, a visual aid to navigation is required to satisfy following demands:

(1) to ensure safety navigation -

A visual aid indicates an obstacle, a traffic route, a remarkable point, etc., neccessary to keep safety navigation and prevents marine accidents and ocean contamination.

(2) to improve navigational efficiency -

A visual aid enables vessels to pass through a new route, a shorter route and the entrance of a port at night.

(3) to support the ocean development -

A visual aid enables mariners to find their accurate positions in the ocean researches for a development of the ocean and the fishery resources.

(4) to stimulate related industries -

The combination of various fields of industry is necessary in establishing, operating and maintaining aids to navigation, and this leads to a furtherance effect on steel, civil and electronic engineering.

6-2 Malacca/Singapore Straits

6-2-1 Outline of the straits

The Malacca/Singapore Straits provides the shortest route from Europe and India to the direction of the South China Sea and the Far East. There are such big ports of foreign trade as Penang, Klang, Singapore, Belawan and Dumai along the straits. Each of the straits is on an important position of the shipping traffic between the East and the West.

The depth of water is sufficient throughout the straits for the navigation of large vessels. The channel normally used by navigating vessels deviates at Malacca Strait to the northern side. The channel branches out into the Main Strait and Phillip Channel in the vicinity of Singapore.

Shallow waters extend to the north coast of Sumatra Island. There are good fishing grounds, and the bottom of this sea area consists of sand waves of 5 to 10 metres high and the tidal current here, both northwest and southeast current, seldom exceeds two knots.

There are many fishing stakes on the both sides of Malacca Strait. There are also set nets made of trees and twigs at the bank at the depth of 6 to 10 metres in the neighbourhood of the estuary.

These set nets serve as land marks to distinguish the estuary, but their positions change quite often, making navigation along the coast at night dangerous.

There are not many storms, but during April through November squalls named "Sumatras" hit this area with sudden gust of 20 metres per second blowing and heavy rain falling for an hour to four hours continuously. In July and August such squalls strike the area six or seven times a month and visibility becomes less than a few hundred metres.

6-2-2 Present state of visual aids

The lighthouses built on the critical cape on the west coast of the Malay Peninsula has long been well furnished and is giving its functions into full play, but the one that has been built in the vicinity of the estuary for the primary purpose of aiding vessels in entering and leaving the port, has too short to be detected from the offing.

In Singapore Strait there are various types of visual aids; the aids to assit vessels in the approaches to port and harbour, the leading marks to show fairways and anchorages, the coastal lighthouses to make mariners in the offing take a compass bearing, and the light buoys to indicate shoals. Almost all of these visual aids are on the north side of the strait, and when viewed at night from the offing of the Port of Singapore, they are hard to be distinguished from lights in the background industrial zone and cities.

Near the east coast of Sumatra long shelving bottom extends, and there are few ports in this area. Most of the visual aids here are light beacons or light buoys to show shoals and reefs.

Generally, the light buoys in this area very often change their prescribed positions or turn their lights off due to strong tidal currents, inclined sea bottoms, or collisions by vessels.

It is said that insufficient maintenance and repair work on those buoys make these aids less reliable.

When the traffic separation scheme is established in the near future, a sufficient number of aids to navigation should be placed mostly in the vicinity of One Fathom Bank, Singapore Strait and Horsburgh. The potential coastal aids will be utilized fully by vessels in these traffic routes.

6-2-3 Plan for establishment of visual aids

It needs a lot of fund to establish aids to navigation for indicating all obstacles which may cause a hazardous situation and remarkable points which assist in vessel positioning by two optical bearings.

Moreover, some problems may exist in maintaining the facilities.

Therefore, site selection must be made for the most indispensable in view of navigation.

The recommendable places for visual aids to be newly established or improved are as follows:

The numerical order means the priority, the scales described are referred to the standard designs for each site. It is necessary, however, to conduct detailed execution survey before implementing the plan.

(1) Tg. Piai (01° 16' N, 103° 31' E)

The southern most end of the Asian continent and the west entrance to Singapore Strait.

It also stands the junction of Phillip Channel and the Main Strait. There are many fishing stakes in the offing. The shore is thickly grown with mangroves. The sea bed up to about 180 metres off from the end of the mangroves dries up at the low tide. A light beacon (LB-1) having visible range of approximately 12 n.m., with a set of the radar reflectors, should be newly installed.

(2) Tg. Babi (01° 12' N, 104° 06' E)

On the south side of Singapore Strait where Batan Island and Bintan Island locate, there are few aids to navigation. The cape Tg. Babi stands near the entrance to Riouw Strait for which an aid should be newly installed. It is proposed to establish a lighthouse (LF-1) having a visible range of approximately 20 n.m. since this cape is in the middle point between Horsburgh and Raffles lighthouses. The Nongsa River runs approximately 300 metres west of the cape. The depth of water at the estuary is about 0.5 metres and there is a village named Nongsa in the neighbourhood.

(3) Pyramid Shoal (02° 27' N, 101° 30' E)

This is a sand patch at the depth of 3.6 metres and locates in the middle of Malacca Strait, the north side of which is the traffic route. Approximately 10 n.m. southeast to this sand patch, a deep water route runs in the south/north direction, providing a very important turning point for a deep draught vessel. A light beacon (LB-1) having a visible range of about 12 ∿ 15 n.m. with a set of the radar reflectors should be installed here.

(4) Tg. Parit (01° 31' N, 102° 28' E)

The offing of this cape is far away from any of existing aids and in a dark sea area. There is an important port, Dumai, between Medan Island and Bengkalis Island.

A visual aid should be installed to show the entrance of Dumai along with Tg. Medan lighthouse.

Shallow waters extend to the northwest direction of this cape and many fishing boats come in the fishing season. The shore is thickly grown with grass. Muntai Village is in the neighbourhood.

A lighthouse (LF-2) with a visible range of approximately 20 n.m. would meet the requirements.

(5) Tg. Beting Tyamar (Larangan 03° 54' N, 98° 41' E)

It is essential to have a visual aid which could show the entrance of Belawan Port and the anchorage at about 10 n.m. off the shore and which could also be used by vessels navigating in coastal waters.

This cape has a shelving bottom. Even small crafts find the difficulty to approach at the low tide or in rough weather. On land, also an approach road should be constructed. The shore is a sandy beach with palm trees.

There are many fixed fishing stakes between this offing and the entrance to the Bay of Belawan.

A lighthouse (LF-2) with a visible range of about 20 n.m. would satisfy such requirements.

(6) Tg. Gabang (02° 41' N, 101° 29' E)

This cape locates between Port Klang and Port Dickson. No aid to navigation is in the offing and the fairways are in a dark sea area.

Besides, the coast line has a low ground level, which makes the radars on vessels difficult to detect the coastal line.

There are shallows in the offing. A light beacon (LB-1) having a visible range of approximately 12 ∿ 15 n.m. with a set of the radar reflectors should be established.

(7) South Sands (02° 43' N, 101° 03' E)

This is one of the shallows scattered on the south side of the strait. It is a sand patch at the depth of 3.6 metres and very close to the traffic route. Shallows at the depth of less than 10 metres extends to the northwest and southeast directions in parallel with the channel. A light beacon (LB-1) with a set of the radar reflectors and with a visible range of about 15 n.m. should be installed to match the One Fathom Bank light which is situated almost in the northern direction, to indicate the main shoals in the vicinity with its sector.

(8) Southwest of Pu. Pisang (01° 23' N, 103° 08' E)

Situated between Fair Channel Bank and Long Bank, the traffic route runs near the north side of this 9.1 metre shoal. There are many banks in parallel along the route and no aids to navigation.

A light beacon (LB-1) having a visible range of about 15 n.m. with a set of the radar reflectors should be installed.

Functions of Each Aids

Place	Outline of Function	Remarks
Tg. Piai Light beacon	Elevation; 12.5 Metres Light Intensity; 770 cd Visible range; 12 n.m. Sollar battery, small type lantern, LD* type lighting apparatus, Radar reflector	* refer to Fig. 6-5
Tg. Babi Light-house	Elevation; 50 Metres (20 M above G.L.) Light intensity; 5,400 cd Visible range; 19 n.m. Sollar battery, middle type lantern, lighting apparatus.	
Pyramid Shoal Light beacon	Elevation; 12.5 Metres Light intensity; 770 cd Visible range; 12 n.m. Sollar battery, small type lantern, LD type lighting apparatus, Radar reflector	
Tg. Parit Light-house	Elevation; about 70 Metres (40 M above G.L.) Light intensity; 250,000 cd Visible range; 22 n.m. Three engine-generators, middle type lantern, Rotary beacon apparatus	
Tg. Beting Tyamar Light-house	Elevation; 40 Metres Light intensity; 250,000 cd Visible range; 18 n.m. Three engine-generators, middle type lantern, Rotary beacon apparatus.	

Place	Outline of Function	Remarks
Tg. Gabang Light-house	Elevation; 13.5 Metres Light intensity; 3,500 cd Visible range; 12 n.m. Sollar battery, small type lantern, LD type lighting apparatus, Radar reflector	
South Sands Light beacon	Same as Tg. Piai	
S.W. of Pu. Pisang Light beacon	Same as Tg. Piai	

Note:
The visible range is referred to the smaller range in two possible definitions; the geographical range and the optical range.

The optical range is defined as 23 miles in the meteorological visibility and 2×10^{-7} lux in the visible illuminance.

6-2-4 Maintenance of visual aids

The reliability of aids to navigation depends on the quality of operation and maintenance.

It is essential to keep the facilities checked regularly in normal operation and promtly in case any accident.

Therefore, the important unmanned aids should be watched in a real time mode with a method preferable.

Particularly, in Singapore Strait where aids to navigation of the three coastal countries are placed closely one by one, establishment of mutual communication system should be taken into account.

Followings would be proposed as the tentative steps.

(1) to establish a buoy base near Bintang Island and station a large buoy tender in order to serve for the whole area of Singapore Strait.

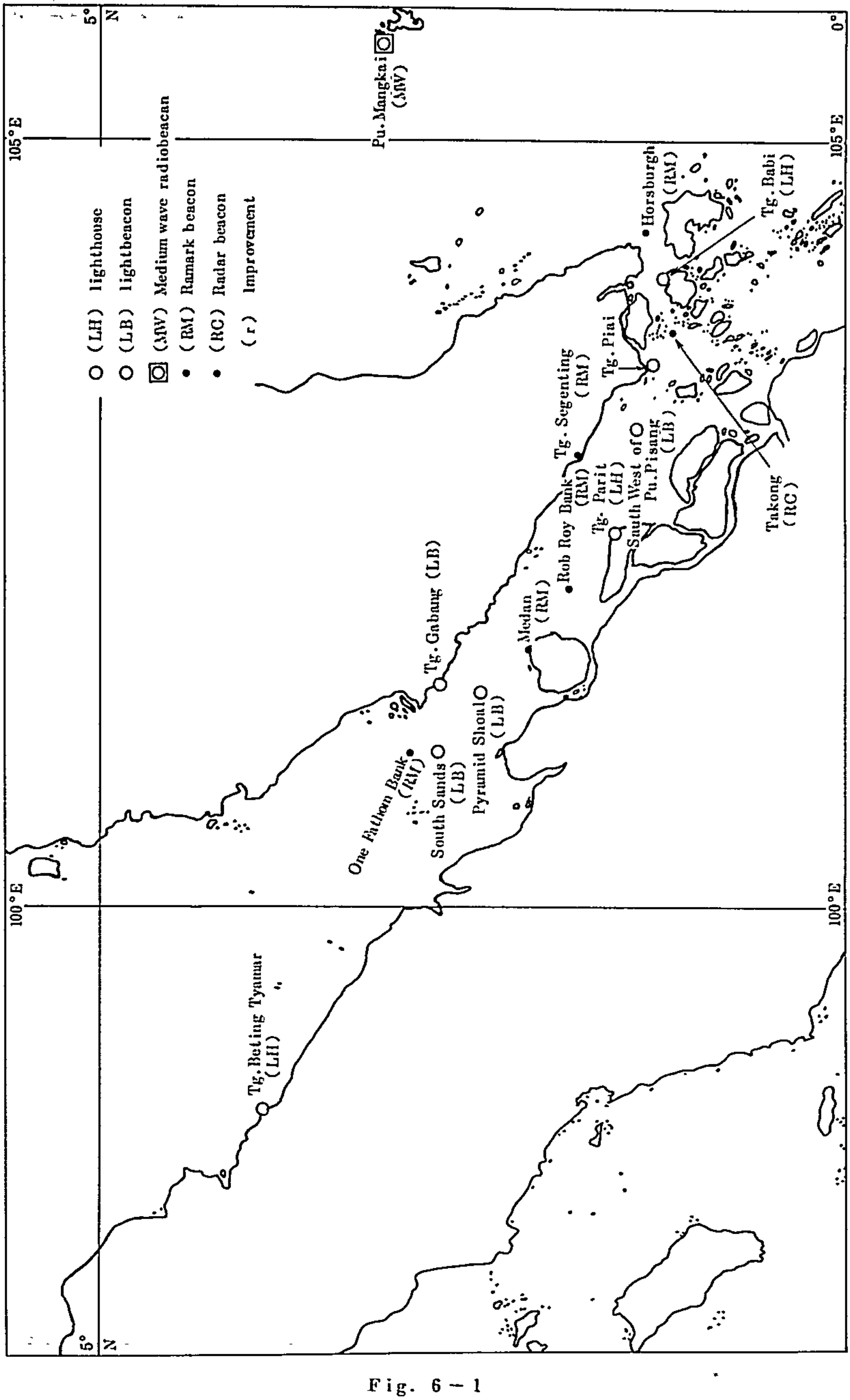
(2) to furnish the communicative capability in manned lighthouses between buoy bases, depots, and/or headquarters.

(3) to stock enough spare parts of equipment.

6-3 Construction costs of visual aids

Construction Costs for Visual Aids

Type of aid	Place	1st year Th. yen	2nd year Th. yen	Total Th. yen
Light beacon	Tg. Piai	62,600		62,600
Lighthouse	Tg. Babi	75,000		75,000
Light beacon	Pyramid Shoal	55,000		55,000
Lighthouse	Tg. Parit	52,500		52,500
Lighthouse	Tg. Beting Tyamar	52,500		52,500
Light beacon	Tg. Gabang		55,000	55,000
Light beacon	South Sands		55,000	55,000
Light beacon	S.W. of Pu. Pisang		60,000	60,000
Total		297,600	170,000	467,000
		Th. US$ 1,063	Th. US$ 607	Th. US$ 1,670



(LH) lighthouse
(LB) lightbeacon
(MW) Medium wave radiobeacan
(RM) Ramark beacon
(RC) Radar beacon
(r) Improvement
105°E
100°E
5°N
0°
Pu. Mangkai (MW)
Horsburgh (RM)
Tg. Babi (LH)
Tg. Piai
Tg. Segenting (RM)
Rob Roy Bank (RM)
Tg. Parit (LH)
South West of Pu. Pisang (LB)
Takong (RC)
Tg. Gabang (LB)
Medan (RM)
Pyramid Shoal (LB)
One Fathom Bank (RM)
South Sands (LB)
Tg. Beting Tyamar (LH)

Fig. 6－1

LANDFALL LIGHTHOUSE (LF-1)

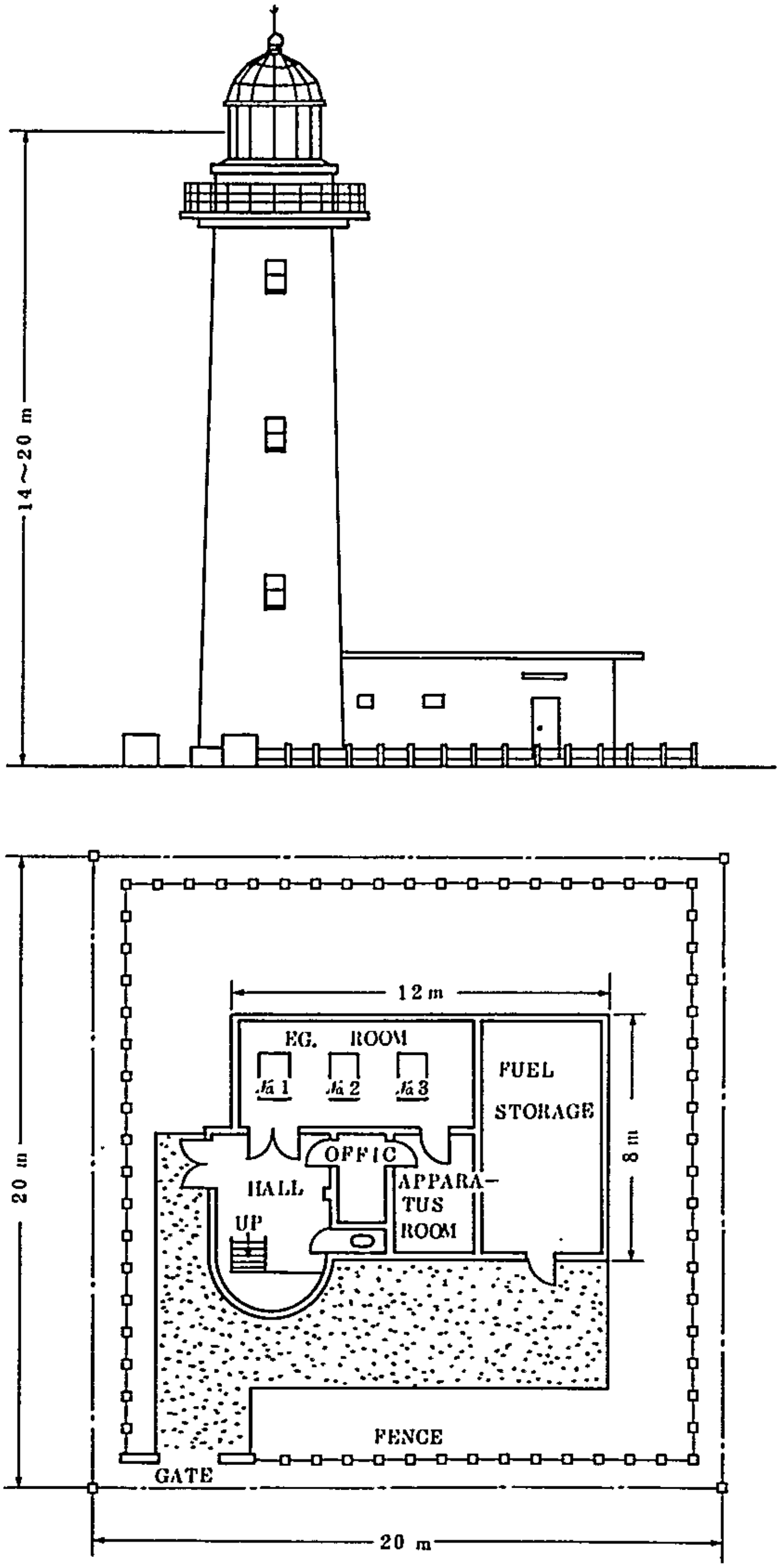


Fig. 6-2

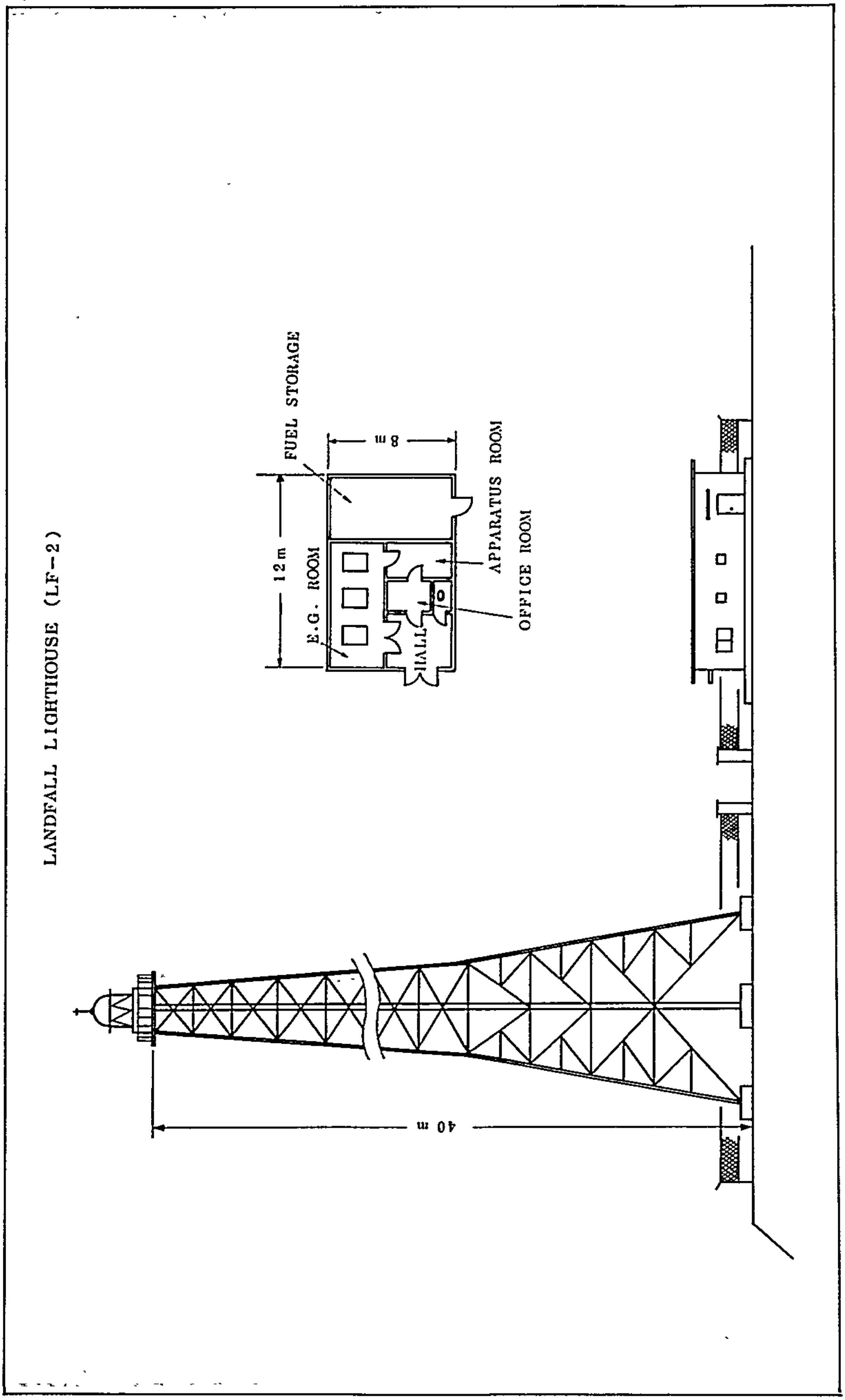

LANDFALL LIGHTHOUSE (LF-2)
FUEL STORAGE
8 m
12 m
E.G. ROOM
HALL
APPARATUS ROOM
OFFICE ROOM
40 m

Fig. 6 — 3

LIGHT BEACON (LB－1)

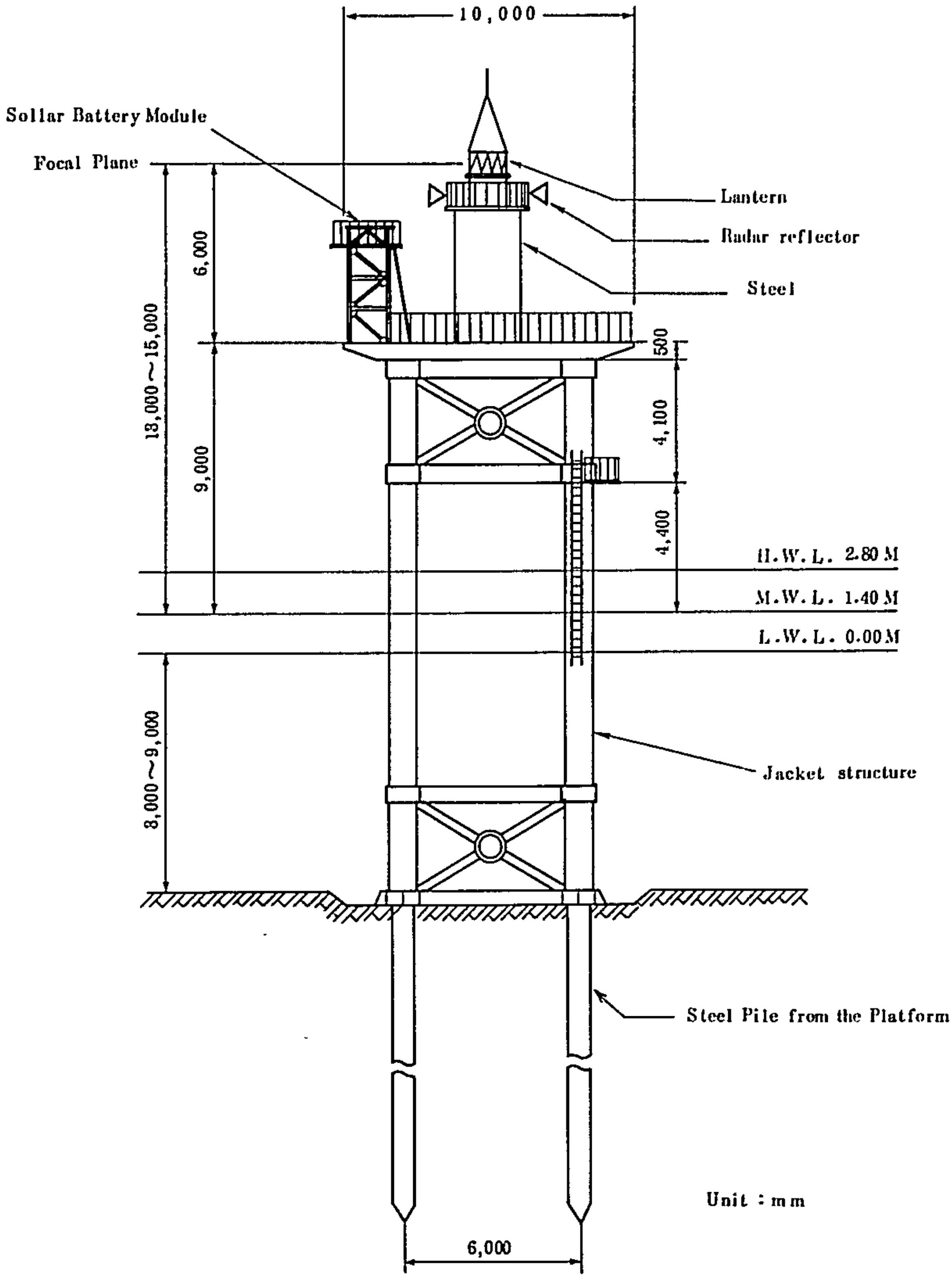
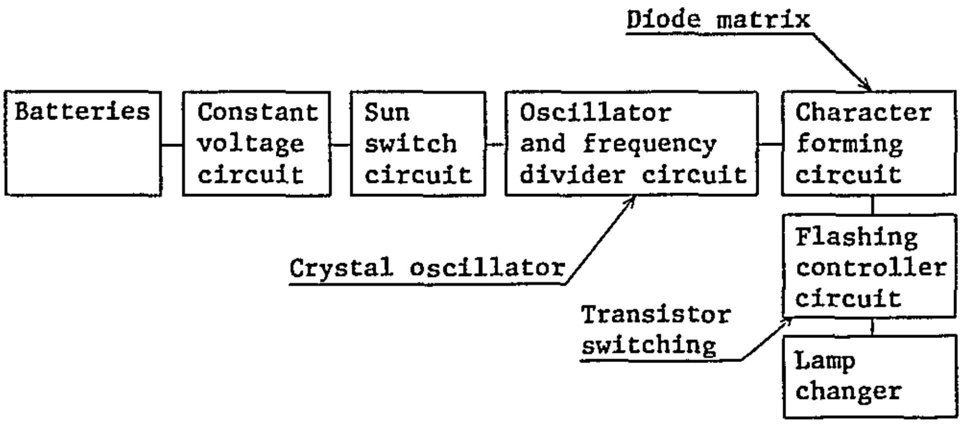


Fig. 6－4

Block diagram of LD type lighting apparatus



Note: LD type lighting apparatus is used for lighted buoys, small lighthouses and light beacons to which commercial electric power cannot be supplied.

Fig. 6-5

Chapter 7

Administration Plan

Chapter 7 Administration plan

Navigation systems are entrusted with an important mission of ensuring the safety of navigation. They must therefore be placed under well administered conditions at all times, so that they may fulfil their functions sufficiently.

In order to enable each system to demonstrate its ability fully, it is first of all essential to give the system good operation and maintenance and to complete arrangements for repairing any troubles to the system at once, and to notify the users of the system of any abnormality in the system. It is also necessary to secure a sufficient number of excellent personnel to maintain the system in good conditions, and furthermore, a continuous effort should be made for the training of personnel.

7-1 Technical agreement

In the case of Decca Navigator system for Malacca/Singapore straits, in particular, the system is spread over the three littoral countries. It would be desirable to have a technical agreement of mutual operation and maintenance concluded among the coutries concerned.

7-2 Personnel plan

In calculating the required number of personnel, it is a general practice to analyse the actual state of the work, labour condition, working setup and organisation, but here in this report calculation has been made of the number of personnel required to man the stations of the navigation systems proposed to be newly established, on the basis of the actual results obtained from the existing stations elsewhere.

Name of system	Unit	Number of personnel
Decca	1 station	10
Medium wave radio beacon	1 station	6
Ramark beacon	1 station	4
Radar beacon	1 station	4
Lighthouse	1 station	5

Note: The numbers of personnel in the above table are those in case that each system was established individually. In this plan, however, Ramark beacon and radar beacon are planned to be attached to lighthouses and just one person has been added and, therefore, 6 persons are planned to operate and maintain a lighthouse and Ramark beacon, etc. No personnel have been summed up for unmanned systems which will be maintained by periodical go-around inspection.

The number of personnel newly required by each year has been tentatively calculated as following Table 7-1:

Table 7-1

Type of system	Name of chain	1st year	2nd year	3rd year	4th year	5th year	Total
Decca	Malacca/ Singapore						
	Singapore			40			40
	Malacca north				40		40
	Malacca south					40	40
Total		0	0	40	40	40	120
Medium wave beacon radio				6			6
Ramark			3	1			4
Radar beacon							
Lighthouse			10	10			20
Total		0	13	17	0	0	30
G. Total		0	13	57	40	40	150

7-3 Personnel training plan

Of the various navigation systems, available today, visual aids to navigation are a system for which the competent authorities of each country have endeavoured to train personnel required to man or take care of such adis. It is advisable to consolidate and expand the existing training courses. for training of personnel is important to ensure satisfactory operation and maintenance of the systems.

For the electronic navigation systems proposed in this report, i.e. Decca Navigator, medium wave radio beacons, Ramark, and radar beacon, a tentative plan to train the required personnel has been made as follows. Trainees should be graduates of the electronic or communication engineering department of a Technical high school or the equivalent, and the training should be given the charactor of "training of instructors", and then the training in future years should be made as autonomous training of the countries concerned.

7-3-1 Overseas training of Decca

A 60-day overseas training has been planned, which includes 30 days (175 hours) in classroom, 10 days (56 hours) at factory, and 20 days (119 hours) at Decca station. The number of trainees in one training course should be 16 and 6 such courses should be conducted.

7-3-2 Overseas training of medium wave radio beacons, Ramark and radar beacon

A 30-day overseas training has been planned which includes 14 days (84 hours) in classroom, 6 days (35 hours) at factory and 10 days (56 hours) at station. 10 trainees at one training course and 3 such courses should be given.

7-3-3 Practical training of Decca

During the first two years of operation at each Decca chain, an expert on the operation and maintenance should be invited to each chain from abroad to give instruction to the personnel.

7-4 Operation, maintenance and other costs

The costs required for the operation, maintenance and training are tentatively calculated as follows:

7-4-1 Operation and maintenance costs

The rough estimates of costs required for the operation and maintenance of each system per year are shown in the Table 7-2. The costs required for the first five years of operation and maintenance are as shown in the attached Table 7-3. All these costs should be defrayed by local fund.

The basis of calculation of these costs per year is as follows:

(1) Salary

The monthly pay for personnel to be assigned for the operation and maintenance at Decca stations, and the medium wave radio beacon stations, Ramark stations, radar beacon station and visual aids to be newly established, has been summed up. Incidentally, the monthly pay for a station master has been tentatively calculated as 120,000 yen and that for a member of a station as an average of 80,000 yen.

(2) Cost to maintain buildings

Cost required for repair of buildings. 300 yen for every square metre.

(3) Cost to maintain roads and piers

Cost required for repair of roads and piers, and calculation has been made as 800 yen for every metre of road and 120,000 yen for every pier.

(4) Cost to maintain lot

Cost required for trimming of lot for station site. It was estimated at 5 yen per square metre.

(5) Cost to maintain aerial and steel tower

Mostly cost required for painting of the steel tower and adjustment of aerial and guy tension and other items. Calculation has been made on the basis of actual results obtained from similar work. In actual cases, these works are not necessarily carried out every year, but cost has been distributed equally to each year.

(6) Cost for repairing equipment and for purchasing spare parts

Cost required for repairing equipment and for purchasing spare parts. Calculation has been made on the basis of actual results obtained from similar cases: Provided that the cost required for purchasing spare parts is not required for about three years, for which period cost of spare parts required has already been summed up in the cost of construction of stations.

(7) Cost for operation of engine generator

This is a cost of fuel for engine generators for power source. Estimates have been made on the basis of 18 yen per litre of light oil and 70 yen per litre of gasoline.

(8) Cost of electric power

Cost of electric commercial power calculated as 15 yen for every kWH.

7-4-2 Cost required for overseas training

Expenses required for overseas trainings are as shown in the attached table 7-4. All these expenses are to be paid by foreign fund.

7-4-3 Cost required for practical training of Decca at the site

The expenses required for stationing foreign technical expert at each Decca chain is as shown in the table 7-5.

Table 7-2 Operation/Maintenance cost per year (Unit: Thousand yen)

	Name of chain	Name of station	Personnel	Building	Road	Pier	Lot	Steel tower	Equipment	Fuel	Power	Parts	Total
Decca	Singapore	P. Tekong	10,080	123	64	120	800	2,073	4,642	11,906	0	7,300	37,108
		Rimba	10,080	123	744	0	800	2,073	4,198	80	9,855	6,800	34,753
		P. Mas	10,080	123	0	120	800	2,073	4,198	11,906	0	6,800	36,100
		Teluk Dalam	10,080	123	0	0	800	2,073	4,198	11,906	0	6,800	35,980
		Total	40,320	492	808	240	3,200	8,292	17,236	35,798	9,855	27,700	143,941
	Malacca St. North	Morib	10,080	123	0	0	800	2,073	4,642	80	9,855	7,300	34,953
		Ujong Parmatang	10,080	123	0	0	800	2,073	4,198	80	9,855	6,800	34,009
		Sinaboi	10,080	123	480	120	800	2,073	4,198	11,906	0	6,800	36,580
		Batu Tengah	10,080	123	368	0	800	2,073	4,198	80	9,855	6,800	34,377
		Total	40,320	492	848	120	3,200	8,292	17,236	12,146	29,565	27,700	139,919
	Malacca St. South	Sungai Aiam	10,080	123	640	0	800	2,073	4,642	11,906	0	7,300	37,564
		Selat Penjang	10,080	123	320	120	800	2,073	4,198	11,906	0	6,800	36,420
		Bukit Kangkar	10,080	123	960	0	800	2,073	4,198	80	9,855	6,800	34,969
		Tg. Punak	10,080	123	104	120	800	2,073	4,198	11,906	0	6,800	36,204
		Total	40,320	492	2,024	240	3,200	8,292	17,236	35,798	9,855	27,700	145,157
		Total	120,960	1,476	3,680	600	9,600	24,876	51,708	83,742	49,275	83,100	429,017

Table 7-3 Operation/Maintenance cost for 5 years

Type of system	1st year	2nd year	3rd year	4th year	5th year	6th year
	Th.yen	Th.yen	Th.yen	Th.yen	Th.yen	Th.yen
Decca Malacca/Singapore Chain	0	0	143,941	283,860	429,017	856,818
Medium wave radio beacon	0	0	6,940	6,940	6,940	20,820
Ramark, radar beacon	0	8,480	12,240	12,240	12,240	45,200
Lighthouse and other aids	0	13,060	14,560	14,560	14,560	56,740
Total	0	21,540	177,681	317,600	462,757	979,578
		Th.US$ 77	Th.US$ 634	Th.US$ 1,134	Th.US$ 1,653	Th.US$ 3,498

Table 7-4 Cost required for training

Classification	First year	2nd year	3rd year	4th year	5th year	6th year	Total
	Th.yen	Th.yen	Th.yen	Th.yen	Th.yen	Th.yen	Th.yen
Decca training	16 people 24,600	16 24,600	16 24,600	16 24,600	16 24,600	16 24,600	96 147,600
Medium wave radio beacons, etc	10 11,700	10 11,700	10 11,700	—	—	—	30
Total	36,300	36,300	36,300	24,600	24,600	24,600	182,700
	Th.US$ 129	Th.US$ 129	Th.US$ 129	Th.US$ 88	Th.US$ 88	Th.US$ 88	Th.US$ 653

Table 7-5 Cost required for practical training of Decca

Name of chain	1st year of operation	2nd year	3rd year	4th year	Total
	Th.yen	Th.yen	Th.yen	Th.yen	Th.yen
Malacca/Singapore					
Singapore Chain	19,750	19,750			39,500
Malacca North Chain		19,750	19,750		39,500
Malacca South Chain			19,750	19,750	39,500
Total	19,750	39,500	39,500	19,750	118,500
	Th.US$ 70	Th.US$ 141	Th.US$ 141	Th.US$ 71	Th.US$ 423