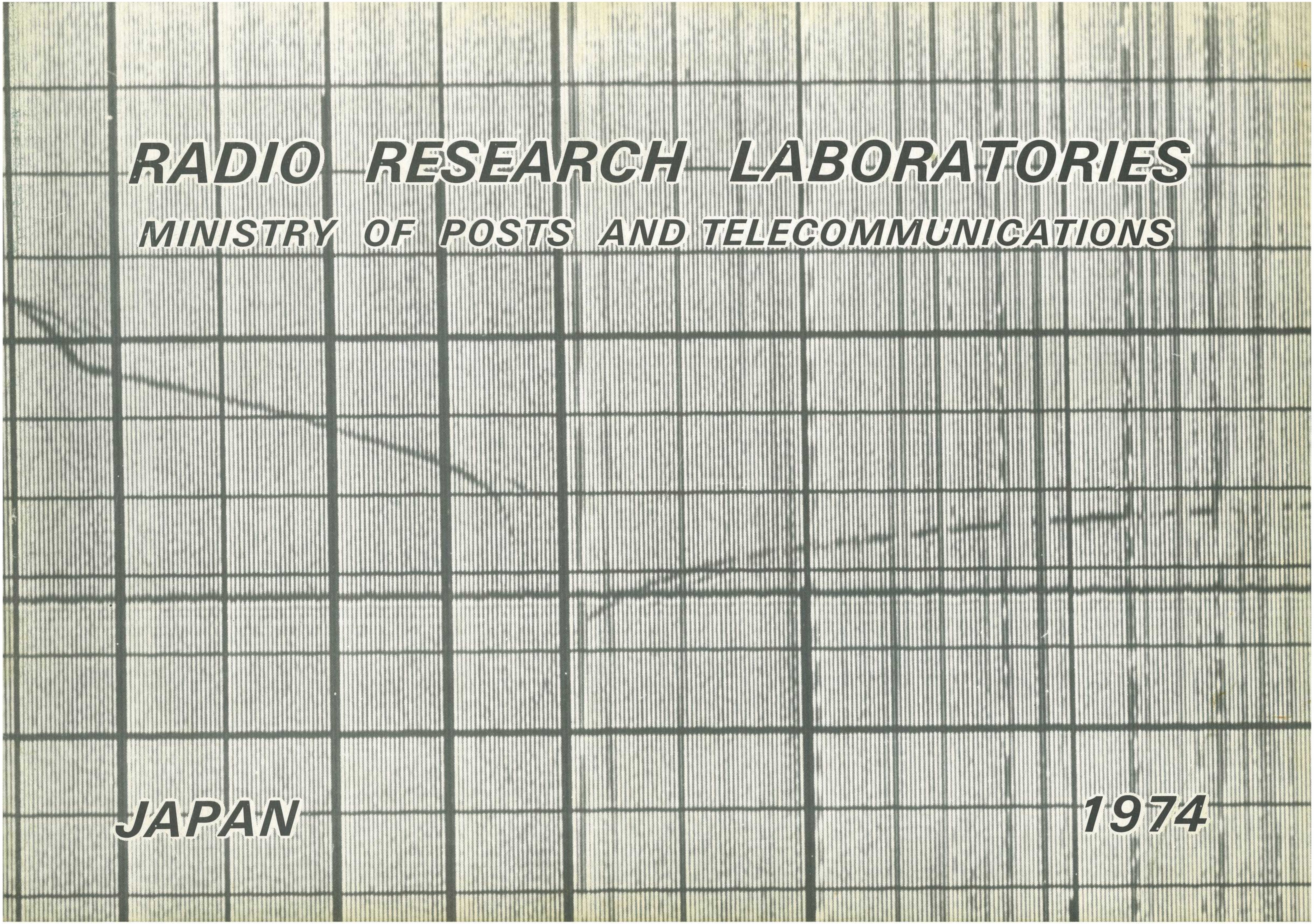


RADIO RESEARCH LABORATORIES

MINISTRY OF POSTS AND TELECOMMUNICATIONS

JAPAN 1974

CONTENTS

DIRECTOR Mr. TERUO ISHIKAWA

PUBLICATIONS AND PERIODICALS

The publications and periodicals issued by the RRL are as follows:

Ionospheric Data in Japan	in English Monthly
Propagation Forecasts	in Japanese Monthly
Journal of the Radio Research Laboratories	in English Bi-monthly
Review of the Radio Research Laboratories	in Japanese Bi-monthly
Catalogue of Data in WDC C2 Center for Ionosphere	in English June, December
Standard Frequency and Time Service Bulletin	in English Annually

OUTLINE OF THE RADIO RESEARCH LABORATORIES

The Radio Research Laboratories (the RRL) came into existence on August 1, 1952, as the only governmental research organization specializing in radio waves in Japan, and as an auxiliary organ attached to the Ministry of Posts and Telecommunications by integration of the Central Radio Wave observatory engaged in researches on the ionosphere and radio propagation, and of two sections of the Radio Regulatory Bureau in charge of the broadcasting service of the standard frequencies, investigation and research in radio technics, and the governmental type approval of radio apparatus and devices.

Ever since several changes have been made, and specially on June 1, 1967, overall reorganization was carried out in order to strengthen the research system for radio physics and technology. The Laboratories are now making good progress in research work in all the aspects of radio waves including experiments of the space communication, information processing, underwater information transmission and the research in apparatus to be mounted on the artificial satellite.

The RRL have their headquarters at Koganei in the suburbs of Tokyo and two branches at Kashima and Hiraiso in Ibaraki prefecture. Throughout the country, there are five regional radio wave observatories at Wakkanai, Akita, Choshi, Yamagawa and Okinawa.

The organization of the RRL is shown in page 3 .

In addition to research work above mentioned, the RRL carry on the following services related not only to radio-communication but also general matters of scientific research or public utility.

(1) Emission of standard frequencies and time signals
(2) URSIGRAM broadcasting
(3) Radio propagation forecast and radio forewarnings
(4) Governmental type approval of radio apparatus and devices
(5) World data center C2 for the ionosphere

The history of sections in charge of respective responsibilities is as follows :

The Physical Institute for Radio Waves, Ministry of Education, the predecessor of the Central Radio Wave Observatory was established in 1942. This establishment was accelerated by the Radio Propagation Research Committee established in the National Research Council of Japan in 1922. In particular, the observation of the ionosphere that began in 1943 is now the work on a world-wide basis. The standard frequency and time signal service, through years of researches made since 1925, officially started at Kemigawa transmitting station and Iwatsuki receiving station, Ministry of Communications, in January, 1940.

The site of this service moved to Koganei, Tokyo in 1949, and up to now rapid improvement bas been made of accuracy.

The work of investigation and research in radio technics originated with research in radiotelegraphy at the Electrotechnical Laboratory, Ministry of Communication, as far back as in 1896. With regard to the type approval of radio apparatus and devices, it first came into force as the result of enactment of the "Convention for the Safety of Life at Sea" and of the Private Radio Telegraph Regulations established in 1915 by the Ministry of Communications in which regulations the standards on radio equipment and apparatus were provided for. In addition the type approval now in force has taken effect since November 1950.

ESTABLISHMENT ········· AUGUST 1. 1952

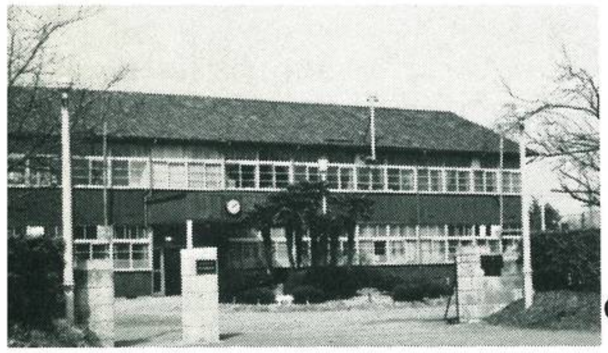
BUDGET ········· APPROXIMATELY 2,000MILLION YEN (1973 FISCAL YEAR)

REGULAR PERSONNEL ········· 449 (AS OF APRIL 1. 1973)

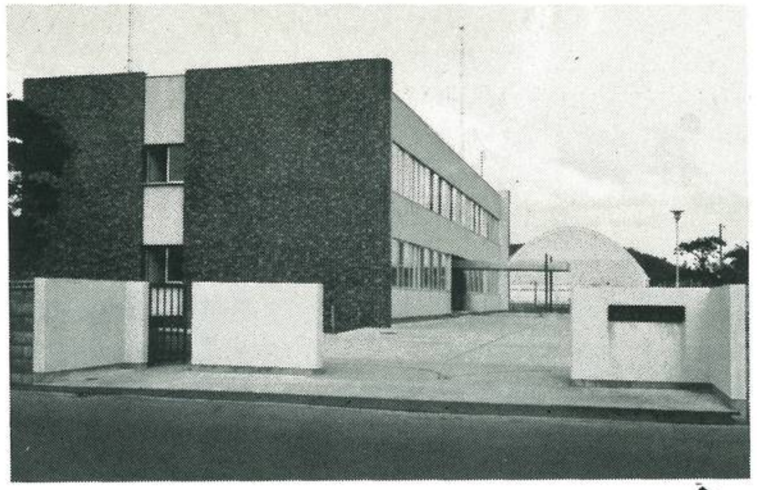
Headquarters, Nukui-kitamach, Koganei-shi, Tokyo

LOCATION OF THE RADIO RESEARCH LABORATORIES

HEADQUARTERS
35°42.4′N 139°29.3′E
4-2-1 NUKUIKITA-MACHI,
KOGANEI-SHI, TOKYO.
TEL. 0423-21-1211

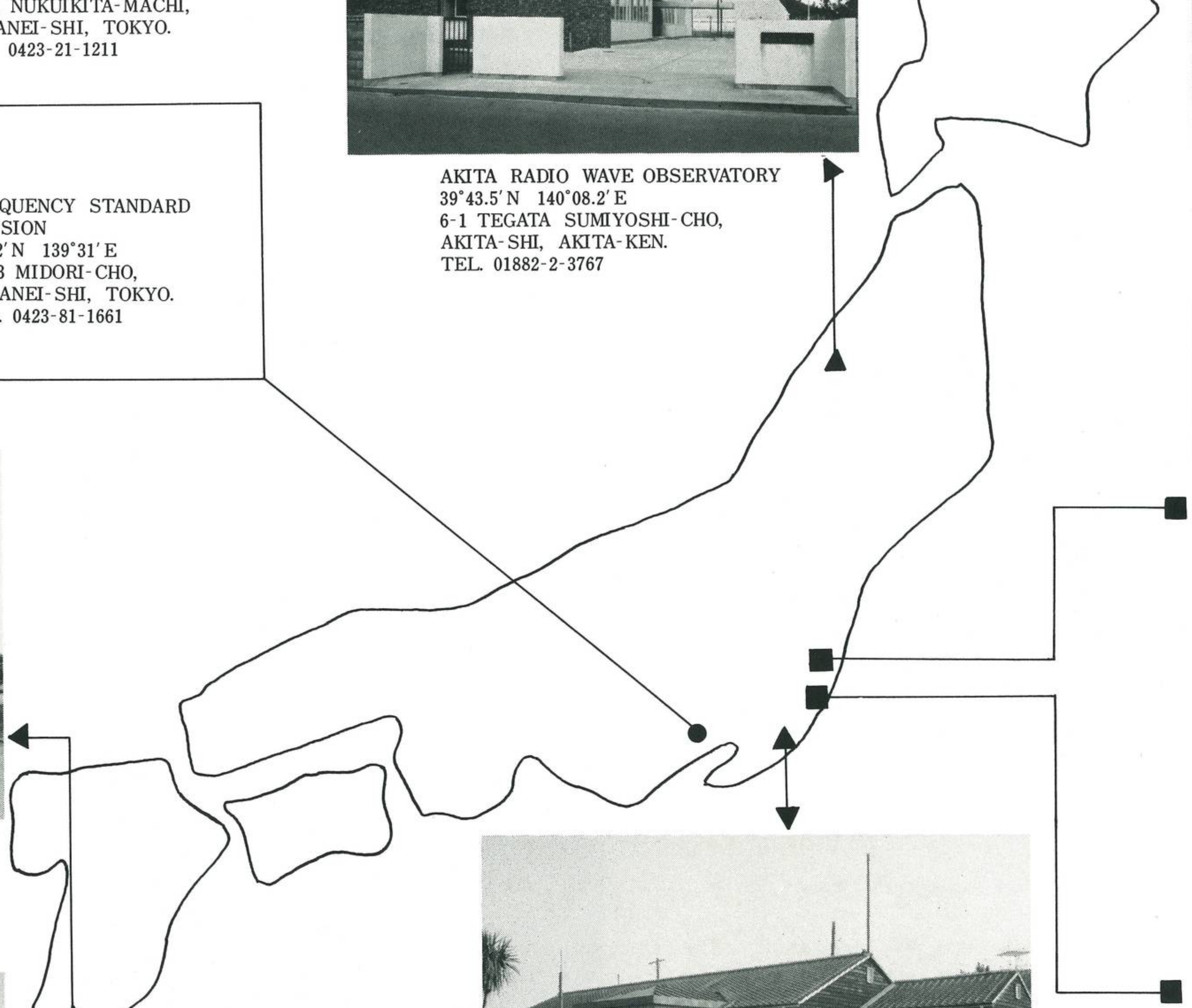


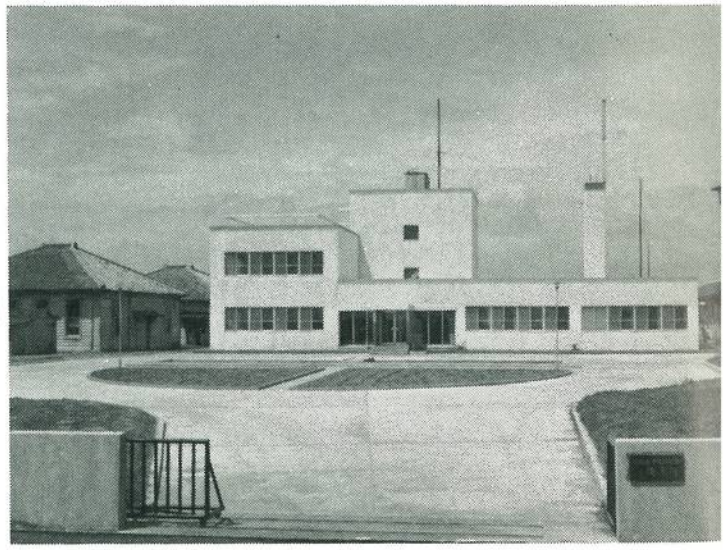
FREQUENCY STANDARD DIVISION
35°42′N 139°31′E
4-1-3 MIDORI-CHO,
KOGANEI-SHI, TOKYO.
TEL. 0423-81-1661



AKITA RADIO WAVE OBSERVATORY
39°43.5′N 140°08.2′E
6-1 TEGATA SUMIYOSHI-CHO,
AKITA-SHI, AKITA-KEN.
TEL. 01882-2-3767

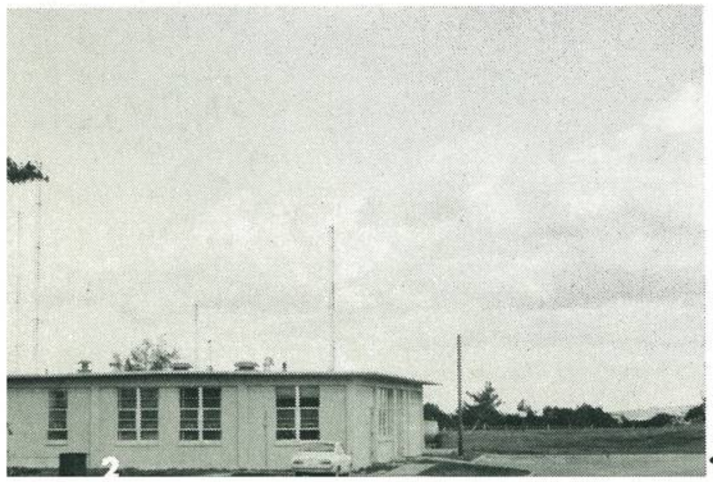
WAKKANAI RADIO WAVE OBSERVATORY
45°23.6′N 141°41.1′E
3-37 MIDORI-CHO, WAKKANAI-SHI, HOKKAIDO.
TEL. 01622-3-3386





HIRAISO BRANCH
36°22.0′N 140°37.5′E
3603 ISOZAKI-MACHI,
NAKAMINATO-SHI, IBARAKI-KEN.
TEL. 029262-2920, 2019

YAMAGAWA RADIO WAVE OBSERVATORY
31°12.1′N 130°37.1′E
2719 NARIKAWA, YAMAGAWA-MACHI,
IBUSUKI-GUN, KAGOSHIMA-KEN.
TEL. 09933-4-0077



OKINAWA RADIO WAVE OBSERVATORY
26°19.0′N 127°46.8′E
TOBARU, CHATANSON, NAKAGAMI-GUN,
OKINAWA-KEN.
TEL. 09893-8-0045

INUBO RADIO WAVE OBSERVATORY
35°42′N 140°51′E 9912 TAKAGAMI TENNODAI,
CHOSHI-SHI, CHIBA-KEN. TEL. 04792-2-0871

KASHIMA BRANCH
35°57.2′N 140°40.0′E
KASHIMA-MACHI, IBARAKI-KEN.
TEL. 02998-2-1211

ORGANIZATION OF THE RADIO RESEARCH LABORATORIES

Director Mr. Teruo Ishikawa

Deputy Director Dr. Hiroo Yuhara

SCIENTIFIC AND TECHNICAL DIVISIONS

As of Mar. 1, 1974

Planning and Support Division	Mr. Y. Nomura
Project Support Section	Mr. K. Konno
Technical Service Section	Mr. F. Ochi
Technical Consulting Division	Dr. K. Tao
International Radio Affairs Research Section	Mr. S. Ishikawa
Frequency Utilization Research Section	Mr. Y. Kurihara
Radio Application Research Section	Mr. K. Sawaji
Communication System Advisory Section	Mr. H. Okamoto
Information Processing Division	Mr. Y. Ogata
Information Processing Research Section	Mr. H. Shibata
Computer Applications Research Section	Mr. N. Imai
Computer System Research and Service Section	Dr. H. Hojo
Radio Wave Division	Dr. I. Kasuya
Radio Propagation Research Section	Dr. T. Kobayashi
Ionospheric Radio Prediction Section	Dr. K. Shinno
Space Physics Section	Dr. Y. Hakura
Radio Meteorology Section	Mr. M. Fukushima
Artificial Satellite Research Division	Mr. K. Kawakami
Communication Satellite Research Section	Mr. K. Tsukamoto
Ionospheric Satellite Research Section	Dr. K. Funakawa
Data Acquisition System Research Section	Dr. N. Nakahashi
Communication System and Apparatus Division	Mr. Y. Suguri
Communication Systems Section	Mr. K. Ikushima
Speech Processing Research Section	Dr. J. Suzuki
System Performance Research Section	Dr. Y. Kadokawa
Standards and Measurements Research Section	Mr. S. Miyajima
Applied Radio Physics Section	Dr. T. Igarashi
Marine Communication Research Section	Mr. Y. Suguri
Communication Apparatus Section	Mr. T. Takahashi
Frequency Standards Division	Mr. Y. Saburi
Atomic Standards Section	Mr. M. Kobayashi
Standard Frequency and Time Research Section	Mr. Y. Yasuda
Standard Frequency and Time Dissemination Section	Mr. T. Suzuki
Special Research Section for Space Physics	Dr. Y. Aono
Special Research Section for Ionosphere Experiments	Dr. Y. Nakata
Special Research Section for Radio Physics	Dr. T. Yonezawa
Special Research Section for Precision Quartz Resonators	Dr. Y. Hiruta

ADMINISTRATIVE SERVICES

Administrative Division	Mr. H. Watanabe
General Affairs Section	Mr. K. Sasaki
Accounts Section	Mr. H. Teshima

REGIONAL BRANCHES AND OBSERVATORIES

Kashima Branch	Dr. T. Ishida
Space Communication Section	Mr. K. Harada
Space Research Section	Mr. N. Kawajiri
Hiraiso Branch	Dr. N. Wakai
Upper Atmospheric Research Section	Dr. R. Maeda
Solar Radio Research Section	Mr. F. Yamashita
Wakkanai Radio Wave Observatory	Mr. T. Koizumi
Akita Radio Wave Observatory	Mr. Y. Takenoshita
Inubo Radio Wave Observatory	Mr. C. Ouchi
Yamagawa Radio Wave Observatory	Mr. M. Nakajima
Okinawa Radio Wave Observatory	Mr. S. Watanabe

GENERAL ACTIVITIES

PLANNING AND SUPPORT DIVISION

Planning and coordination of researches and investigations, publication, and public relations.
Collection of technical information, administration of books and publications, communications and URSIGRAM broadcasting, and engineering workshop for research requisites.

TECHNICAL CONSULTING DIVISION

Fundamental research and investigation in the radio science and technology called for by the international conference or by consultation with foreign countries.
Fundamental research and investigation for the development and utilization of radio frequencies, elimination of interference, prevention of radio noise, and in technical matters of radiocommunication circuits.

INFORMATION PROCESSING DIVISION

Information processing and research for increase in efficiency of its conveyance.
Research in the application of an electronic computer.

RADIO WAVE DIVISION

Research in the characteristics of radio waves and related phenomena of the ionosphere and atmospherics.
Research in radio forecasts, ratio warnings, aerospace and ionospheric observations in Antarctica.

ARTIFICIAL SATELLITE RESEARCH DIVISION

Research in planning and designing satellites for communications and for the ionosphere.
Research in the composition and functions of satellites.

COMMUNICATION SYSTEM AND APPARATUS DIVISION

Research in the radiocommunication system and routes.
Research in measurement of radio waves and in their standardization.
Research in analysis and disposition of the voice.
Basic studies in the relation between radio waves and the property of matter and in radio apparatus with the property of matter applied to.
Basic research in marine communication systems.
Governmental type approval, performance test and calibration of radio apparatus and devices.

FREQUENCY STANDARD DIVISION

Research for the atomic frequency standards.
Determination of the standard frequency value and maintenance of the atomic time on its basis.
Transmission on the standard frequencies of time singnals and bulletins for radio warning.
For the above purposes, research in precision metrology, development of utilization, international comparison and so on.

SPECIAL RESEARCH SECTION FOR SPACE PHYSICS

Synthetic studies in space physics.

SPECIAL RESEARCH SECTION FOR IONOSPHERE EXPERIMENTS

Experimental research in the ionosphere by the use of satellite frequencies.

SPECIAL RESEARCH SECTION FOR RADIO PHYSICS

Theoretical research in the characteristics of radio waves and the ionosphere.

SPECIAL RESEARCH SECTION FOR PRECISION QUARTZ RESONATORS

Research in highly stable quartz.

ADMINISTRATIVE DIVISION

Taking charge of the general affairs, documents, personnel affairs, salaries and wages and the welfare of the personnel.
Budget planning,acts of obligation for various supplies, and ιaking charge of the government property and of articles and commodities for maintenance purposes.

KASHIMA BRANCH

Research and development of space communications.
Experimental research in cosmical space with radio waves.

HIRAISO BRANCH

Researches in radio propagation and the ionosphere.
Observations and studies necessary for radio warning, measurement of HF field intensity on the international standard, and observations and studies of solar and cosmical radio waves.

WAKKANAI RADIO WAVE OBSERVATORY

Observations of the ionosphere and gemoagnetism, and studies of radio propagation.

AKITA RADIO WAVE OBSERVATORY

Observations of the ionosphere and studies of radio propagation.

INUBO RADIO WAVE OBSERVATORY

Observations and studies of radio propagation.

YAMAGAWA RADIO WAVE OBSERVATORY

Observations of the ionosphere and studies of radio propagation.

OKINAWA RADIO WAVE OBSERVATORY

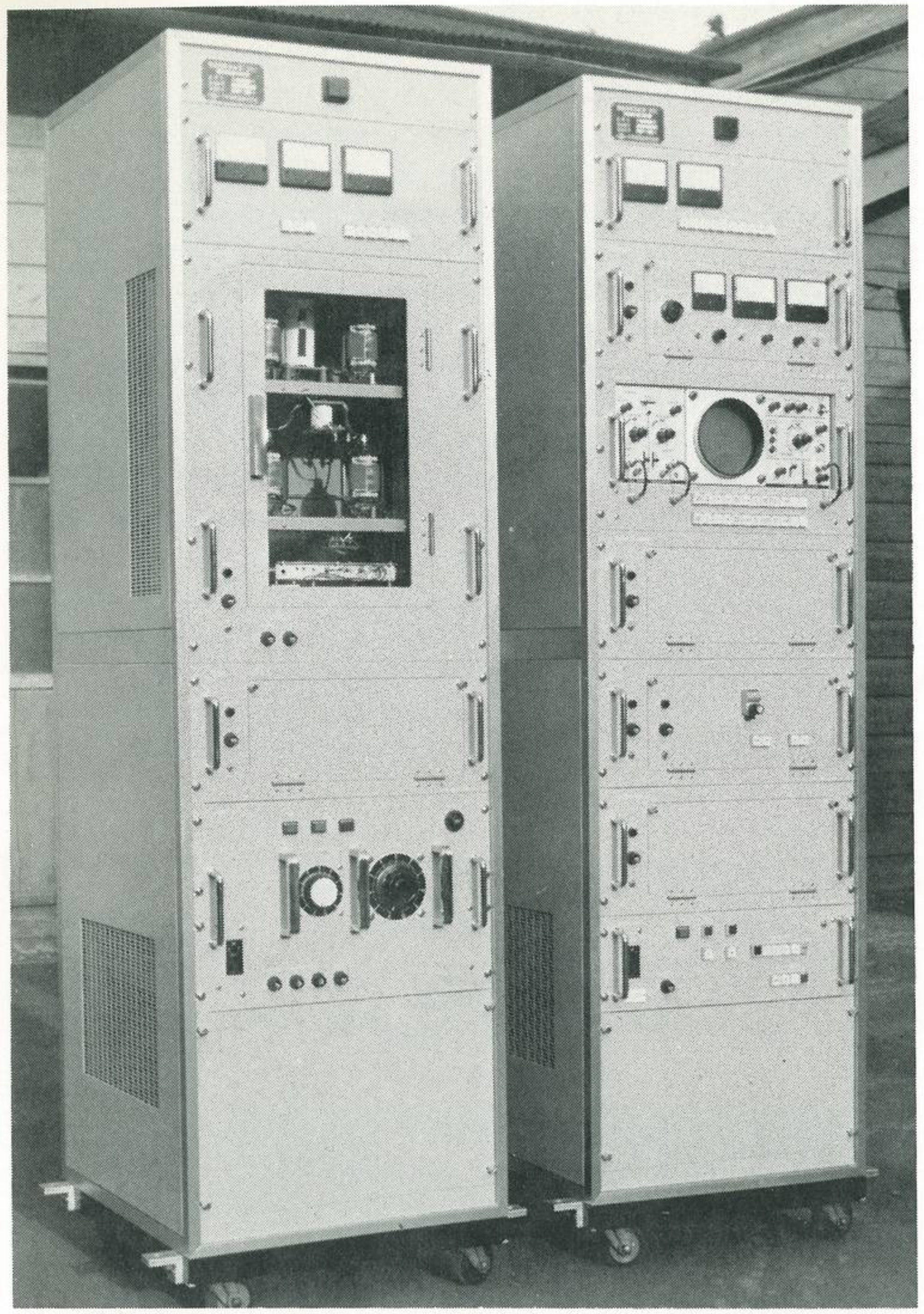
Observations of the ionosphere and studies of radio propagation.

IONOSPHERIC OBSERVATIONS

Observations on the ionosphere by means of vertical sounding technique are being conducted at five observatories of Wakkanai, Akita, Kokubunji(Tokyo), Yamagawa and Okinawa located at about every five degrees separation of latitude on the 135°E longitude zone, in order to Monitor the Solar Earth Environment on a permanent basis (MONSEE), in cooperation with activities of the international scientific communities. It should especially be mentioned that ionospheric soundings in Tokyo district are commenced in 1932 and the history of ionospheric soundings in Japan is as old as in the U.S.A. (Washington D.C.) and England (Slough).

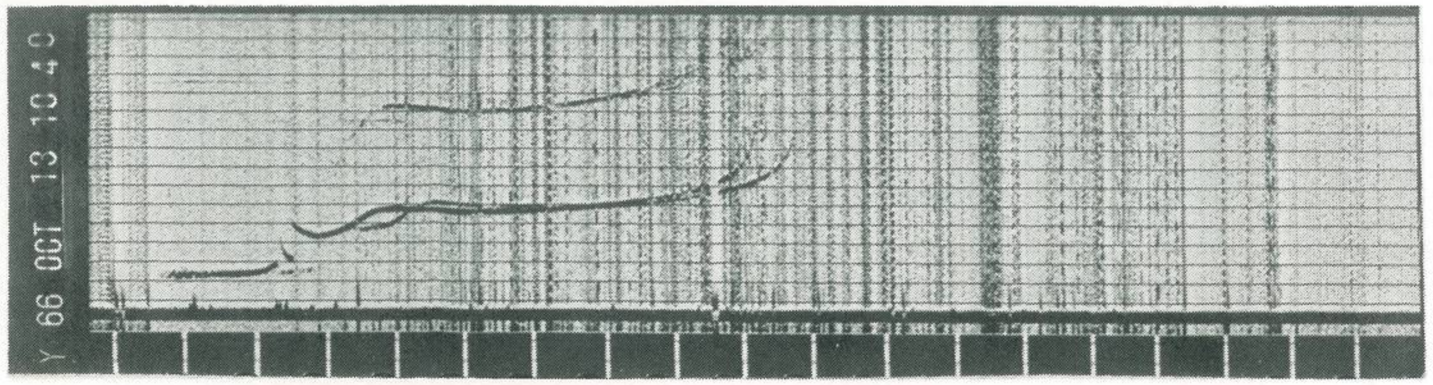
The observational results of the ionosphere give not only the most important informations on the condition of ionospheric radio propagation but also the data which are most contributory to the investigation of physical properties of the ionosphere itself.

In general, all ionospheric observatories make observations normally every 15 minutes on a routine basis and the scaling of the ionograms is done in accordance with URSI rules, and is published monthly in the "Ionospheric Data in Japan" for distribution among the World Data Centers and the Agencies concerned at home and abroad.

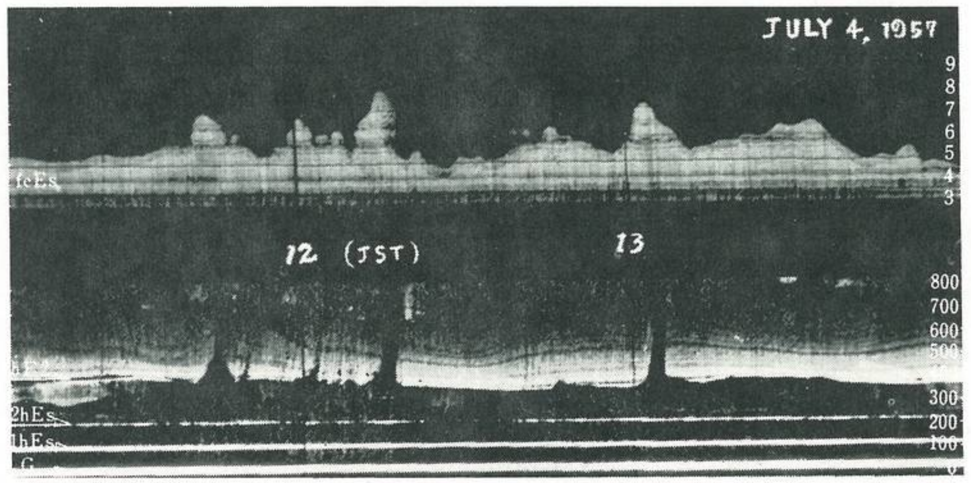


Ionosonde (Type–9)

Ionofax, direct recording system for ionogram using by optical fiber tube



An example of recording of ionospheric vertical observation (h′–f record)



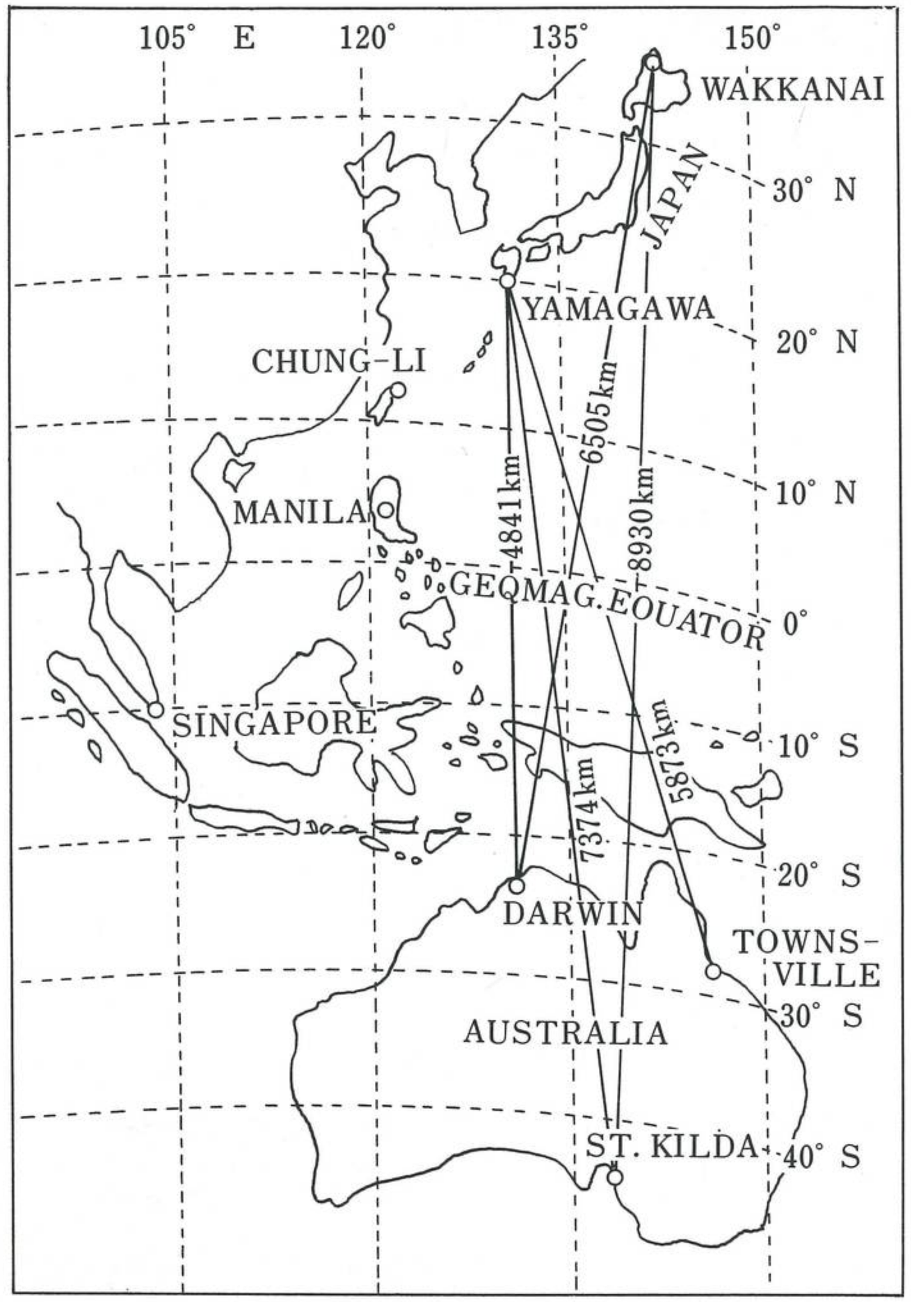
Frequency (MHz)

Virtual height (km)

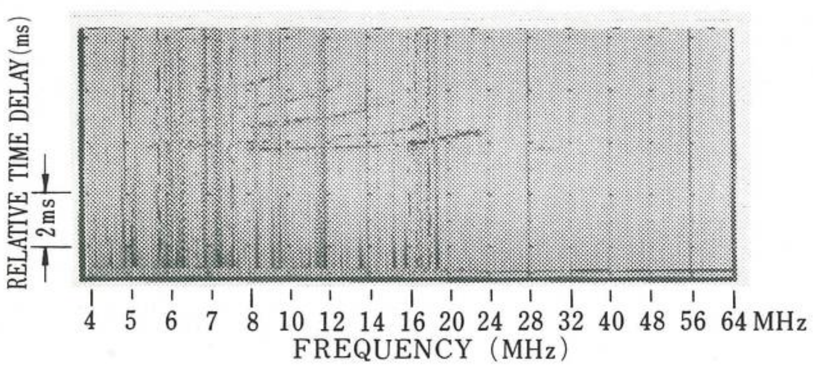
Examples of special ionospheric recordings. fc–t (upper) and sh′t recordings (lower).

EXPERIMENT ON TRANS-EQUATORIAL RADIO PROPAGATION

The propagation experiment in VHF band (32-102 MHz, CW) was commenced in August 1964, between Yamagawa and Darwin, North Australia at approximately conjugate points of the magnetic equator. The VHF radio waves propagate in special ionospheric propagation mode almost across the magnetic eqator. For the explanation of this mode, an oblique sounder was installed at Yamagawa, in cooperation with the sounders at St. Kilda, South Australia and Townsville, Queensland. Besides, Wakkanai has joined in the experiment since 1971.



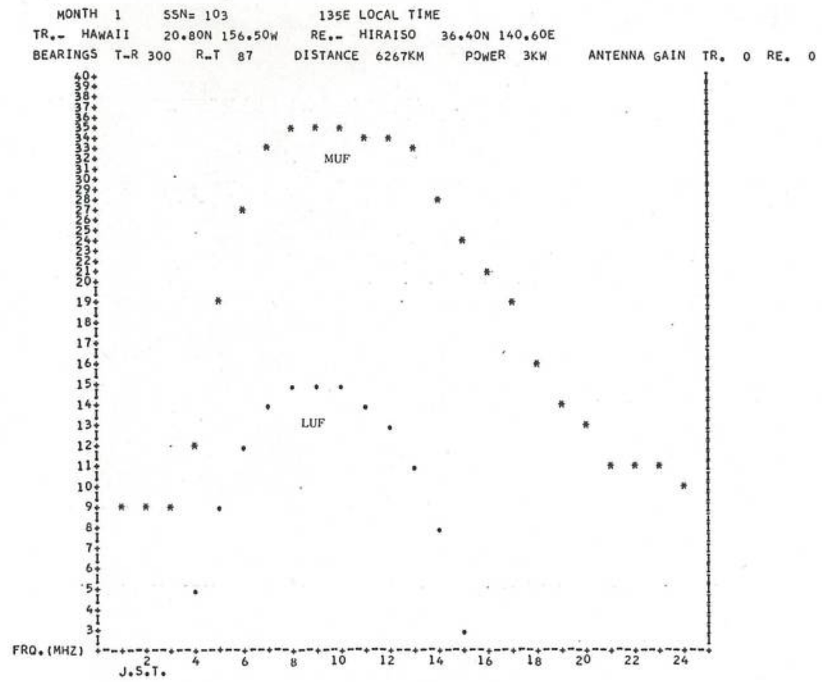
Map of the trans-equatorial propagation paths



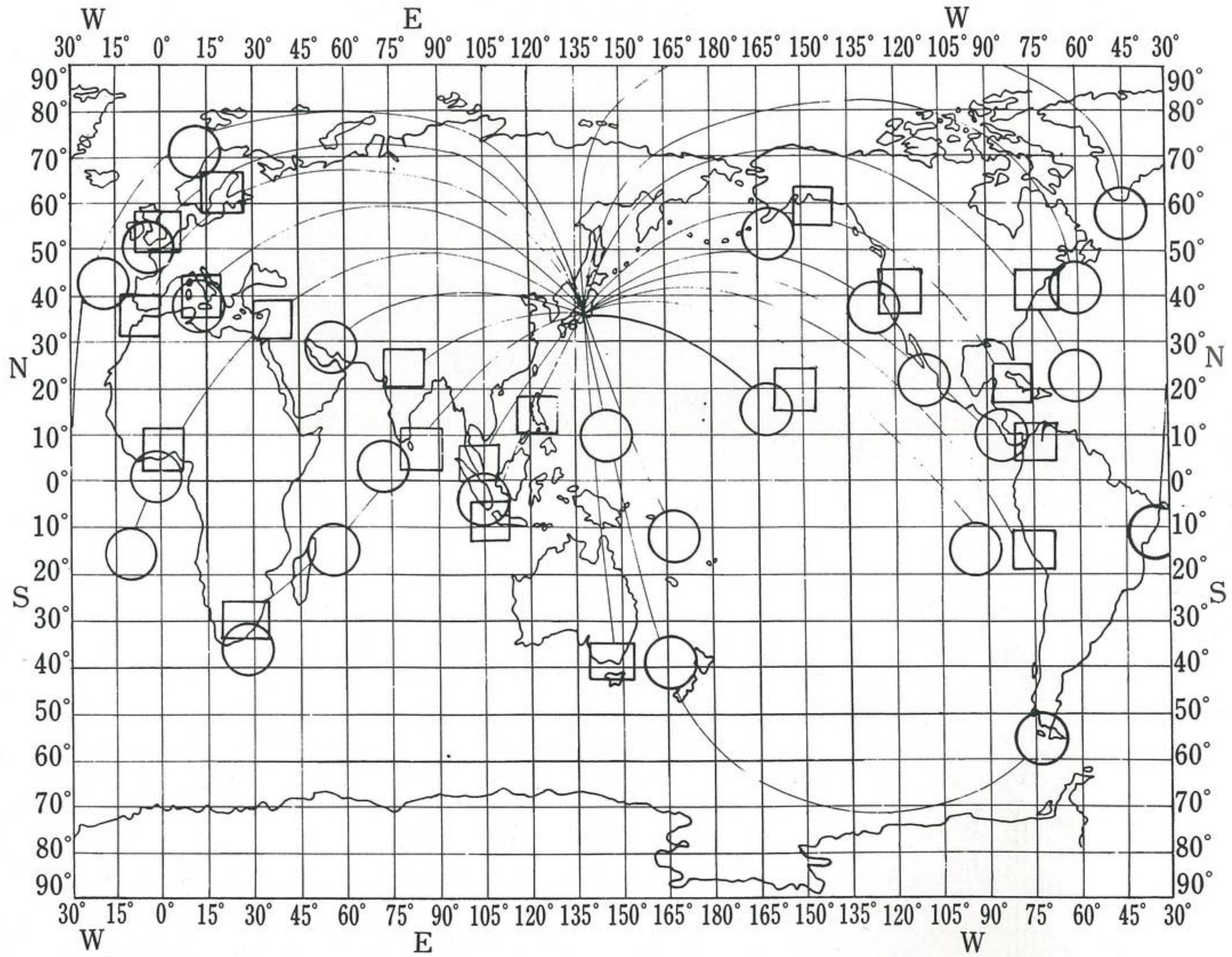
An example of oblique ionogram

RADIO FORECASTS

The radio forecasts are made by electronic computer in respect of the frequencies and powers for efficient use of communications between two places at a certain time. The RRL are carrying on the service of radio forecasting for months ahead concerning the ciricuits between Tokyo and each of several principal districts as well as the waters where merchant of fishing fleets are on voyage.



An example of HF radio propagation prediction



Service area of radio prediction and paths

○ ······waters □ ······principal districts

URSIGRAM AND WORLD DAYS SERVICE

The ursigram and world days service system is applied to the rapid service of solar and geophysical data for researchers and observatories as the worldwide communication network. In general, its message contains two kinds of information; one is the solar and geophysical data on the sun, geomagnetism, cosmic rays, ionosphere, etc., the so-called URSIGRAM, closely related to radio propagation, and the other is "PRESTO" (Report of major events) "GEOALERT" (Geophysical Alert), etc. The type of messages is regulated under the International Ursigram and World Days Service (IUWDS) as the international organization.

The IUWDS has identified five regions of the world, each with a Regional Warning Center. One of the RWCs (the Western Hemisphere RWC at Boulder, USA) serves at the IUWDS World Warning Agency.

The RRL have taken on the services of the Western Pacific Regional Warning Center since the establishment of the International Geophysical Year (IGY) in 1957, and the URSIGRAM have been exchanged with four Regional Warning Centers (Boulder, USA; Moscow, USSR; Paris, France; Sydney, Australia).

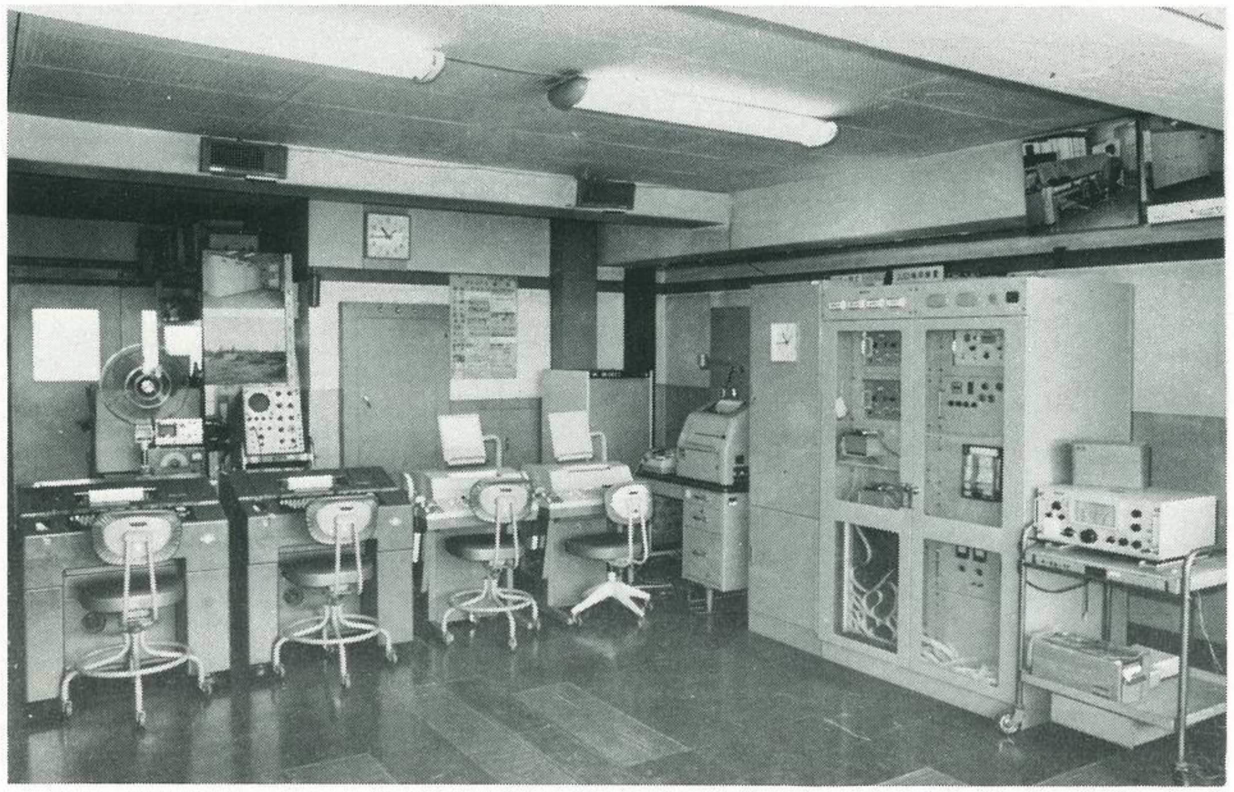
The URSIGRAM broadcasting is outlined as follows:

Communication center; RRL, Koganei, Tokyo

Transmitting station; Usui, Chiba (about 60km east of the RRL: 35° 43.7′ N, 140° 12.2′ E).

Current broadcasting schedule:

Call Sign	Frequency (kHz)	Class of Emission	Time (UT)	Power (kW)	Beam
JJD	10.415	Al	08: 00	5	Non-directioal
JJD2	15.950	Al	08: 00	5	Non-directional



Communication center

WORLD DATA CENTER C2 FOR IONOSPHERE

World Data Centers were established in order to collect and keep observational data obtained during the International Geophysical Year (IGY) by IGY Participating Committees under International Council of Scientific Unions (ICSU). World Data Centers are as follows:

Center A:	All disciplines	U.S.A.
Center B:	All disciplines	U.S.S.R.
Center C:	Each discipline	Nation accomodated in each field.

Since 1958, World Data Center C2 for Ionosphere under the RRL has continued to collect, exchange and keep all incoming data from organizations or ionospheric stations participated in worldwide scinetific cooperation. At present this center has a large quantity of ionospheric data (68000 copies in paper sheet or book, 12700 rolls in film) from sixty-two nations in the world. Other World Data Centers concerning ionosphere are as follows;

World Data Center A for Solar-Terrestrial Physics
National Oceanic and Atmospheric Administration
Boulder, Colorado 80302, U.S.A.

World Data Center B2
Solar-Terrestrial Physics
Ulitza Molodezhmaya 3, Moscow B-296, U.S.S.R.

World Data Center C1
Appleton Laboratory
Ditton Park, Slough, SL3 9JK, England

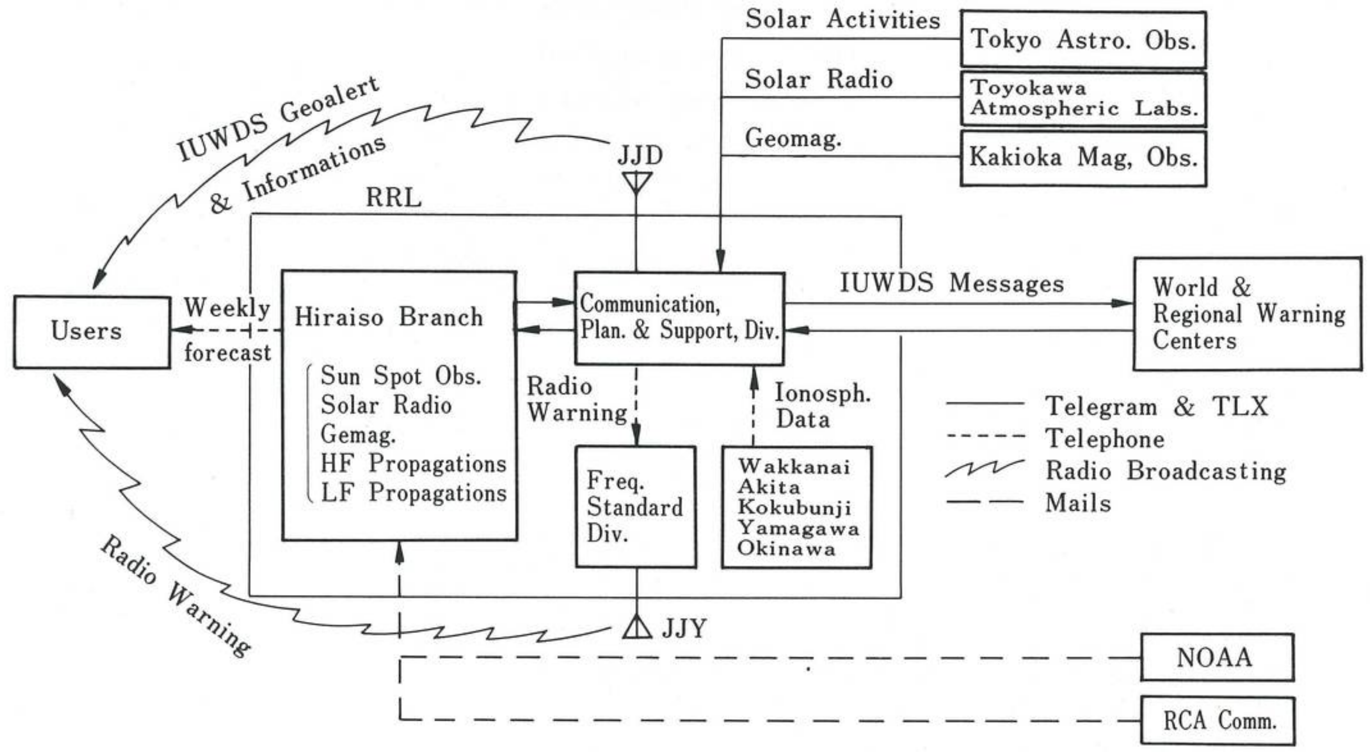
World Data Center C2 for ionosphere

RADIO WARNINGS

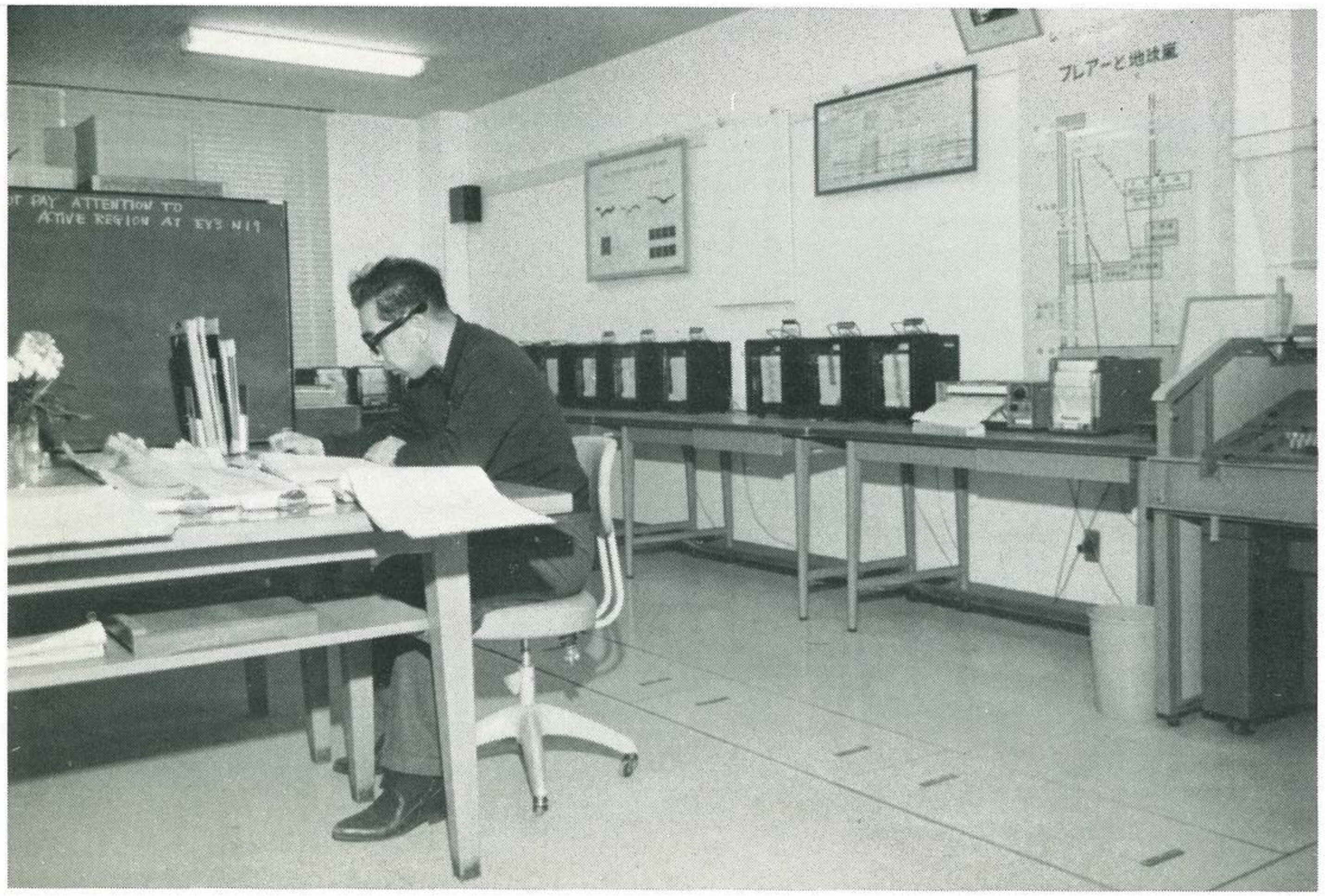
The ionosphere is influenced by the solar activities, owing to seasons and local times and is sometimes disturbed by the magnetic storms. Consequently, HF radiocommunication in particular encounters with considerable difficulties. Therefore, radio warnings are requested to predict such troubles in regard to the time and degree of occurence. For warning against radiocommunication hindrance, the Hiraiso Branch of the RRL is collecting, through the Regional Warning Centers for URSIGRAM and World Day Service, varied informations on field intensities of long-distance propagation, ionosphere, gemagnetism and solar observations at home and abroad, in addition to observation data gathered by itself, and is issuing radio warnings every day.

Recently, an auto-processing system of radio warning services, named RADWIS (Radio Disturbance Warning Issuance System) was introduced for the improvement of services.

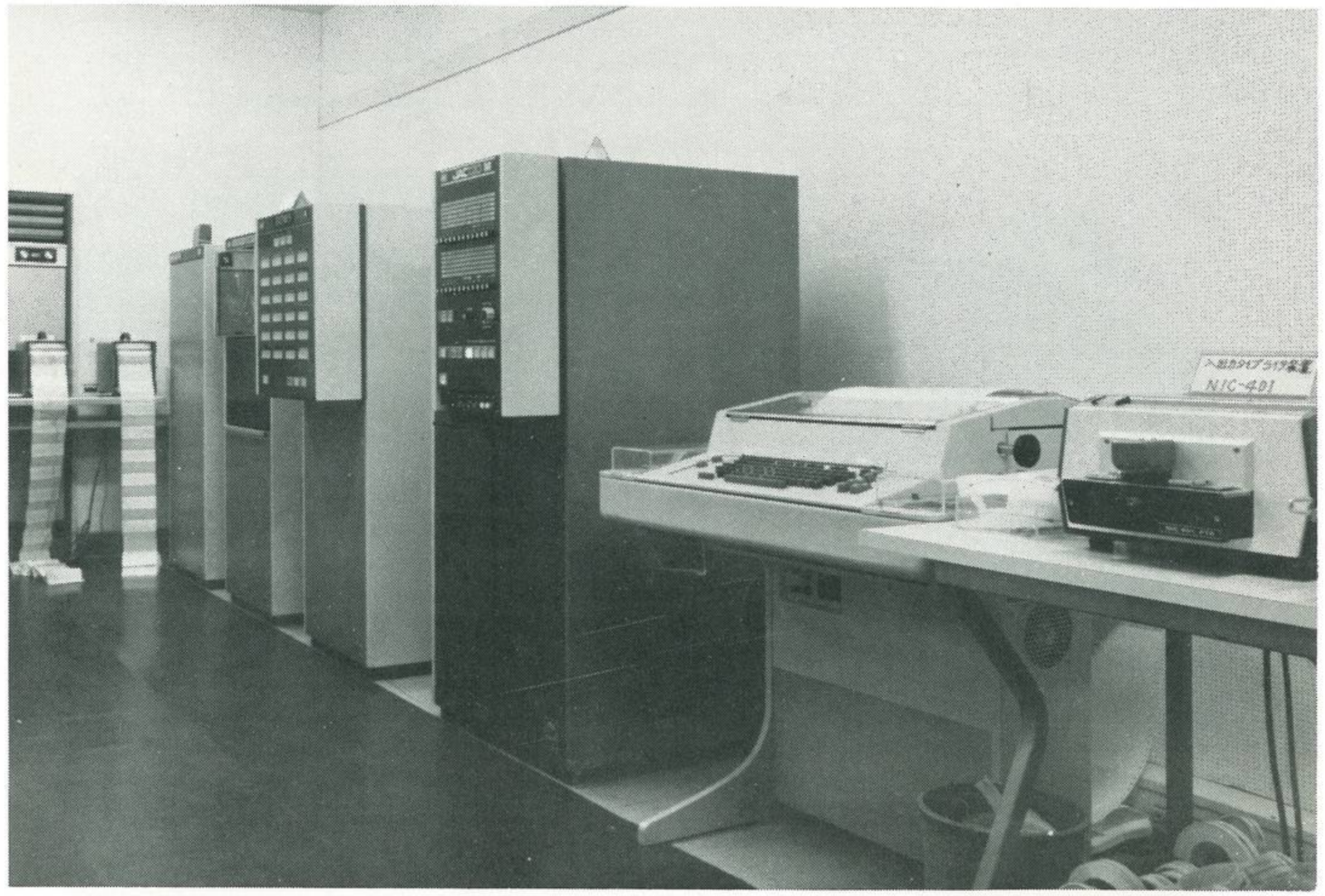
The radio warnings are broadcast on the standard radio frequencies (JJY) by the RRL. Some are sent to the specified Agencies by telephone, telegram or post.



System of radio disturbance warning services



Radio warning room at Hiraiso Branch



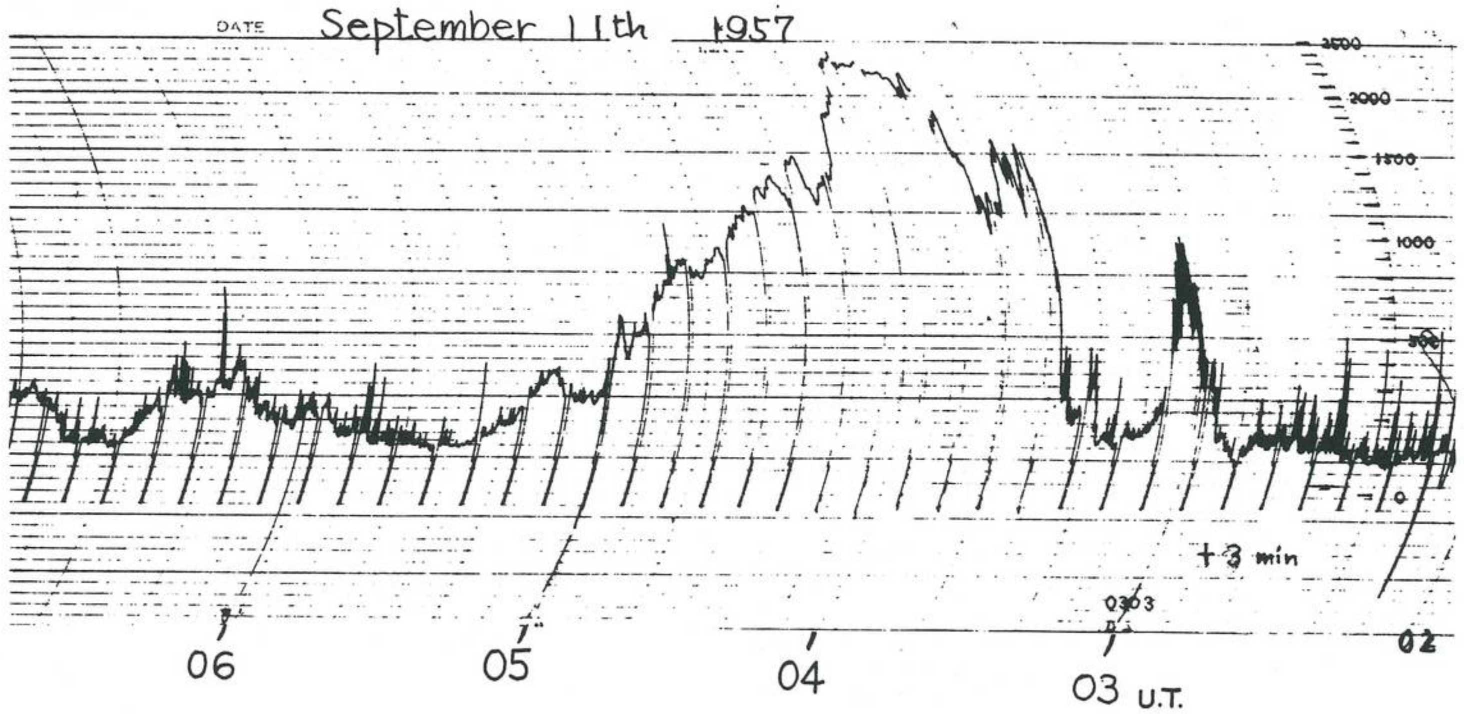
RADWIS, an electronic computer for radio warnings

OBSERVATION ON THE SOLAR RADIO EMISSIONS

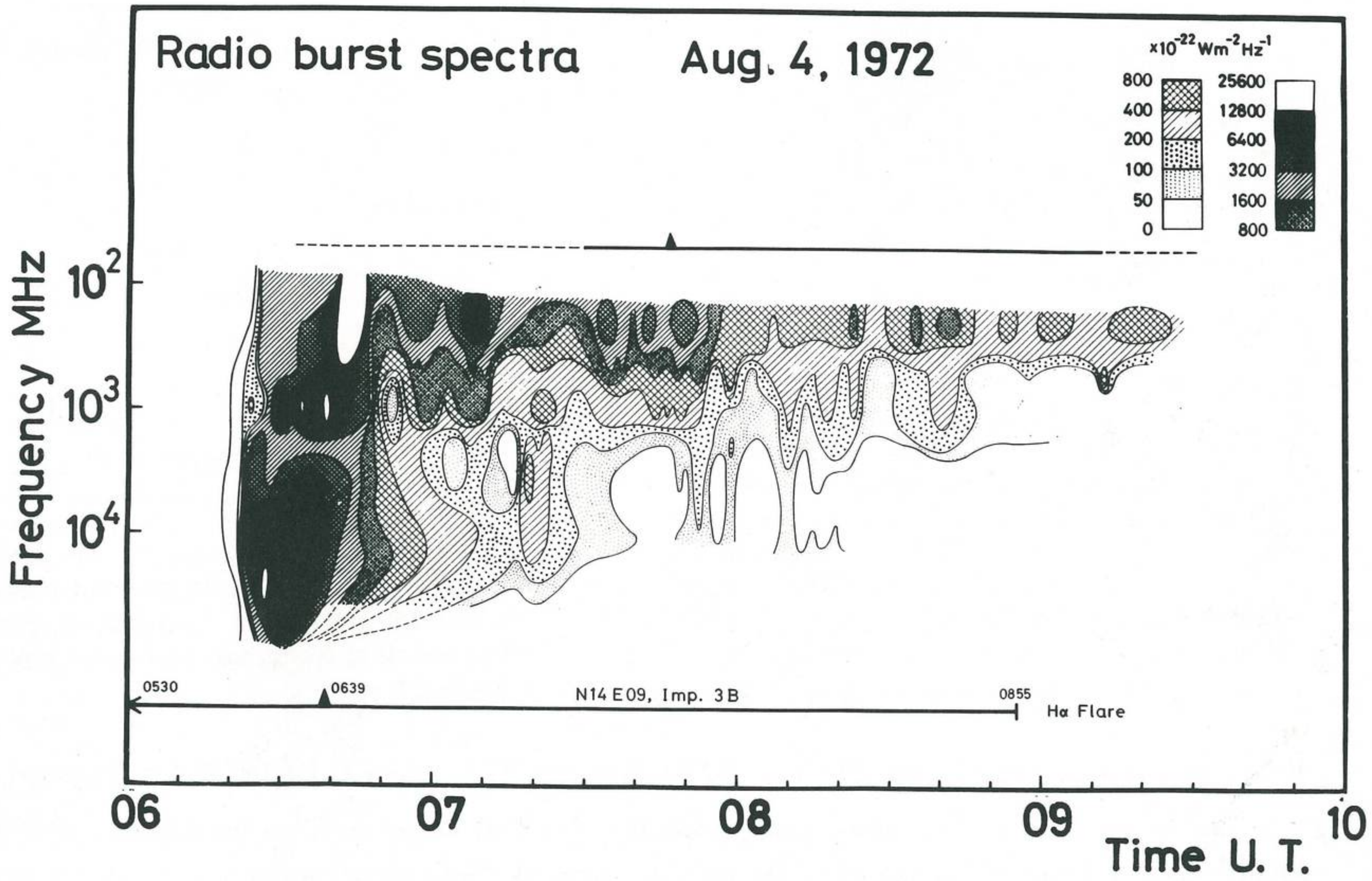
Observations on the solar radio emissions at four frequencies, 100, 200, 500 and 9500MHz are carried on at Hiraiso Branch on a routine basis and very useful information are furnished to the radio warnings prepared there.

The enhancement of the emission usually occurs associated with the solar optical flare, known as the burst, and is clarified into several types according to its variation and spectrum. The type IV burst is useful information for the prediction of geomagnetic storms and polar cap absorptions. Some examples of the type IV burst recorded at Hiraiso on 200 MHz and dynamic spectrum with wide frequency range are shown in Figures. The data are published monthly in the "Ionospheric Data in Japan".

10 m parabolic antenna for 100 and 200 MHz



An example of type IV solar burst

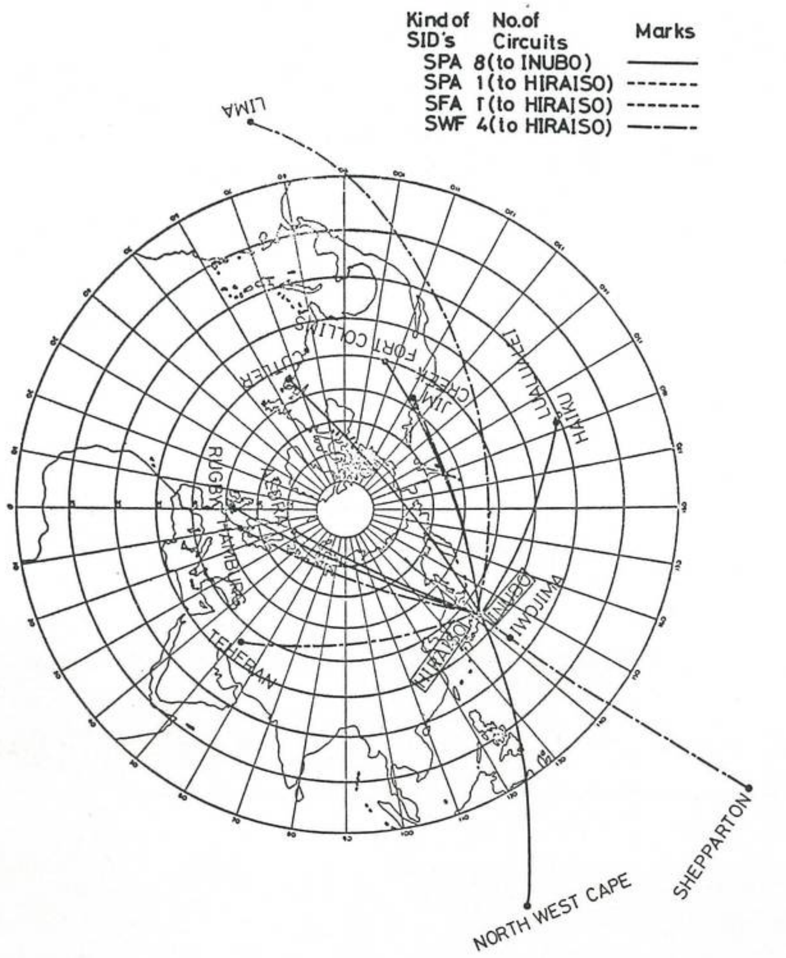


An example of representation of dynamic spectrum with wide frepuency range

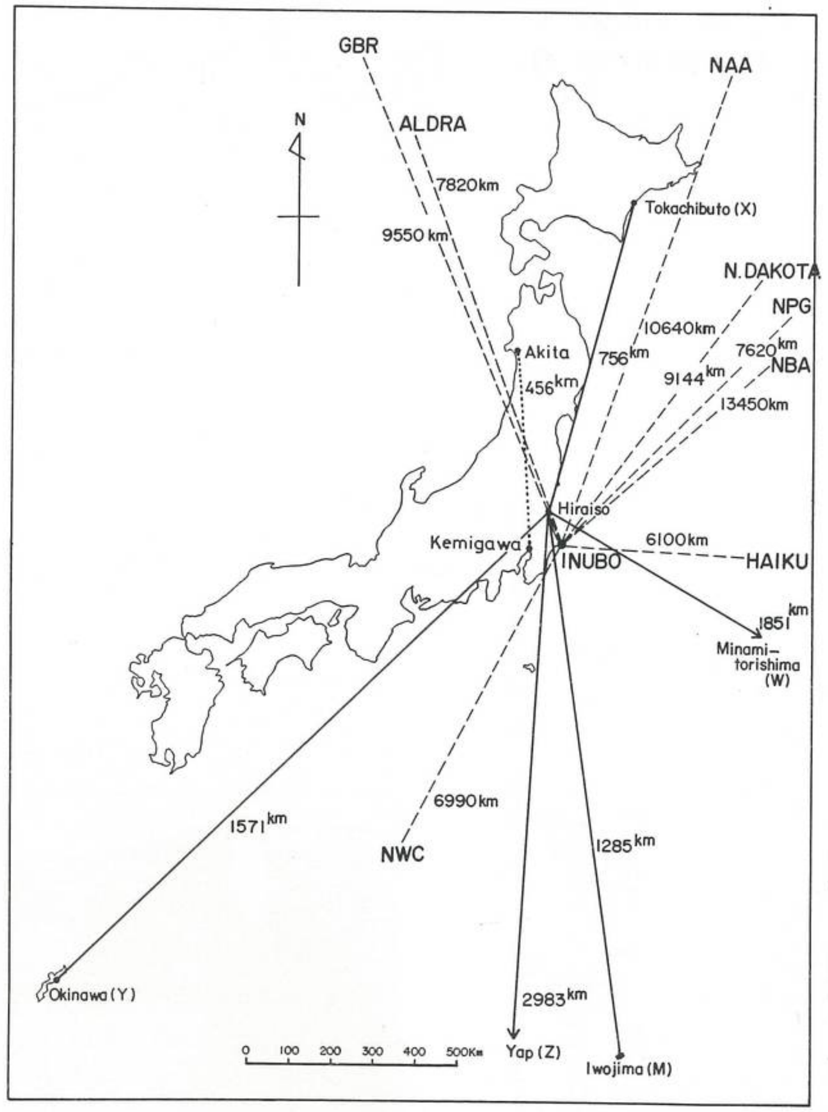
RESEARCH ON VLF AND LF RADIO WAVE PROPAGATION

Routine Observations of VLF and LF Radio Wave Propagation

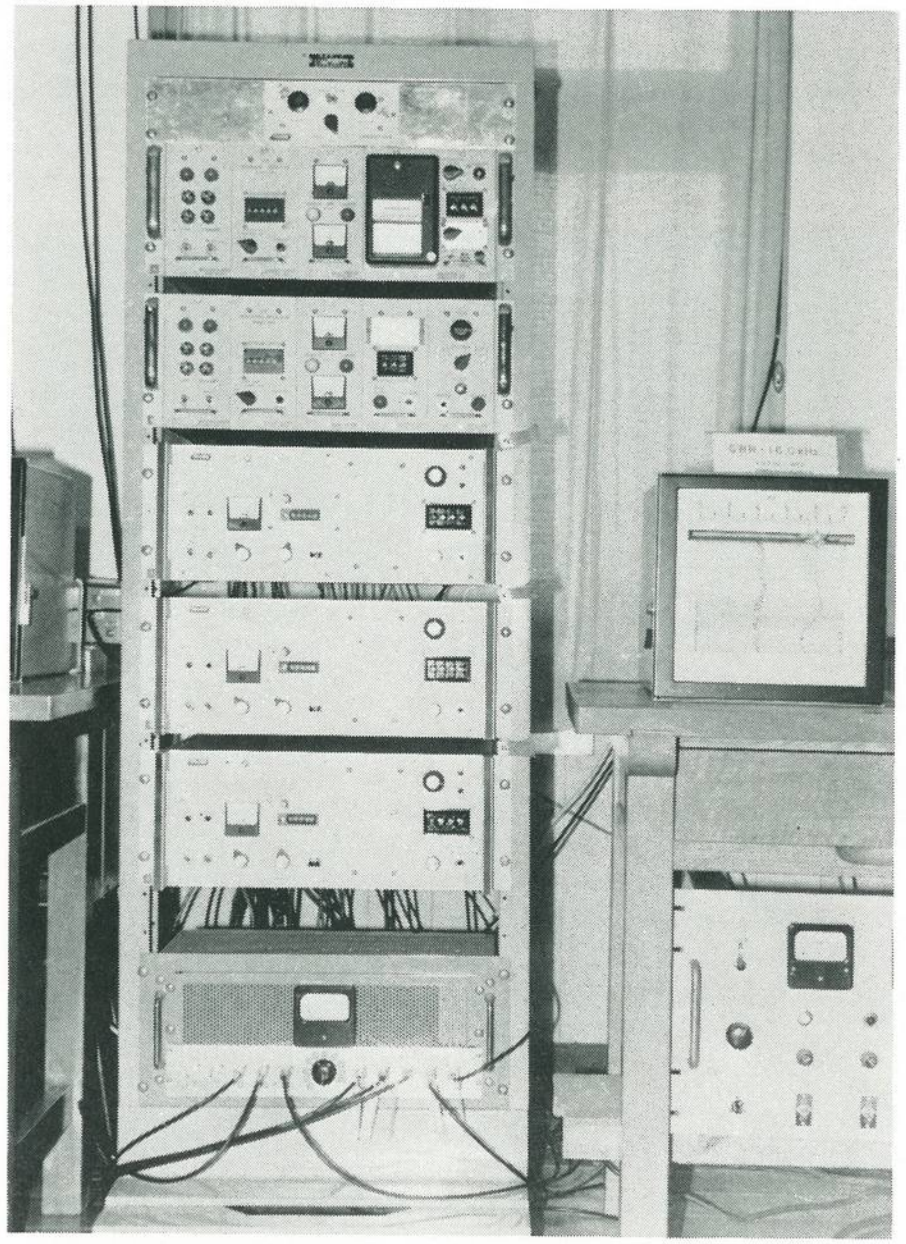
The RRL continuously carry out VLF and LF radio wave propagation experiments parallel to HF and VHF ones. Several VLF radio waves including Omega ones are received at Inubo Radio Wave Observatory, several LF radio waves as Loran-C (100 kHz) at Hiraiso Branch, and an internal LF radio wave as a standard frequency, 40 kHz at Akita R.W.O. in their respective phase and amplitude.



Geographical disposition of SID (including SWF) world-wide circuits received at Inubo and Hiraiso. Two SPA circuits, HAIKU-INUBO and LUALUALEI-INUBO almost all overlap each other on the map. The Loran-C circuit, IWOJIMA (master station) – Hiraiso and the SWF circuit, SHEPPARTON-HIRAISO are superposed each other on the map. The other four slave stations of Loran-C are depicted on the next map of Japan.



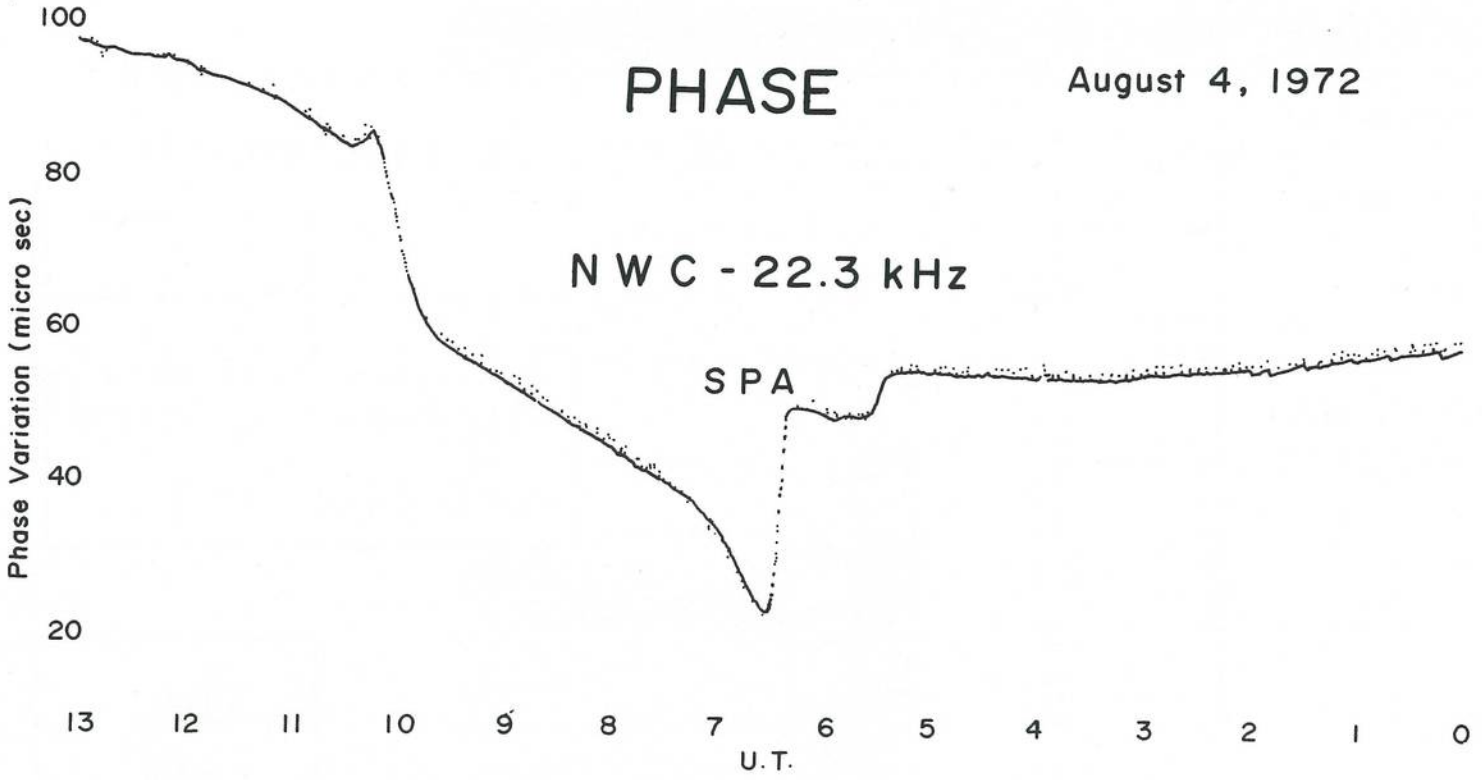
Geographical disposition of LF radio wave (Loran-C, 100 KHz) circuits received at Hiraiso, an internal LF radio wave (standard frequency, 40 KHz) circuit at Akita, and VLF radio wave circuits at Inubo.



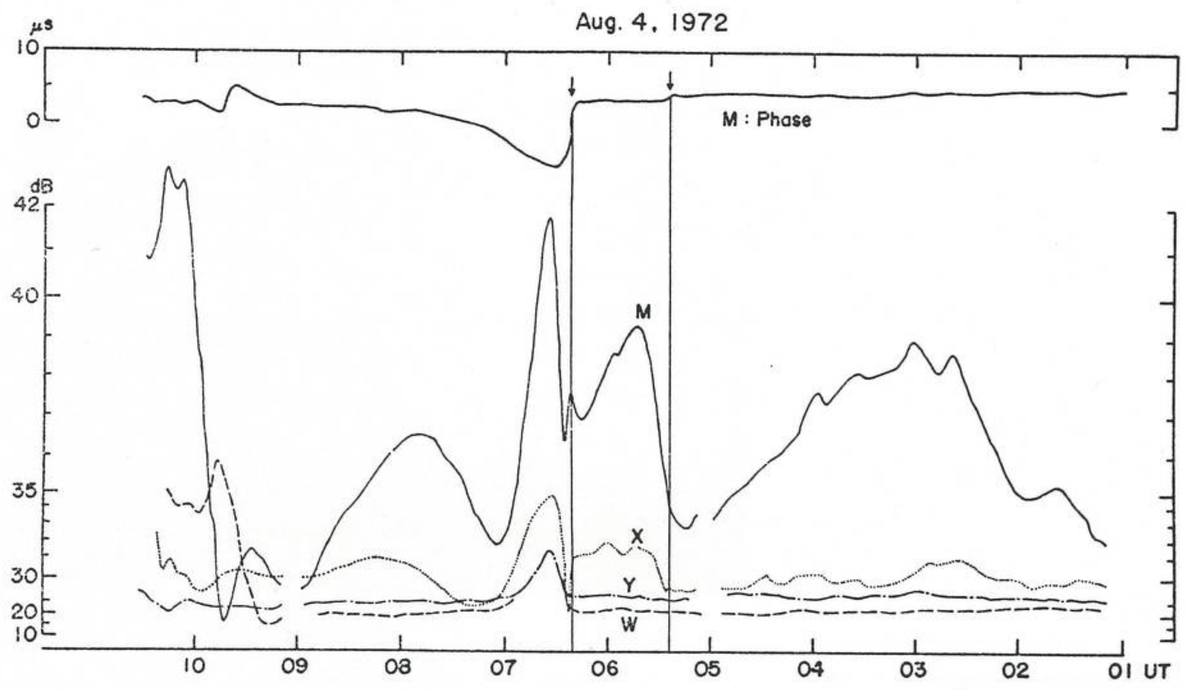
VLF radio wave receiving apparatus and recorders used at Inubo.

Research on Solar Terrestrial Physics (STP) through VLF and LF Radio Wave Propagation

Monitoring VLF and LF radio wave propagation furnishes information on the related ionospheric physical conditions, above all, those in disturbed state clearly, parallel to monitoring HF and VHF radio wave propagation. These informations suggest aspects with STP scale. SPA (sudden phase anomaly) and SFA (sudden field anomaly) are offered to study the relation to solar X-ray flares and the ionospheric physical conditions, together with SCNA (sudden cosmic noise absorption observed at Hiraiso), SIF (sudden increase of fmin observed at five Observatories), and G.s.f.e. (geomagnetic solar flare effect observed at Hiraiso and Wakkanai). Negative SPA's after prediction of their presence were discovered on WWVL circuit in November 1969. The phase advances of VLF radio waves made estimations of the unknown solar X-ray maximum fluxes possible in August events 1972. This gave the basis of relation between LF (100 kHz) phase and the flux. The lowering of phase heights was also estimated for LF radio wave (40 and 100 kHz) in these big events.

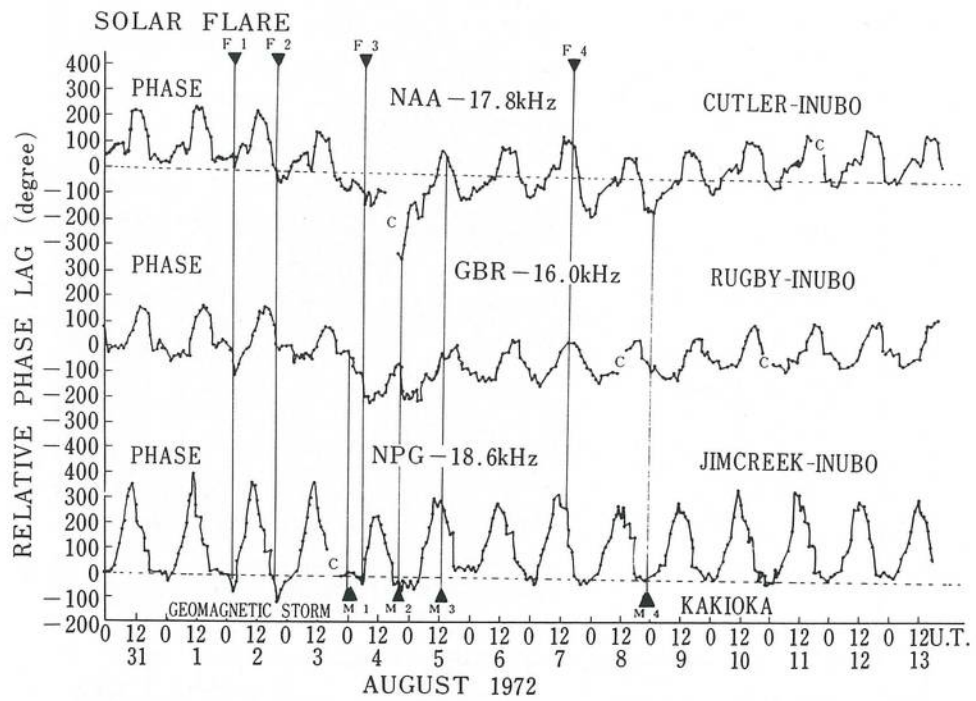


An example of SPA phenomenon recorded at Inubo.



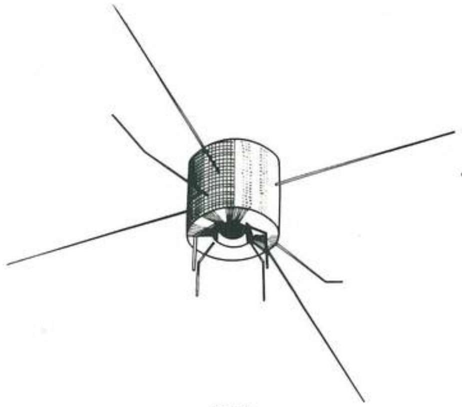
An example of SPA (upper) and SFA (lower) phenomena recorded at Hiraiso.

The occurrence of PCPA (polar cap phase anomaly) and AZPA (auroral zone P.A.) plays a role as an analyzer of solar and magnetospheric particles impinging into the earth's atmosphere. This field was also studied coupled with observational results of geomagnetic disturbances, cosmic ray variations and solar radio bursts in PFP (proton flare project performed in 1969), IASY and August 1972. These studies resulted in some characteristics of solar disturbances and interplanetary space. The study of this field greatly owes to the settlement of a highly stabilized Cs beam frequency standard. Under the same circumstances, phase measurements of VLF radio waves also contributed to the study of winter anomaly absorption to have occurred in 1971-2.

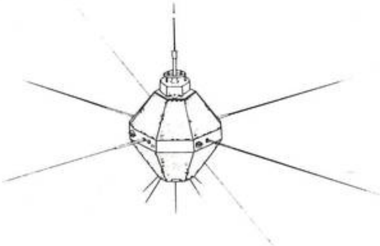


An example of solar proton event to have influenced the available trans-polar VLF radio wave circuits to Inubo. The circuits from CUTLER, RUGBY, and JUM CREEK pass through the polar cap, auroral zone, and sub-auroral zone, respectively.

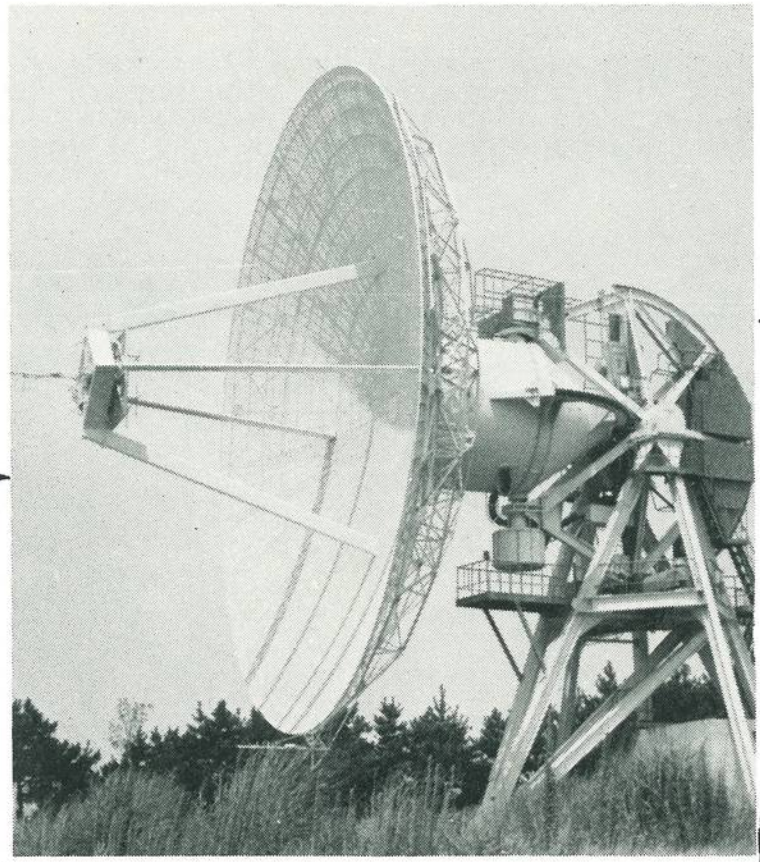
SPACE RESEARCH BY ARTIFICIAL SATELLITES



ISS



ISIS



Telemetry antenna

Control Center for Ionospheric Observation Satellites (KASHIMA BRANCH)

Pass Report

Orbital Prediction

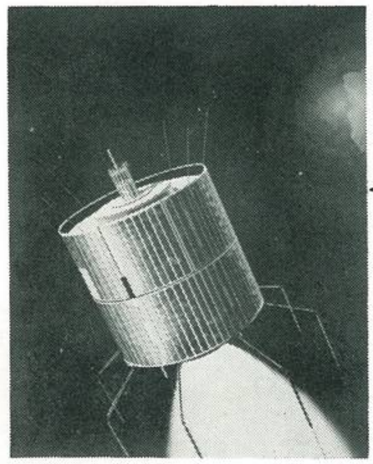
Pass Report

ISIS Working Group

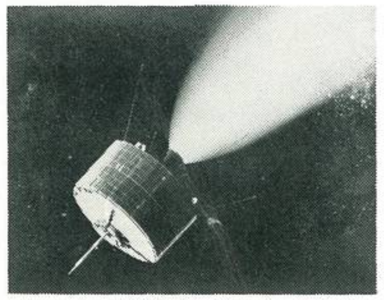
ISIS Project Office (KOKUBUNJI H. Q.)

Data

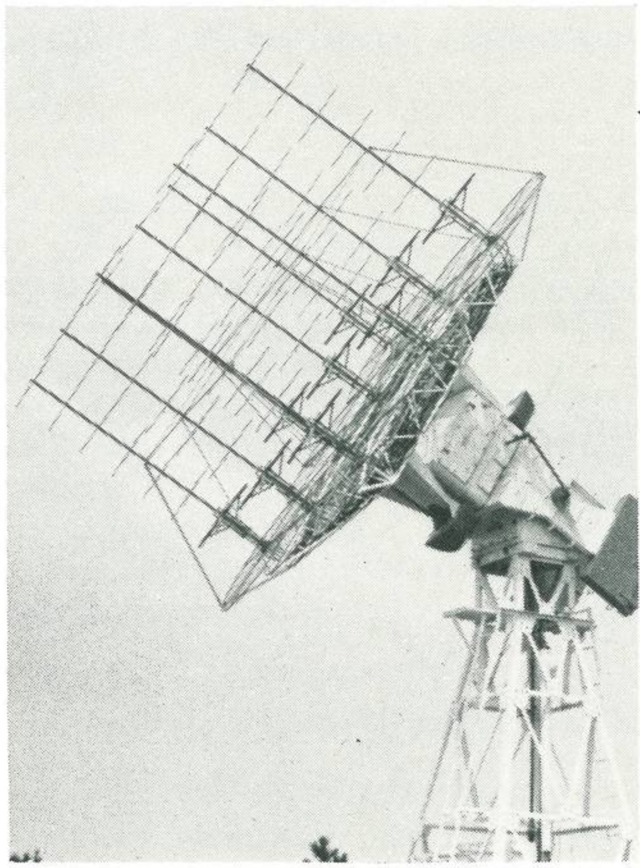
Data Processing System (KOKUBUNJI H. Q.)



ATS-I

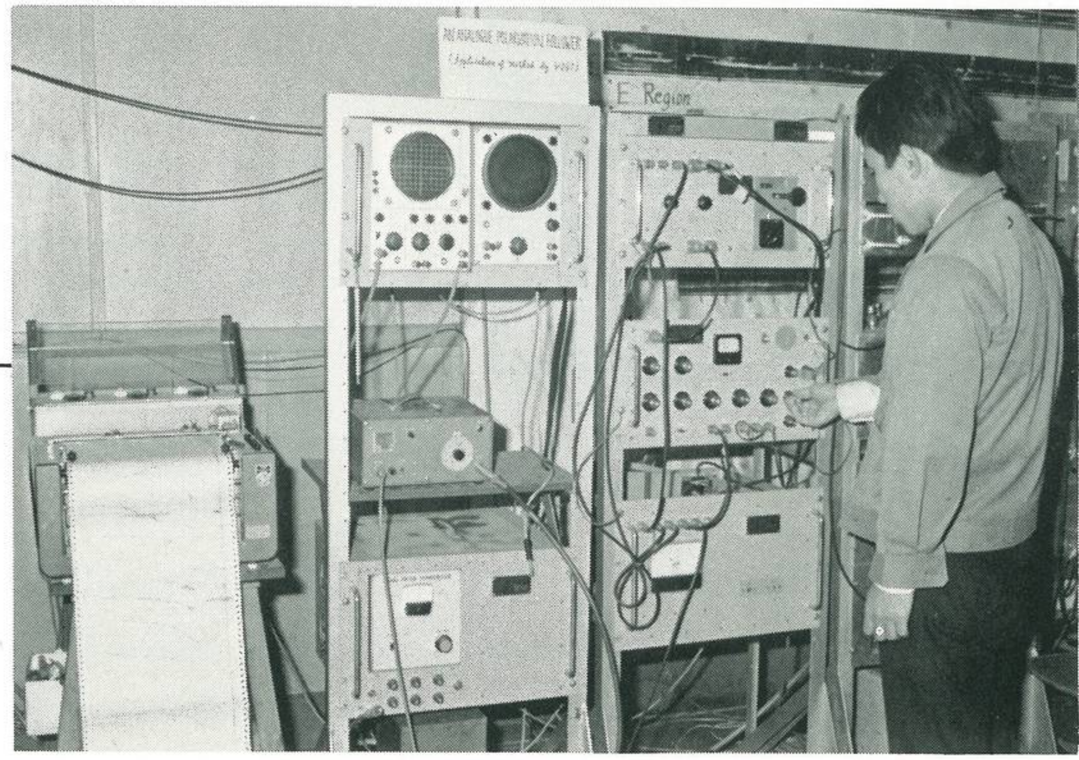


SYNCOM-III



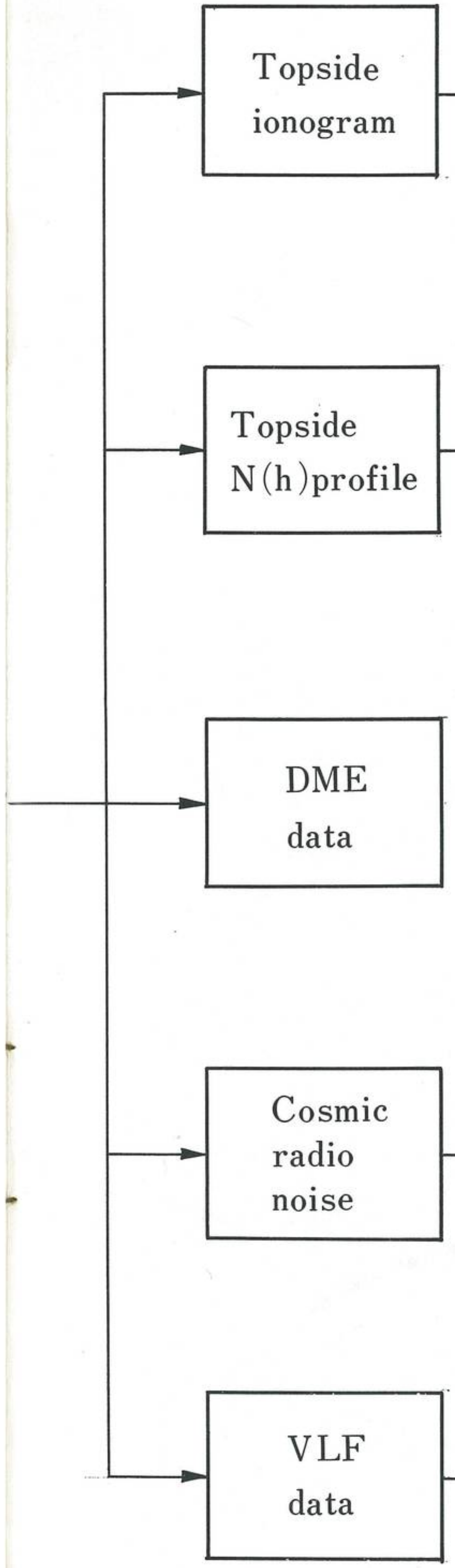
Command antenna

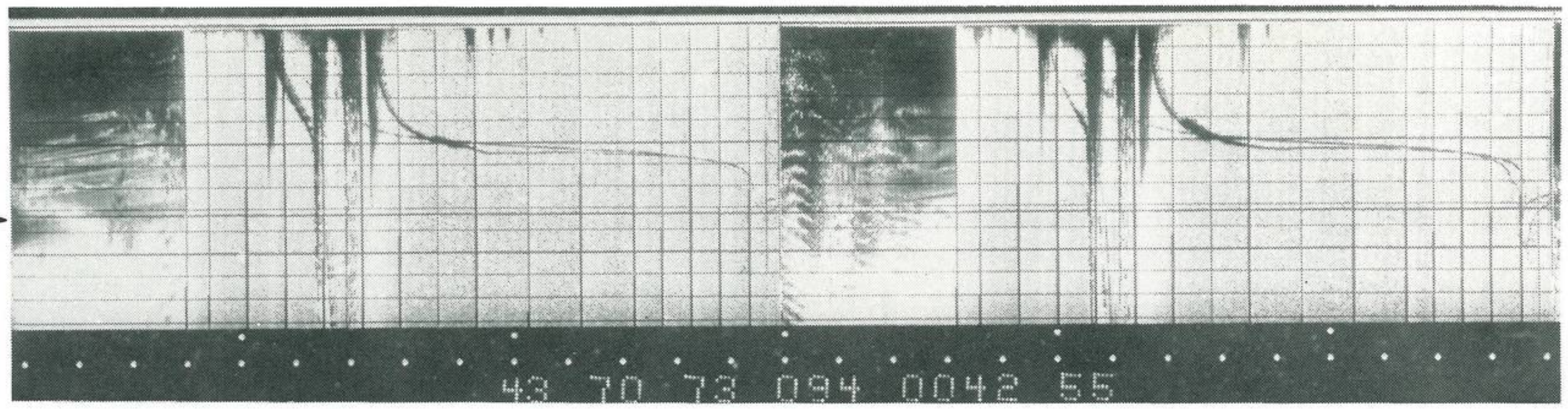
Telemetry antenna



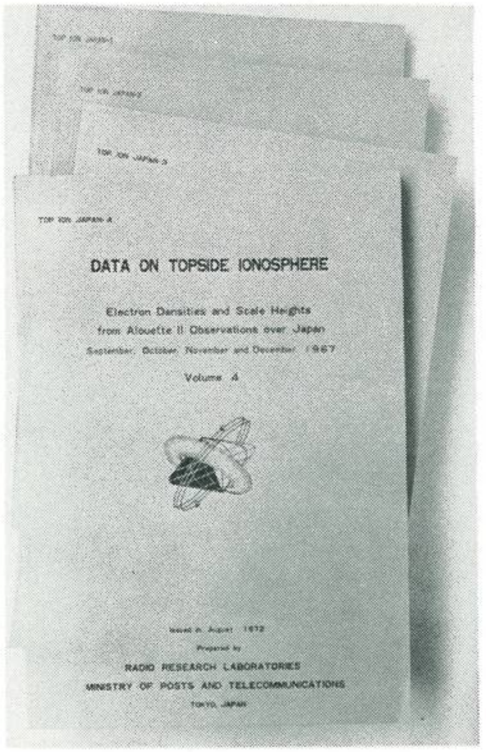
Analogue polarization follower

Total electron contents

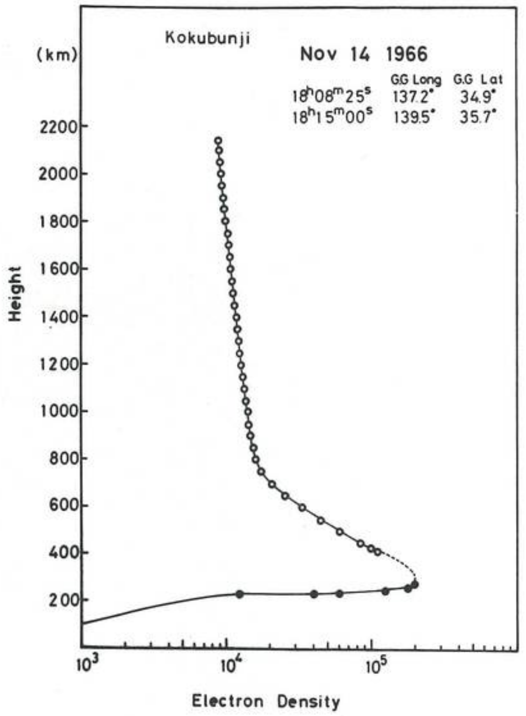




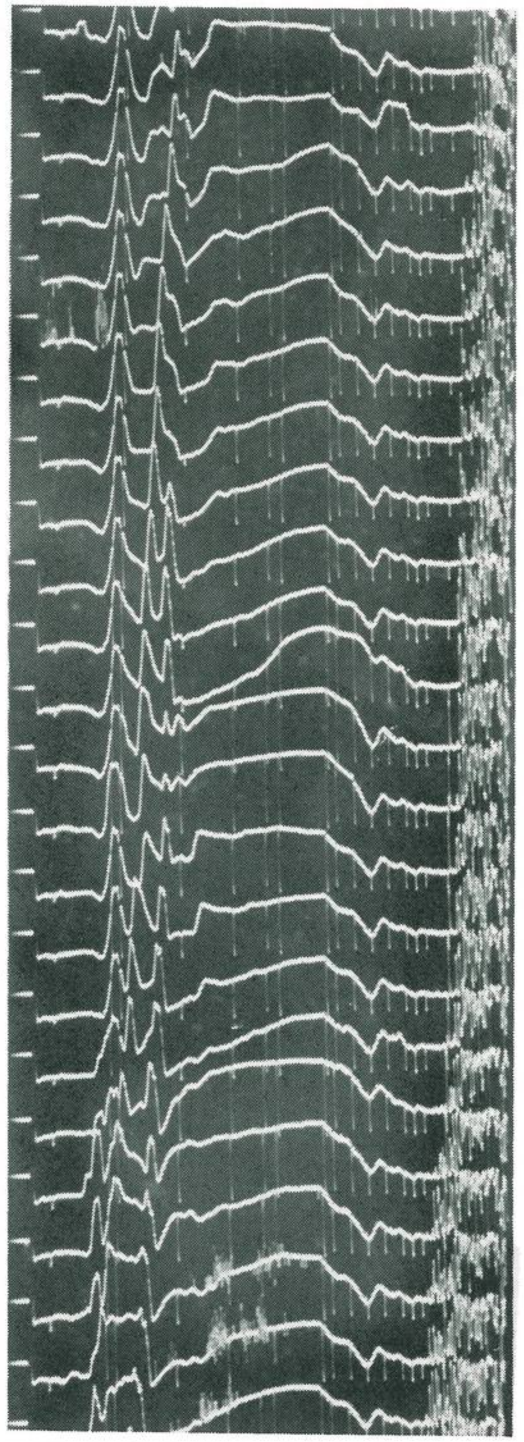
ISIS-II, Topside ionogram (swept and fixed frequency modes)



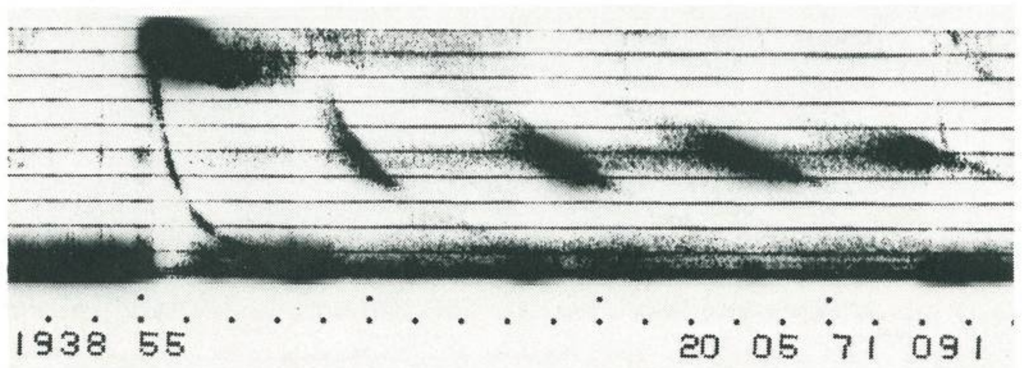
Data books



N(h) profile



Cosmic and solar radio noise in AGC voltage data of Alouette-II



Dynamic-spectrum of whistler echoes, observed at Alouette-II

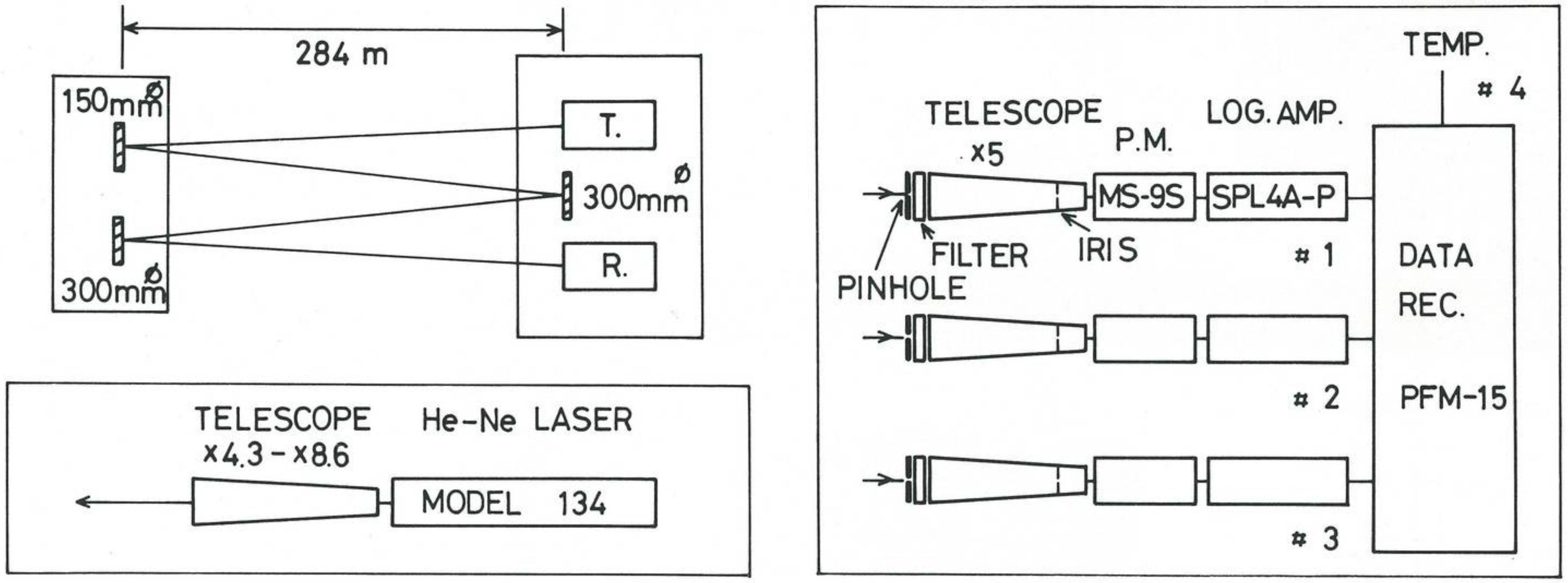
The ground-based ionospheric observation by radio waves does not clarify the conditions above the height of the maximum electron density of the ionosphere. Therefore, the ionospheric observation is carried out by a "topside sounding satellite" carrying an ionosonde on board and flying in the upper region of the ionosphere. The RRL took part in the International Satellites for Ionospheric Studies (Alouette/ISIS) project in August, 1966, and are carrying on observations around Japan. The photograph is the ionogram obtained by an international topside-sounding satellite. Such recording gives the entire picture of distribution of electron densities in the ionosphere (N-h profile), interdependent on the ionogram obtained on the ground.

The international ionospheric satellite observes whistlers, radio waves produced in lightning discharge and propagating along the geomagnetic field lines, and various audio waves originating in the magnetosphere. Such photograph as shown here affords information on the structure of the upper ionosphere and the magnetosphere. The topside sounding satellite also observes extra-terrestrial radio waves in the hectometric wave region, which can not be observed from the ground. The characteristics of galactic and solar radio emissions were clarified by this means.

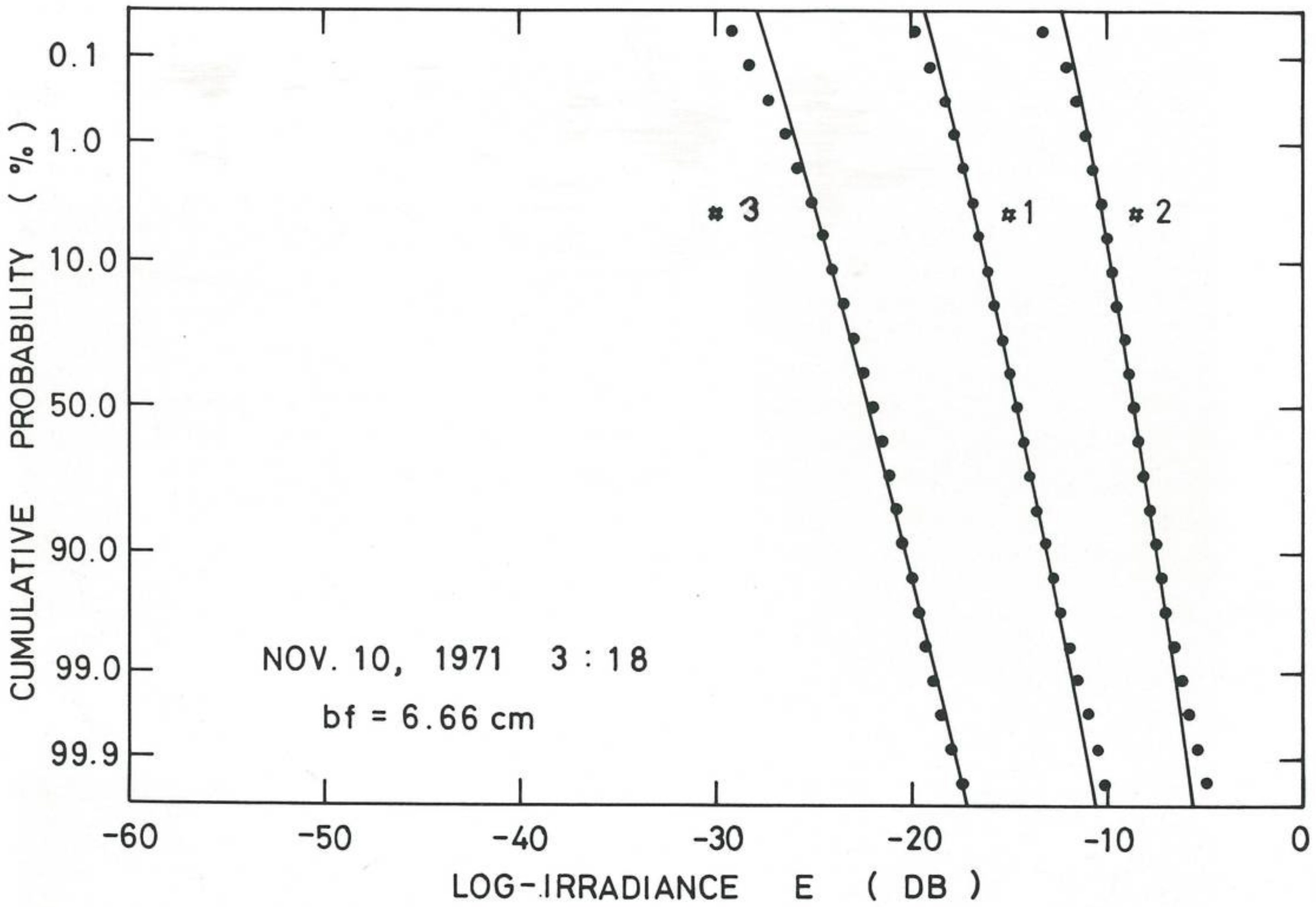
In addition, the study of the ionospheric conditions is in progress by monitoring Faraday effect on radio waves transmitted from various satellites (ATS–I, SYNCOM–III, etc.)

RESEARCH IN LASER WAVE PROPAGATION THROUGH THE TURBULENT ATMOSPHERE

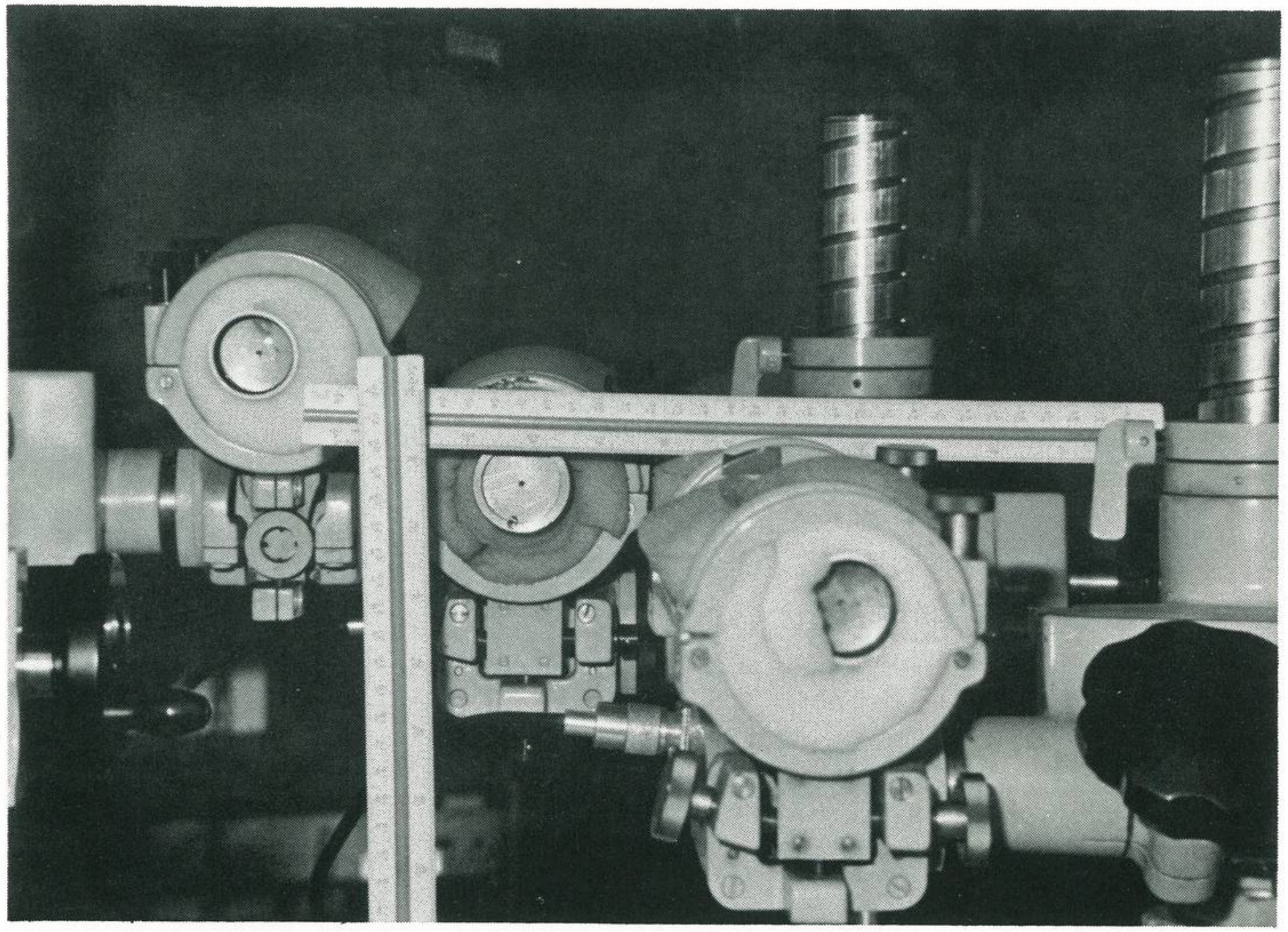
An experiment of He-Ne laser wave propagation was conducted on the folded path of about 1 km distance over the flat grass field in order to find out the characteristics of optical wave scintillation. Log-irradiance fluctuation of He-Ne laser waves were simultaneously measured at three different points on plane of radiance spot. The cumulative probability distribution of log-irradiance showed excellent agreement with Rice-Nakagami distribution in the region of weak fluctuations.



Block diagram of transmitter and receiver systems.



Cumulative probability distribution for log-irradiance fluctuations. The solid curves are theoretical and the dots are experimental. "bf" is the beam radius at the receiving point.



Arrangement of three-channel detector system. Each pinhole separation is 10 cm.

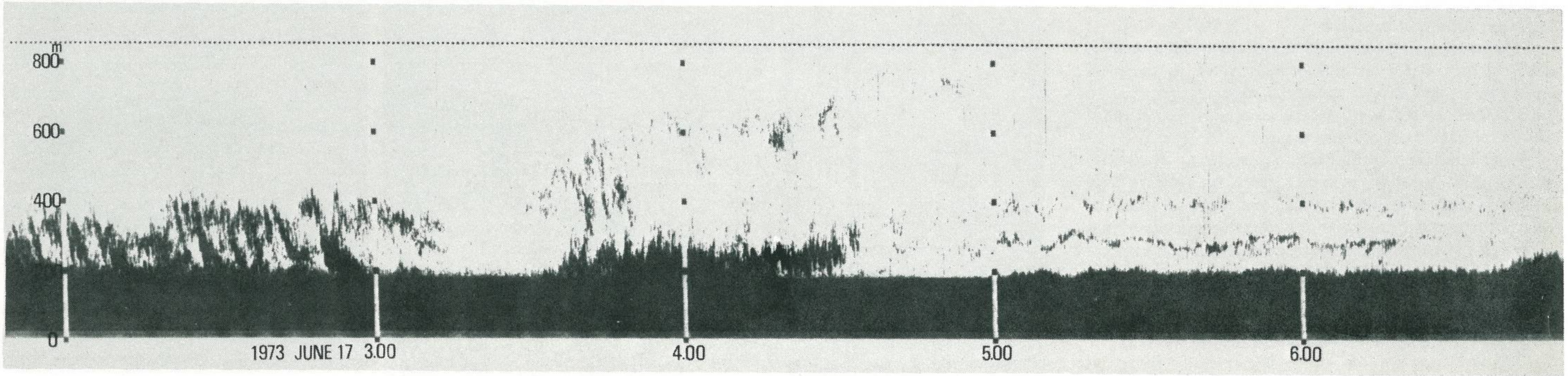
A 16-meter concrete paraboloidal dish and a 3-meter metal dish for acoustic sounding.

ACOUSTIC SOUNDING OF THE LOWER TROPOSPHERE

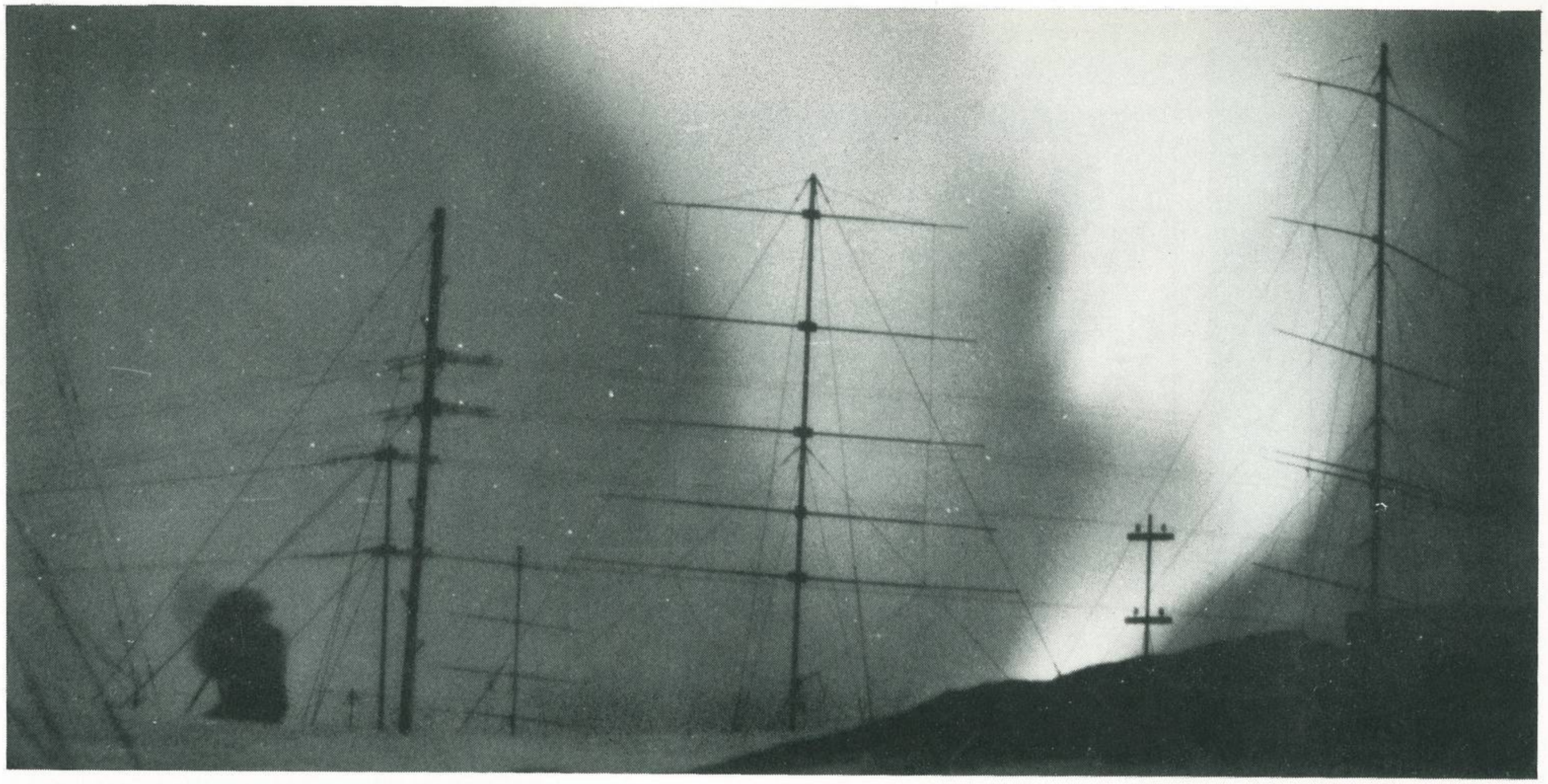
Acoustic sounding of the lower troposphere is now in progress by using a monostatic soder (acoustic sounder) in order to study the fine structure of the atmospheric boundary layer. The parameters of the sodar used in recent observation are as follows:

Sound frequency:	850 Hz
Output peak power:	30 W
Pulse width:	60 msec
Pulse repetition period:	9 sec

Soder



Soder records showing a typical examples multiple wavy layering



Riometer antennas

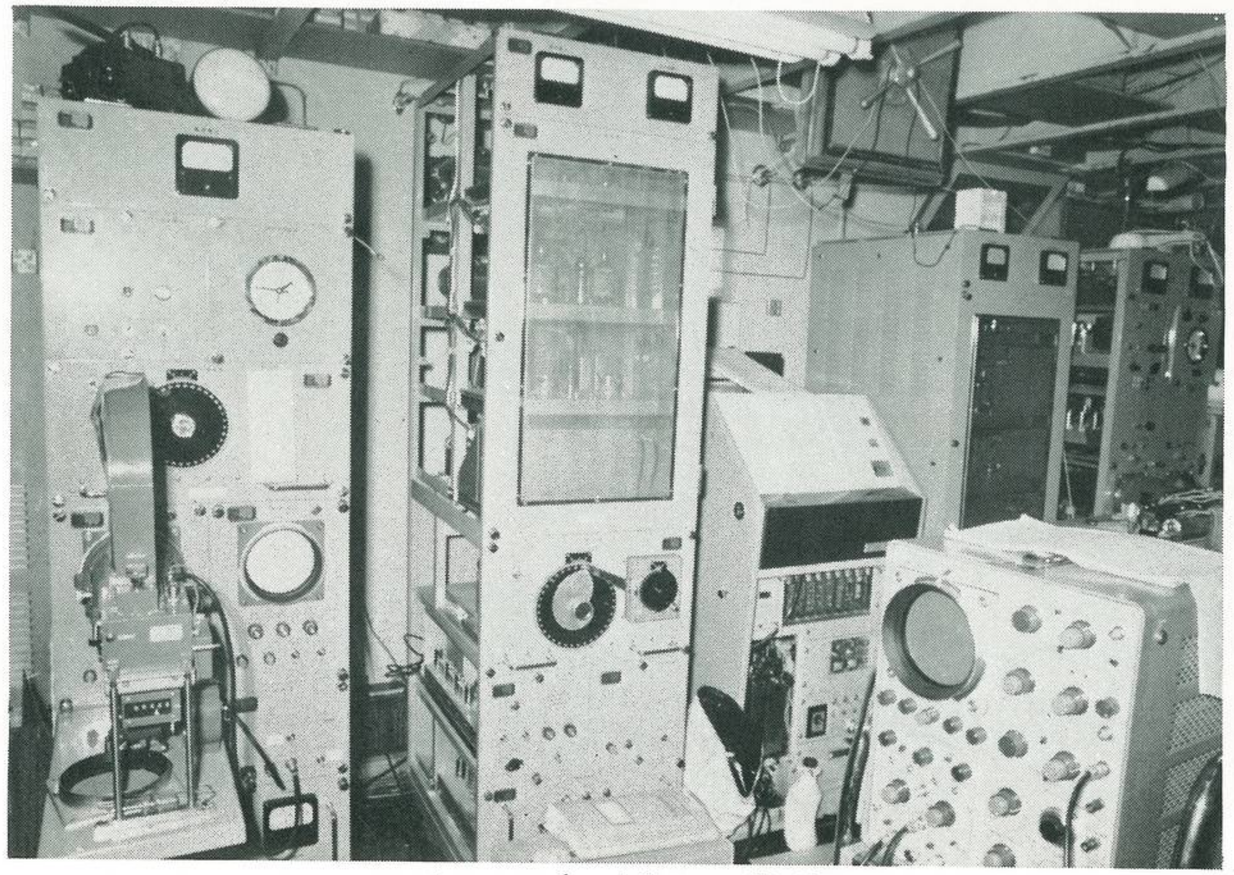
IONOSPHERIC OBSERVATIONS IN THE ANTARCTICA

Observations on the ionosphere have been carried out at Syowa Station, located at 69.0°S, 39.6°E in the Antarctica, since IGY period under the project of the Japanese Antarctic Research.

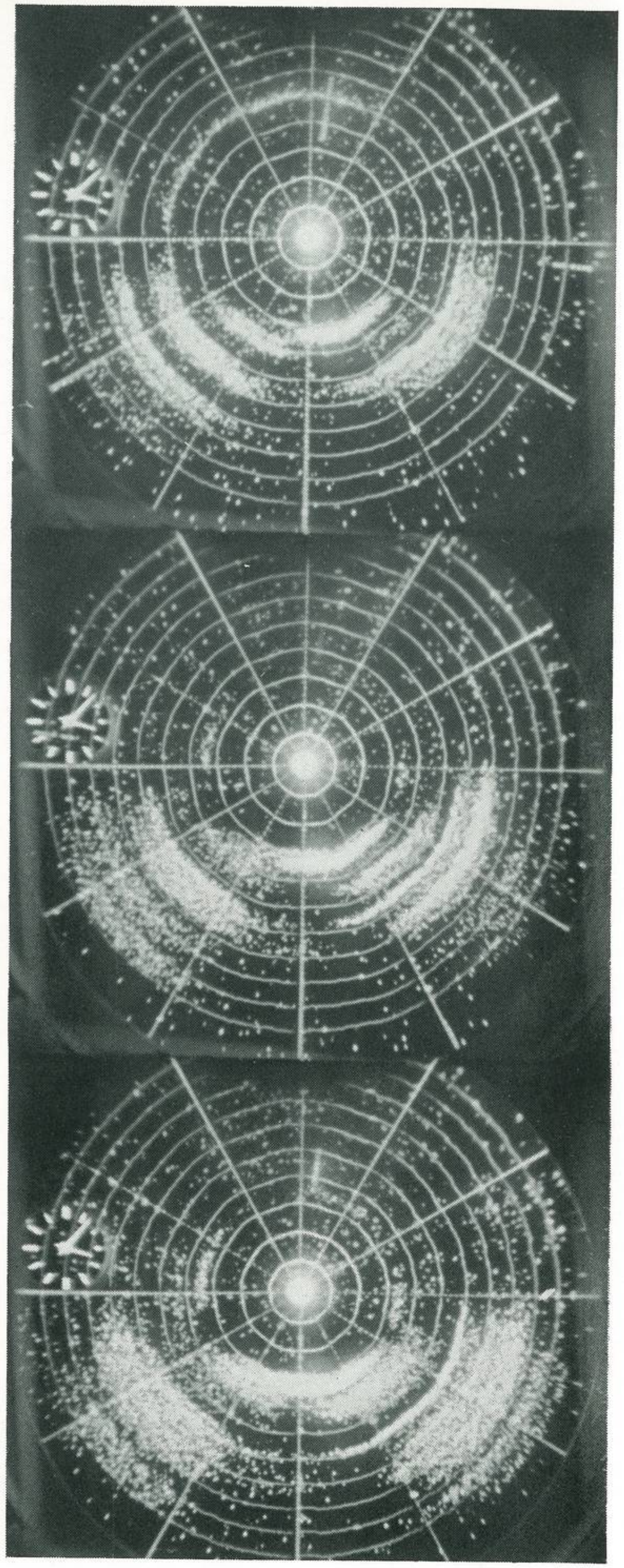
Items of the ionospheric observations which the RRL are responsible for at the present stage are vertical ionospheric soundings, measurements of ionospheric absorptions by using riometers, observations on radio aurora on VHF band and reception of VLF signals.

Sometimes, the intensified observations by rocket with various sensors, such as, electron density, high energetic and radio observations, are made in order to clarify the mechanism on various representations of the polar phenomena including aurora, ionospheric Es, geomagnetic disturbances, VLF emissions, etc.

The results of the observations are summarized and distributed to those who are interested in the polar aeronomy as well as trans-polar radio propagations.



Ionosonde at Syowa Station



Example of PPI record for radio aurora

DEVELOPMENT OF MILLIMETER WAVE TRANSPONDERS

The RRL is taking charge of development of millimeter wave transponders for the Experimental Communication Satellite (ECS) which is to be launched into the geostationary orbit early in 1977 by the three stage N rocket.

A bread board model (BBM) was produced in 1969 which translates 30 GHz input signal to 35 GHz output signal through 4 GHz IF amplifier with 500 MHz bandwidth. In the BBM, IMPATT oscillator was used in the local signal generations for the up and down frequency converters, and both of tunnel diode and transistor amplifiers were used in the IF stage.

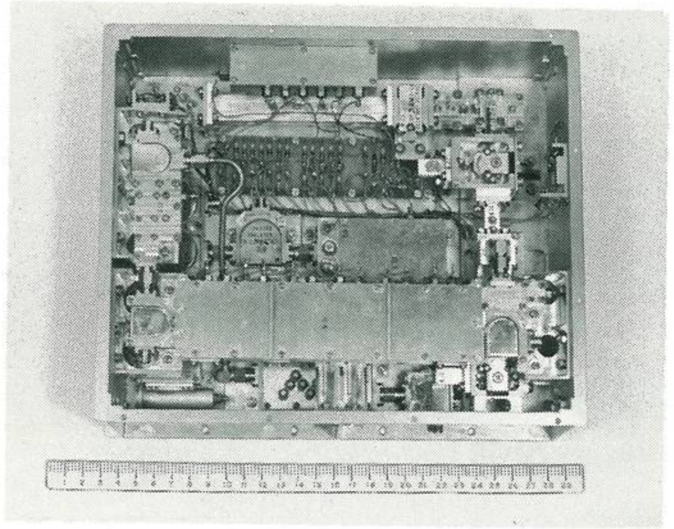
The first phase engineering models (EM_{1-1}) for receiving section were produced in 1971. In this phase, three kinds of model were developed; crystal controlled local oscillator type, gunn diode local oscillator type and parametric amplifier type. The production of space qualified components of light weight, small size, minimized power consumption, etc., and the development of integration technique were the main objectives of this phase.

The second phase engineering models (EM_{1-2}) for the receiving section were produced in 1972 based on the specifications (Table) settled reflecting the results of EM_{1-1} and WARC frequency allocation rule. In this phase, two kinds of models were produced; crystal controlled local oscillator and gunn diode local oscillator types. In the former, low noise GaAs Shottky barrier diode was used in the down converter and low noise, high gain transistors were adopted for the IF amplifier.

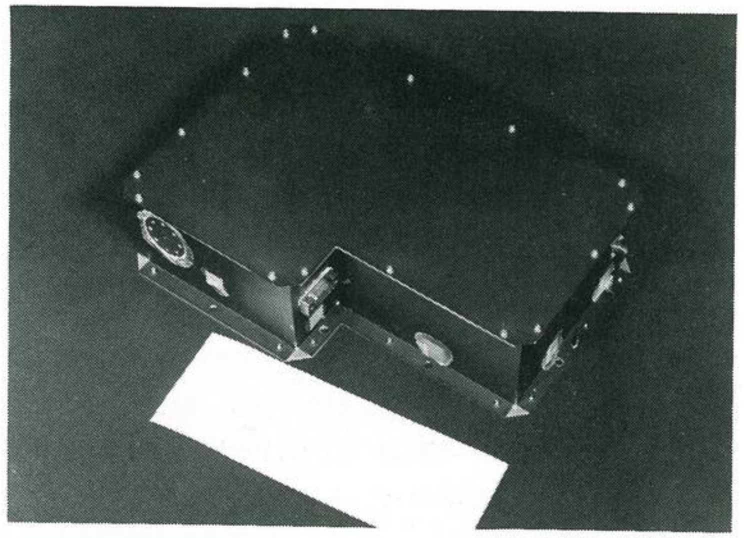
Especially, small power consumption and good frequency stability characteristics were obtained by adopting a lock–in amplifier into which the frequency multiplied crystal controlled oscillator signal in the local signal generator circuit is injected. In the latter, specially developed field effect transistors of low noise characteristics were used in the IF amplifier and GaAs Shottky barrier diode was adopted in the down converter. The frequency stability of the local signal was attained by inserting a high Q cavity rejection filter in the gunn diode oscillator circuit.

These EM_{1-2} passed all specified space environment and launch phase vibration tests. The outside views are shown in Photograph.

30 GHz and 4 GHz parametric amplifiers for space use were developed in the EM_{1-1} phase, and good noise figure of about 6.5 dB in the over-all performance was obtained.



An engineering model (EM_{1-2}) of mm wave transponder (crystal controlled local oscillator type)



An engineering model (EM_{1-2}) of mm wave transponder (gunn diode local oscillator type)

Table 1. Characteristics of millimeter wave transponder EM_{1-2}

1. Electrical characteristics	
receiving freq.	34.7 GHz
local freq.	30.75 GHz
IF freq.	3.95 GHz
gain	23.5 to 26.5 dB
band width	100 MHz (1 dB), 300 MHz (3 dB)
noise figure	12 dB
linearity in gain	3rd order cross modulation: −25 dB (−53 dBm input)
DC supply source	±21 V to 30 V
power consumption	4.5 W
2. Thermal characteristics (0～45°C)	
gain variation	1.5 dB
noise figure variation	1.0 dB
local freq. variation	$\pm 1 \times 10^{-5}$
3. Mechanical characteristics	
weight	2.5 kg
vibration test	4 to 8.5 G (5 to 2000Hz)
thermal vacuum test	10^{-5} Torr., 24°C

STUDY OF SATELLITE DESPIN ANTENNAS

Two kinds of electrical despin antenna (EDA) have been developed for S and C bands operation.

One is a horn array type which consists of 16 square horns arranged along the surface of cylindrical satellite body in a circular plane perpendicular to the spin axis.

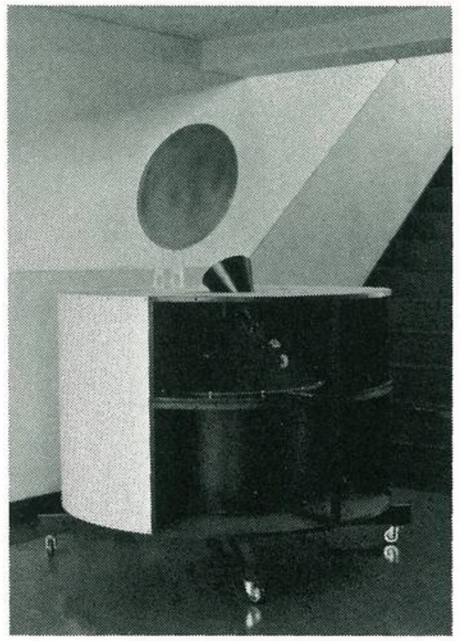
The electrical signal is switched synchronously with the satellite spin motion in such a manner that only two horns, adjacently placed are always activated.

The other is a unipole elements array type which consists of 16 unipole elements circularly arranged in the central portion of the circular parallel plane horn radiator. Successively placed 4 elements are simultaneously activated by electrical signals of properly phased equal amplitude. The active elements are switched synchronously with the satellite spin motion.

The mechanical despin antenna (MDA) is superior to EDA in the higher frequency operation due to increased feeder loss in the latter. Since 1971, the RRL started the study of MDA used in multiple frequencies of SHF and millimeter waves, and made two kinds of model in trial. One is conical horn-offset parabolic antenna which is applicable to the ordinary single body spin satellite. A coaxially stacked two biconical horn assembly is mounted in the center of top plane of the satellite body, and multifrequency signals are fed through inner circular or outer coaxial wave guides. A parabolic reflector is rotated around the primary radiator of the biconical horn assembly.

The other is corrugated horn-offset parabolic antenna developed for applying to a despin platform type satellite. The shape of the reflector and the corrugated horn primary radiator were designed for the antenna beam to cover Japan proper and its surrounding islands effectively over wide frequency range.

An electrical despin antenna of unipole elements array type



A mechanical despin antenna of corrugated horn-offset parabolic antenna type

OBSERVATIONS ON MILLIMETER WAVE PROPAGATION CHARACTERISTICS

To study the propagation characteristics of millimeter wave in various weather condition is very important for determining millimeter wave satellite communication link parameters.

By using a kind of sun-tracker system, absorptional and scattering attenuation measurement in 35 GHz frequency band has been carried out since November 1970 at Koganei (headquarters of the RRL), and also the 3 km diversity effect measurement was conducted from June 1971 to December 1972 by installing the second equipment of the same type at the site 3 km east of the headquarters of the RRL.

In February 1973, the diversity distance was extended to 15 km by moving the second equipment from Koganei site to Hamura site, 15km west of Koganei.

In addition to the sun-tracker observation, radiometer attenuation measurement at 45° elevation angle has been also carried out.

The observation results are summarized as follows.

Attenuation statistics of one site show that the time percentages to which attenuation exceeding 20 dB and 10 dB are 0.02% and 0.1% respectivly in winter and spring time, and 0.1% and 0.8% respectively all through the year. Although the diversity effects were scarecely observed in the 3 km diversity distance case, the effects due to rain cells and their movements have been often observed in the 15 km distance case.

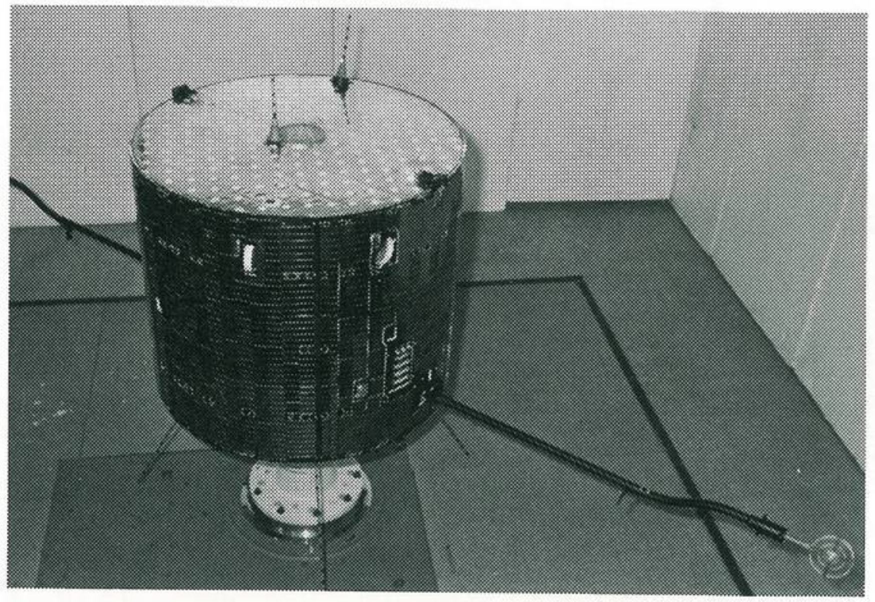
A sun-tracker for observation of mm wave propagation characteristics

SOUNDING SATELLITES OF THE UPPER ATMOSPHERE

The Ionosphere Sounding Satellite (ISS) planned in 1967 by the RRL will be launched in 1976. The ISS, which is now under construction at NASDA (National Space Development Agency) in close cooperation with the RRL, has four mission instruments; Topside Sounders (TOP) of the ionosphre, Retarding Potential Trap (RPT) for measuring ionospheric plasma density and temperature, the mass spectrometer for measuring Positive Ion Composition (PIC), and the instrument for measuring Radio Atmospheric Noise (RAN).

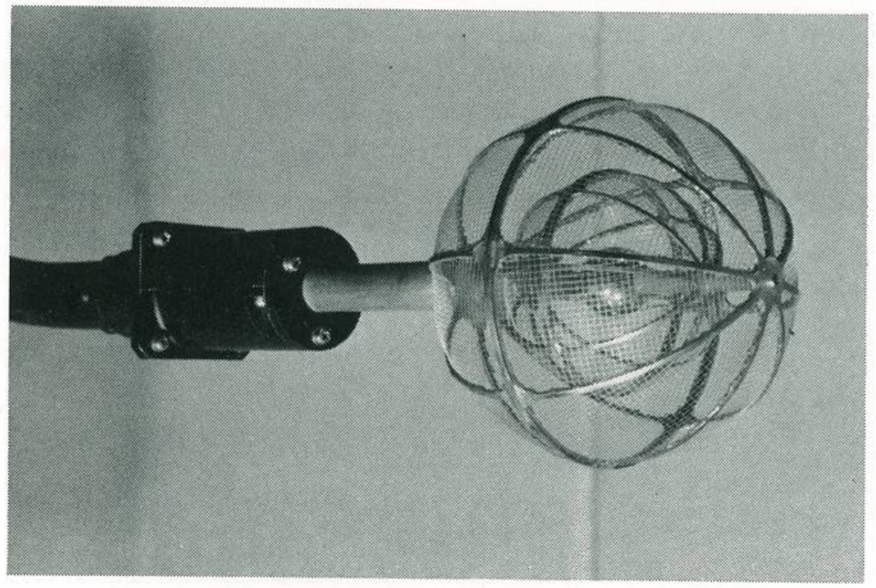
A future plan for the ISS series is being formed, in parallel with the development of new types of on board instruments.

Further, members of the ionospheric Satellite Research Section are also participating in the scientific satellite programs of the Institute of Space and Aeronautical Science, Tokyo University, in the sounding plasma probe and the mass spectrometer developed by the RRL.



Ionosphere sounding satellite

The apperture of positive ion composition is seen at the center on the upper side.
The antenna of Topside Sounders and Radio Atmospheric noise are rolled up in the frame.



Retarding potential trap

STUDY OF PLASMA CHARACTERISTICS OF THE UPPER ATMOSPHERE

Various plasma probes have been developed in the past fifteen years; for example, the radio frequency resonance probe, electrostatic probes including the retarding potential trap. The availability of these probes for ionospheric observations has been often proved by a number of rockets launched from Kagoshima Space Center of Tokyo University, and from Syowa Station in Antarctica.

Emphasis of the research is recently placed on clarifying the mechanisms by which plasma waves are excited and maintained, and on energy transfer processes by plasma waves propagating through the space.

In addition to the in si-tu measurements of the upper atmosphere by sounding rockets and satellite, the space plasma chamber in the RRL has been used for studying the characteristics of upper atmospheric plasmas.

STUDY OF COMPOSITION AND CHEMICAL REACTION IN THE UPPER ATMOSPHERE

Air composition of the upper atmosphere, in a neutral gas state and/or in a plasma state, is being studied by mass spectrometers on board rockets and satellites. To this end, several types of mass spectrometers including guadrupole type and Benett type have been developed for space use. Stratospheric air composition at the height of 20–40 km has also been measured by the mass spectrometer installed in a baloon, in cooperation with Tokyo University.

The laboratory experiment simulating chemical reactions in the lower ionosphere is the major subject of the recent research, and specially the photoionization in NO-H_2O mixtures produced by a hydrogen ultra-violet source is investigated with the aid of the mass spectrometer.

DEVELOPMENT OF PORTABLE MASS SPECTROMTERS FOR POLLUTE AIR COMPOSITION

The techniques for mass spectrometers for space use mentioned above are being applied to developing a portable mass spectrometer for measuring polluted air composition, under the sponsorship of the Environment Protection Agency. This research aims at gaining the wide coverage of mass number up to 300 AMU, the high resolution (1 AMU at 300 AMU), and the high sensitivity (0.01 PPM).

ISS DATA ACQUISITION AND PROCESSING

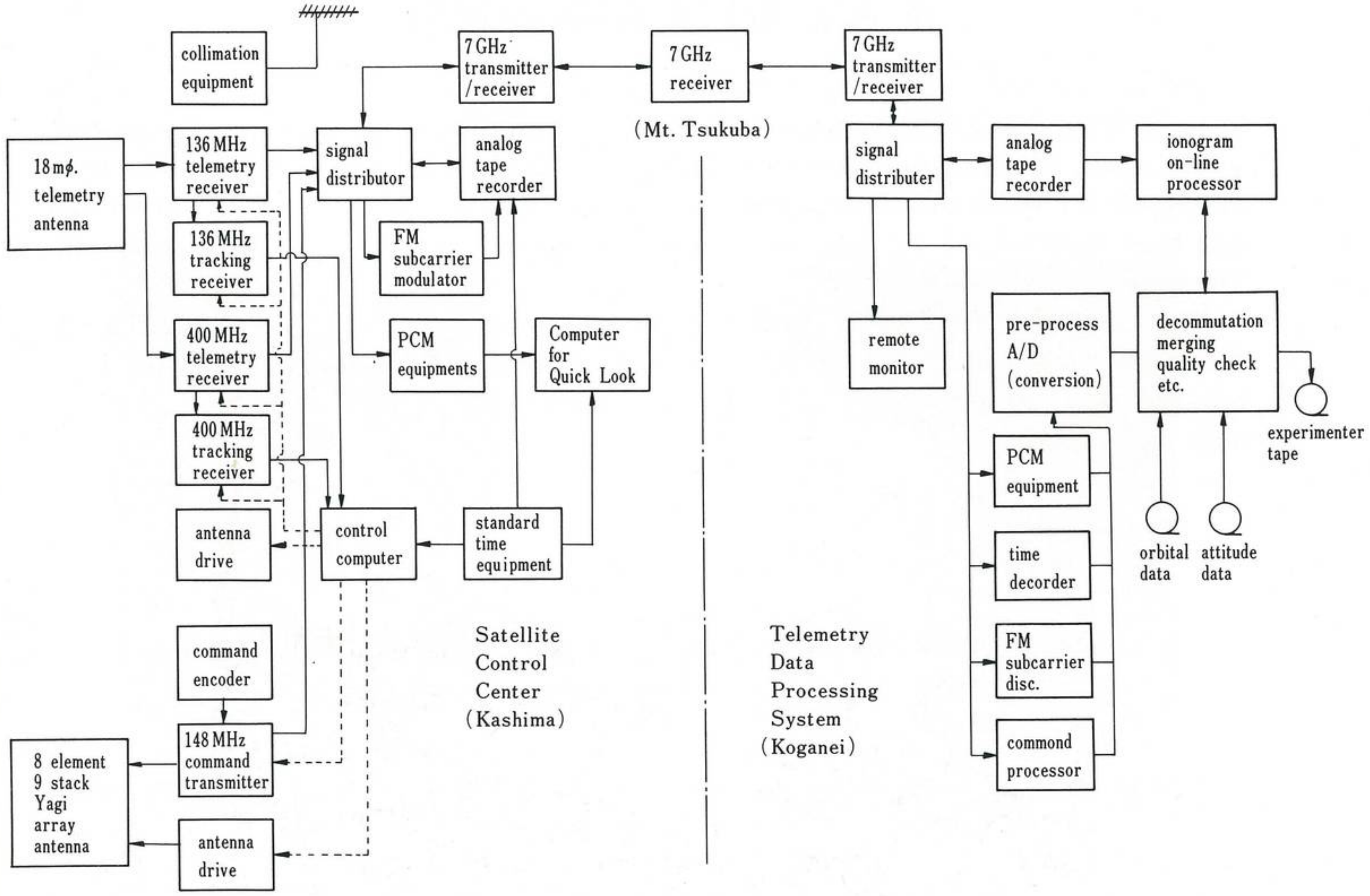
ISS (Ionosphere Sounding Satellite) is scheduled to be launched early in 1976 and the ground facilities are being prepared at Kashima and Koganei as shown in Figure (under). They were designed for applications to various satellites besides ISS and are currently operated for Alouette/ISIS satellites.

The Satellite Control Center at Kashima receives telemetry signals of 136 MHz and 400 MHz and sends command signals of 148 MHz. Quick-Look data can be processed to monitor spacecraft status on real-time basis. Telemetry data recorded on magnetic tapes are sent to Koganei for data processing and analysis. The 7 GHz radio link between Kashima and Koganei is to be used for the transmission of telemetry data.

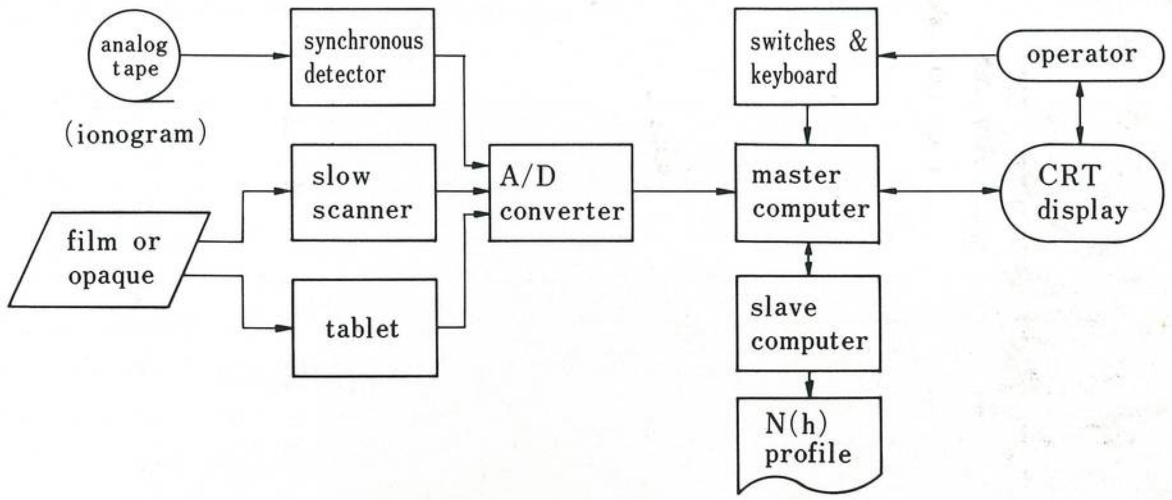
A feature of the Satellite Control Center is computer-controlled operations of equipments such as pointing the antenna to a satellite, turning on the command transmitter, and starting the tape recorder. The photograph (page 21) shows the control building and the telemetry antenna with 18 meter diameter.

The telemetry data processing system at Koganei converts the analog tapes sent from Kashima into digital tapes, which are then decommutated by a computer to generate each experimenter tape in which orbital data and attitude data are merged Commands and other station data are also processed to be correlated with telemetry data.

For the topside sounding experiment of Alouette/ISIS and ISS, a particular system called "ionogram on-line processor" is prepared as shown in Figure (under). The processor is a man-machine system to convert sounder data into electron density N(h) profiles with the abilities of a human operator for pattern recognition and decision making. The operator scales a trace out of composite echo traces on the CRT display, and commands the slave computer to calculate the corresponding N(h) profile and the ionogram that is obtained from the profile. The operator then compares the computed trace and the remaining traces of the original on the CRT, and rescale until good agreement is achieved.



Block diagram of ISS data acquisition and processing



Block diagram of ionogram on-line processor

RESEARCH ON ORBITS AND ATTITUDES OF SATELLITES

The orbit and attitude of artificial satellites have been studied, so that the suitable orbit and attitude may be selected for various satellite missions.

Characteristics of sun synchronous, recurrent, near recurrent, polar, synchronous and stationary orbits, and the relations between them were examined. On sun synchronous, recurrent or near-recurrent orbits, a precise method of determining orbital elements has been presented, and on synchronous orbits, there have been found special cases in which satellites are nearly stationary for a few hours at medium or high latitudinal points.

The attitude stability conditions have been found for unsymmetric multiple spin satellites, where the friction at the bearings of the rotational axes is not negligible. The method of predicting the long-term attitude drift of unsymmetric multispin stabilized satellites has also been presented.

The study of controlling effectively the attitude of three axis statilized satellites is now in progress.

OUTLINE OF KASHIMA EARTH STATION

Introduction

In October 1957, the USSR first launched an artificial satellite "Sputnik" with success. Since then, techniques on the artificial satellite have been developed remarkably, and many of them have secured excellent results in practical use for observations into space, communications, meteorologies, navigations, surveyings and so on.

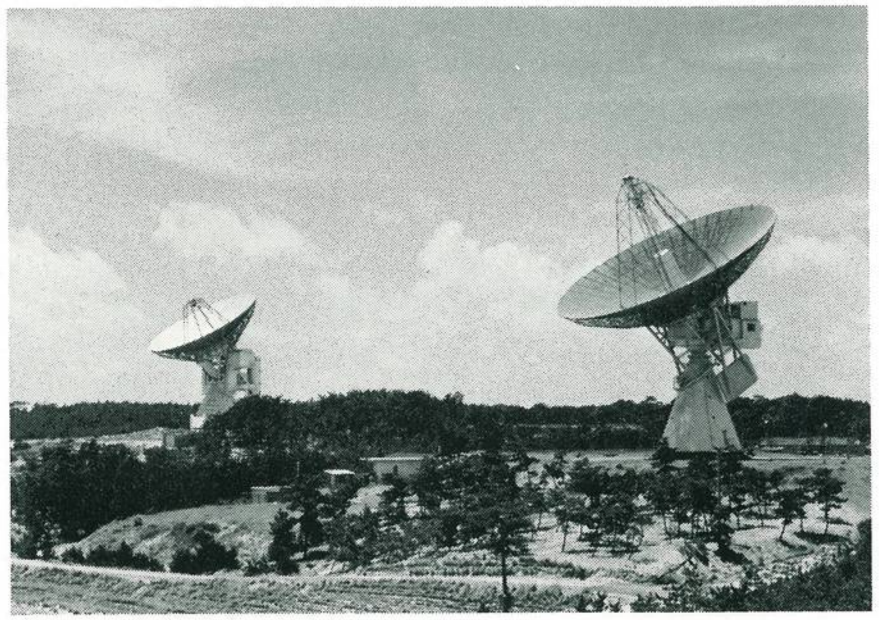
The RRL, in preparation for the days of space communications, erected a 30mϕ paraboloid antenna which is the largest in diamteter in Japan, at Kashima-machi, Ibaraki-ken, 90 km to the east-northeast of Tokyo, in 1963 and established the Kashima Branch as an earch station for space research and space communication experiments in May 1964. Then the station started the various communication experiments by the use of NASA's mobile and stationary communication satellites in cooperation with the USA, Northern Europe and Australia. On the occasion of Tokyo Olympiad in 1964, Kashima earch station successfully contributed to the first international relay of TV pictures via Syncom-III. At that time, additional 7GHz micro-wave terminals were installed in the existing 13GHz micro-wave link between Kashima and the RRL headquarters in Tokyo via Mt. Tsukuba, for the transmission of TV pictures. In February 1966, the radio astrononomical observations, especially a survey of Galaxy at 4GHz, were commenced with Tokyo Astronomical Observatory by the use of 30 mϕ antenna, time sharing with the communication experiments. In August of the same year, Kashima earth station constructed further a 9-element and 8-stack Yagi array antenna facility for the 136 MHz tracking and telemetry of satellites, and started the date acquisition of Alouette-I, the Canadian ionosphere soudning satellite launched in September 1962.

In 1966, NASA launched an Applications Technology Satellite (ATS-I), SHF transponder frequencies of which were 4GHz for down link and 6 GHz for uplink. Therefore, the modification of 30 mϕ antenna facilities for the ATS-I had been made, and Kashima earth station conducted a PCM-FM multiple access communication experiment in cooperation with Nippon Telegraph and Telephone Public Corporation (NTT) with the support of NASA. This experiment leads to a new way for the usage of PCM on the future practical satellite communications. In 1968, another parabolic antenna 26 meters in diameter was constructed for the 4/6GHz geostationary satellite communication experiments, because the 30 mϕ antenna was overflowing with many communication and radio astronomical experiments and was somewhat low in gains at 6GHz due to the surface roughness of main reflector. Figure (left) shows 30 mϕ and 26 mϕ antennas. By the use of 26 mϕ antenna, various experiments via ATS-I have been carried out, i.e. R/RR and poralization angle measurement of ATS-I in a routine basis, SSB-PM multiple access communication experiments (1969 to 1971), receiving experiment of SSCC pictures with Japanese Meteorological Agency (1969 to 1971), TV transmission test for PCM multiplexed sound with NHK (1970), TV transmission test for TDM dual pictures and 14 sounds in a TV channel with NHK (1971), narrow band digital tone ranging and data transmission test with Ministry of Transport (1972), and so on. The collimation equipments for 26 mϕ antenna are set up on the top of a chimney of 175 meters high above the ground and about 5 km far from the station.

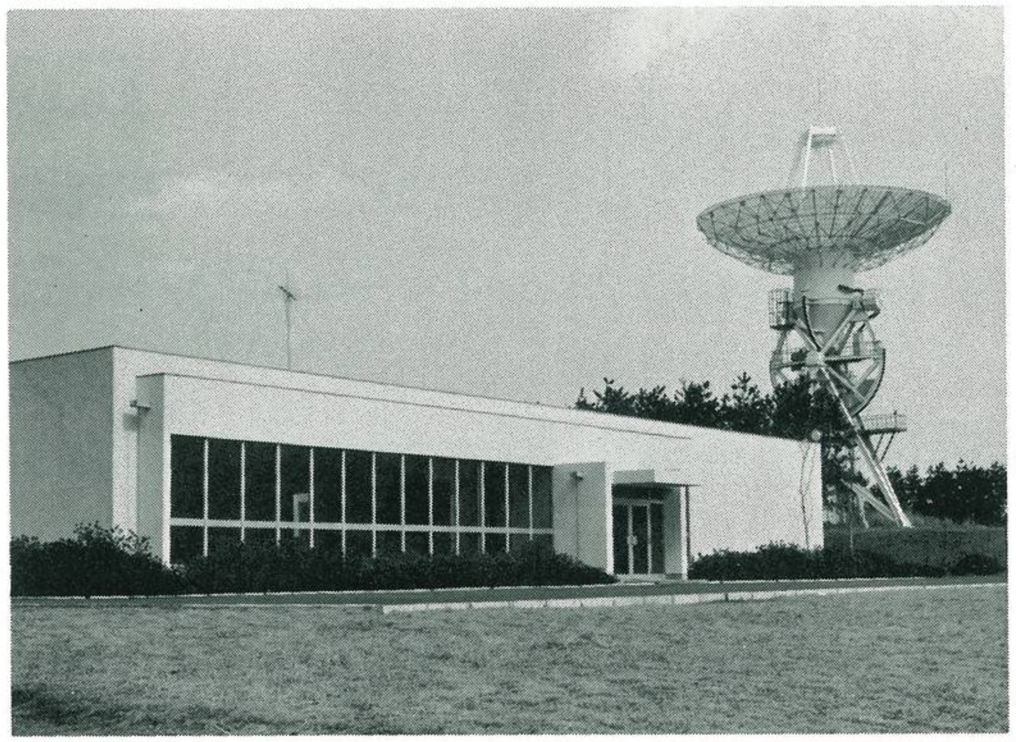
In 1970, the construction of a parabolic antenna 18 meters in diameter and 8-element and 9-stack Yagi array antenna were commenced at Kashima earch station for the VHF tracking, telemetry and commanding (T. T & C) for the Japanese ionosphere sounding satellite (ISS) to be launched in 1976. Figure (right) shows the control building and the 18 mϕ receiving antenna.

Therefore, Kashima earch station has now three paraboloidal antennas, 30 mϕ, 26 mϕ and 18 mϕ, and two Yagi array antennas. Table (next page) shows main characteristics of each antenna. Total area of the station is about 10 hectares (about 25 acres).

In the following sections, the study projects now in progress at the station are briefly described.



Telemetry antenna (left) 26 mϕ (right) 30 mϕ



Control building and 18 mϕ telemetry antenna

Antenna performances

Antenna Performance	30mϕ (Cassegrain)	26mϕ (Cassegrain)	18mϕ (front feed)	Yagi (Command)
Latitude Longitude	35° 57′ 22.037 140° 39′ 45.567	35° 57′ 14.919 140° 39′ 45.648	35° 57′ 22.380 140° 39′ 36.820	35° 57′ 12.000 140° 39′ 37.763
Height abv. S. L. G. L. abv. S. L.	42.2m 24.7m	43.44m 25.44m	44.76m(X)40.90m(Y) 29.20m	40.60m(X)39.65m(Y) 32.26m
Mount type	Az−El	Az−El	X−Y	X−Y
Rotation Speed	Az. 0.002−7°/s El. 0.002−3°/s	Az. 0.002−1°/s El. 0.002−1°/s	0.01−2°/s 0.01−2°/s	0.01−2.5°/s 0.01−2.5°/s
Surfacc roughness	5mm r. m. s.	0.8mm r. m. s.	2.3mm r. m. s.	
Receiv. freq. (MHz) (Coverage band)	4178±12.5 (4.1−4.2GHz)	4119±12.5; 4178±12.5 (3.7−4.2GHz)	(V)135.5-139.0(137±3) (U)398.6-403.4(400±5)	137.0±1.5 (137±3)
Transmit. freq. (MHz) (Coverage band)	 (6.25−6.35GHz)	6301.05±12.5 (5.925−6.425GHz)		148.255 : 148.270 (151±5)
Gain	56dB(4GHz) 55dB(6GHz)	59dB(4.1GHz) 62dB(6.2GHz)	23dB(137MHz) 34dB(400MHz)	20dB(148MHz)
Noise temparature (4GHz)	Zenith 57°K 8°El. 93°K	Zenith 21°K 5°El. 46°K		
Beam width (3dB down)	<0.2° (4GHz) 6.2°	<0.2° (4GHz) <0.12° (6GHz)	3° (400MHz) 8° (137MHz)	18° (148MHz)

STUDY ON THE GEOSTATIONARY SATELLITE COMMUNICATION SYSTEMS

MEASUREMENT OF R/RR AND POLARIZATION ANGLE OF ATS- I

The position and orbit of satellite are determined by the measurement of range and range rate (R/RR) between earth station and satellite, and also the attitude of satellite are measured from the polarization angle of satellite beacon wave. For very precise determination of them, it is necessary to measure the R/RR and polarization angle simultaneously by three earth stations separated from each other as far as possible.

Kashima earth station has been supporting NASA on the measurements of R/RR and polarization angle of ATS-1 at 4 GHz regularly once every two weeks with Rosman and Mojave (ATS stations in USA). On the occasions of ATS (I—V) launching, the data from Kashima earth station have played especially an important role in injecting the satellite into the geostationary orbit, because the apogee of transfer orbit of the satellite came above the Far East.

The R/RR equipment at Kashima earth station, called ATSR, was one of four sets developed by NASA for ATS ranging and was provided by NASA at the ATS-I launching in 1966. The instrumental accuracy of the ATSR is 1.5m in the range and 1 cm/sec in the range-rate. The date obtained every 10 seconds at Kashima are immediately transmitted into the GSFC computer directly by teletype and the orbit of ATS-I is computed out with data of two other stations. The measurement of polarization angle is made by a polarization auto-tracking equipment and azimuth/elevation angle encorders, both being equipped in the 26 mϕ antenna system. The angle resolution of polarization auto-tracking equipment is 0.1 degree.

Recently, Kashima earth station has developed an SSRR (Spread Spectrum Range and Range rate) equipment, which can measure the R/RR and polarization angle almost automatically the use of mini-computer installed in, and the accuracies of these data measured are almost the same as ATSR. Therefore, since April 1973 the regular R/RR and polarization angle measurements of ATS-I have been made by the SSRR equipment instead of the ATSR. The ATSR is to be sent Ahmedabad in India and to be installed at the station for the ATS-F project.

SSRA AND SSRR EXPERIMENTS VIA ATS- I

Various communication experiments have been conducted at Kashima earth station using ATS-I SHF transponder. Especially the experiments based on PCM-FM systems were worthy of mention. In PCM-FM system, it was intended to get as many communication channels as possible, by the time sharing of information. On the other hand, the SSB-PM system is based on the principle of frequency sharing of information carrier. The results of both experiments showed an effective usage of the whole channel capacity, but the necessity of large and sophisticated facilities.

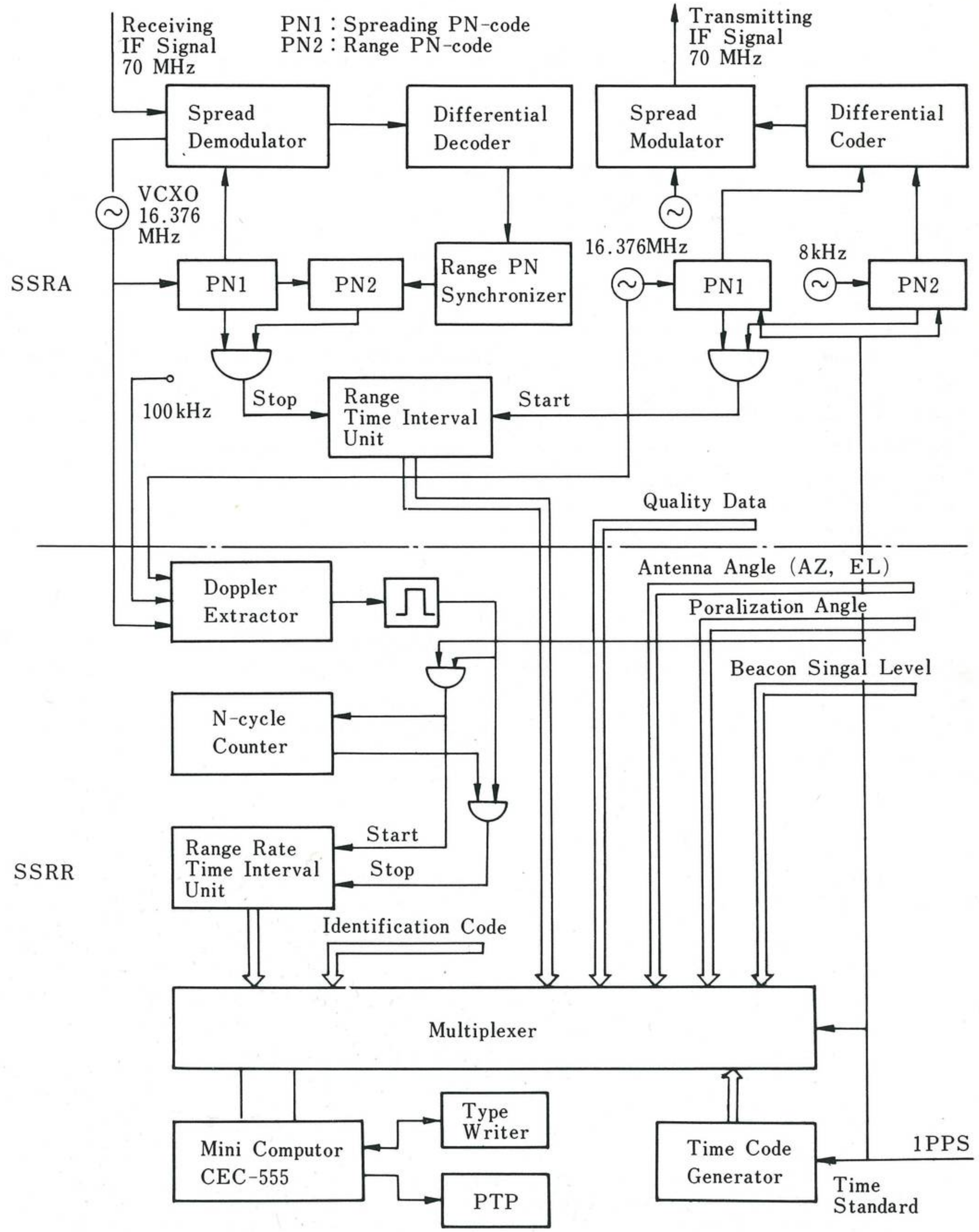
The spread spectrum random access (SSRA) system which is now under experimental investigation at Kashima, utilizes the whole frequency band and time domain simultaneously and channel separation is made by the division of transponder output power, that is, the primary frequency or phase modulated signal is secondary phase modulated by a PN code assigned to the communication mate for the identification of each station, and then emitted to the satellite. The received signals from the satellite are correlated with receiving station's own PN code pattern and if there is same code pattern in the signals, the signal is locked on that pattern and then the information is deduced. This system is essentially suitable for the small users such as mobile or solitary island stations, because of random access and the needlessness of large antenna. Further, this system has an ability of range measurement between earth and satellite, simultaneously with the communications. Therefore, the spread spectrum range and range rate (SSRR) equipment was developed and suing this equipment, the regular R/RR measurements for ATS-I have been performed instead of the ATSR. Figure (right) shows the simplified functional diagram of SSRA and SSRR equipment. Table (upper) indicates the SSRA system parameters and Table (lower) indicates the resolutions of SSRR system.

System Parameters of SSRA

Modulator Specifications	
Operating frequency	70 MHz
Input signal	Voice : 300 Hz to 3.4 kHz BW FSK data : 100 bauds (1700±400Hz)
Primary modulation	FM with 3.4 kHz to 12 kHz peak frequency deviation
Secondary modulation code	Maximum length linear sequence
Code clock rate	16.376 MHz and 8.188 MHz selectable
Code length	2047-32767 bits by 15-stage feedback shift register
Demodulator Specification	
Operating frequency	70 MHz
Predetection bandwidth	Selectable (15kHz, 28kHz, 4kHz)
Message demodulator	Conventional FM discriminator and feedback FM discriminator
Output frequency response	300Hz to 3.4kHz
Cross-correlation tracking	Delay-lock discriminator
Acquisition	Sweep by clock frequency offset up to 500Hz
Ranging Specification	
Mesuring range time accuracy	1×10^{-8} sec
Reading digits	8 digits
Sampling rate	1 sample/sec
Range ambiguity signal	8000 bits PN code with clock rate of 8 kHz

Calculated errors of range and range rate of SSRR

	Resolution	R.M.S. Error	Condition
Range	1.5 m	60 cm	total C/N in IF = −17 dB
Range-rate	20 cm/sec	6 cm/sec	total C/N in IF = −17 dB total count $N=5\times10^4$



SSRA & SSRR simplified functional diagram

STUDY ON THE TRACKING, TELEMETRY AND COMMAND SYSTEMS

DEVELOPMENT OF T.T. & C. FACILITIES FOR ISS

The construction of an 18mϕ paraboloidal antenna and an 8-element and 9-stack Yagi array antenna was commenced in 1970 for the tracking, telemetry and commanding for the Japanese ionosphere sounding satellite (ISS) to be launched in 1966. The main part of the facilities was almost completed in the summer of 1972, but there are some portions which remain to be accomplished by March 1975. Those are PCM data handling equipment, a process computer for satellite orbit calculation, data processing, status display and control of the subsystem. The block diagram of the system is shown in Figure (right) in which some broken-lined blocks show the remaining equipments.

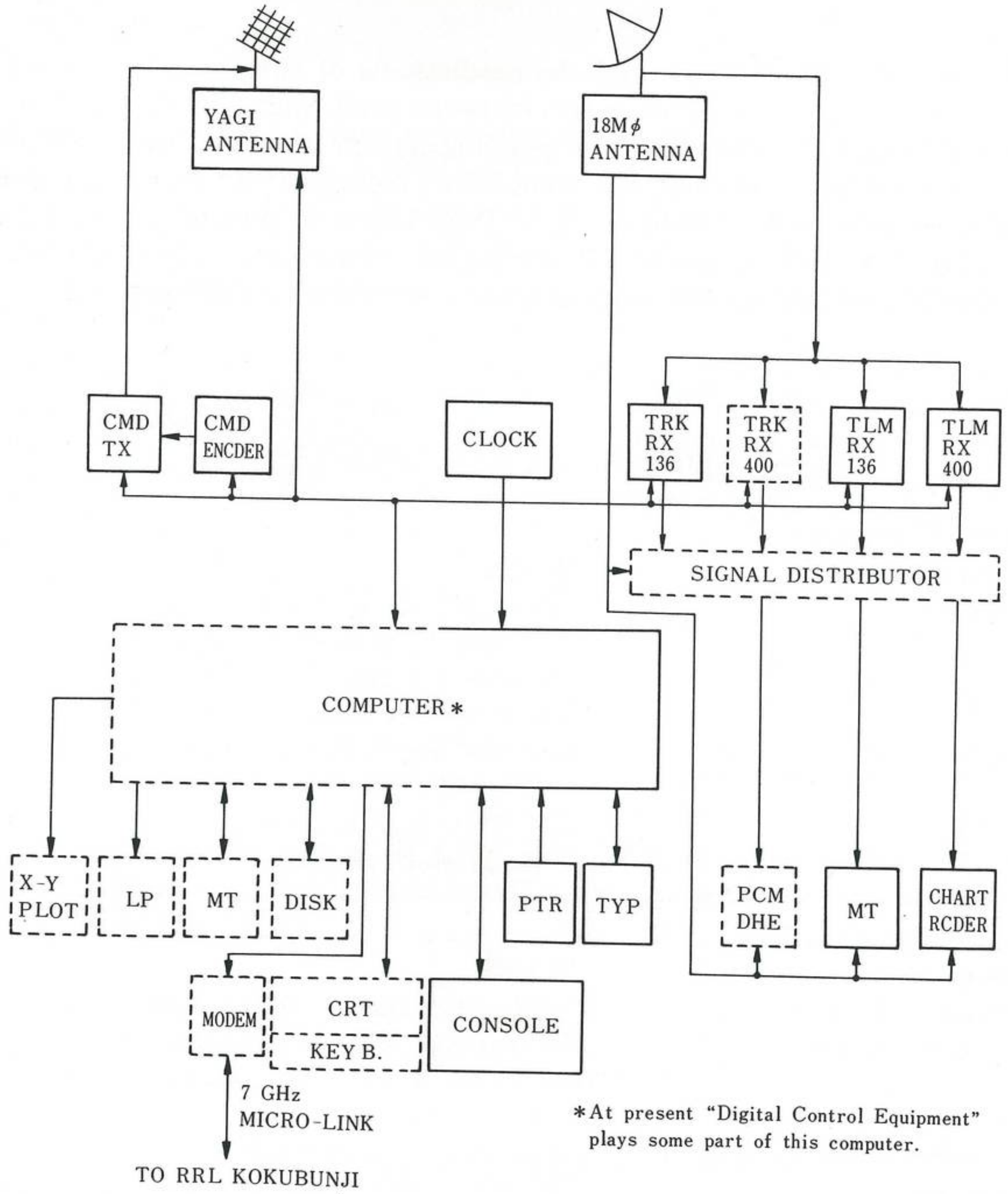
The system has been designed so that operations may be conducted with the least man power, and data acquisition may be made with the greatest reliability, that is, each subsystem is controlled by a process computer and its functional status is displayed and monitored at a status control console concentrically. Tables (under) show the main characteristics of telemetry receiver, tracking receiver and command transmitter respectively.

Overall characteristics of telemetry receiver

frequency	VHF : 136～128 MHz UHF : 400～402 MHz
signal type	AM, FM, PM
combining method	polarization diversity, maximal-ratio combining at IF
noise figure	4 dB (VHF), 5 dB (UHF)
input level	−140 dBm～−70 dBm
image signal supression ratio	60 dB
equivalent noise band width (coherent mode)	10, 30, 100, 300 Hz (selectable)
tracking range of Doppler Shift	5.5 kHz (VHF), 16 kHz (UHF)
tracking range of Doppler rate	200 Hz/sec (VHF), 600 Hz/sec (UHF)
2nd LF band width	3, 10, 30, 100, 300 kHz (selectable)
demodulation mode	coherent, incoherent
demodulation output	3 VIV (P-P, 10k load)

Overall characteristics of 136 MHz tracking receiver

frequency	136～138 MHz (selectable 1 kHz step)
polarization	linear (X, Y), circular (R, L), (selectable)
noise figure	4 dB
threshold level	−157 dBm (for equivalent noise band width 10 Hz)
image signal suppression ratio	60 dB
equivalent noise bandwidth input level	10, 30, 100, 300 Hz (selectable) threshold～−70 dBm
tracking range of Doppler shift	5 kHz
tracking range of Doppler rate	200 Hz/sec
angle error output	2V/deg
AGC band width	0.3, 1, 3, 10, 30 Hz (selectable)
variation of phase difference (between sum and diff. signal)	within 10 degree (for sum-signal level : −140～−80 dBm)



18mϕ antenna T.T. & C. system (normal phase)

Overall characteristics of command transmitter

frequency	148～154.2 MHz 148.255 MHz (for ISIS−I/II) 148.270 MHz (for ISS)
frequency accuracy	$\leqq 2.0 \times 10^{-6}$
power	7kW (for ISIS-I/II), 0.5kW (for ISS) (selectable)
modulation	AM, frequency: 100 Hz～12 kHz (0～−3 dB) mod. degree: max. 100% S/N ratio: ≧ 40 dB (mod.deg. 95%)
spurious	< −60 dB
load (rated)	50 Ω (axial)

DATA ACQUISITIONS OF ISIS I & II AND ESRO TD-1A

Kashima earth station started the reception of telemetry signal of Aloutte I in August 1966 and the magnetic data tapes were continuously sent to the RRL at Koganei for analysis. At present, the ISIS-I/II telemetry data are recorded and sent to Koganei. The ISIS-I/II are the series of Alouette-I/II, the Canadian ionosphere sounding satellites. The operations of T.T. & C. for ISIS/I/II have been carried out at the rate of 6 passes every week, by the 18mϕ antenna for tracking and telemetry reception, and 8-element and 9-stack Yagi array antenna for commanding since the summer of 1972. On the other hand, the old Yagi array antenna which had been used for Alouette-I/II and ISIS-I/II until 1972, are now used for the data recovery of TD-1A satellite launched by ESRO in March 1972. This supporting of ESRO is made because the onboard two tape recorders failed and the satellite worked only in a real time mode. The magnetic data tapes are sent to ESRO regularly.

The characteristics of ISIS-I/II and TD-1A are listed in Table (under).

Characteristics of ISIS-I/II and TD-IA

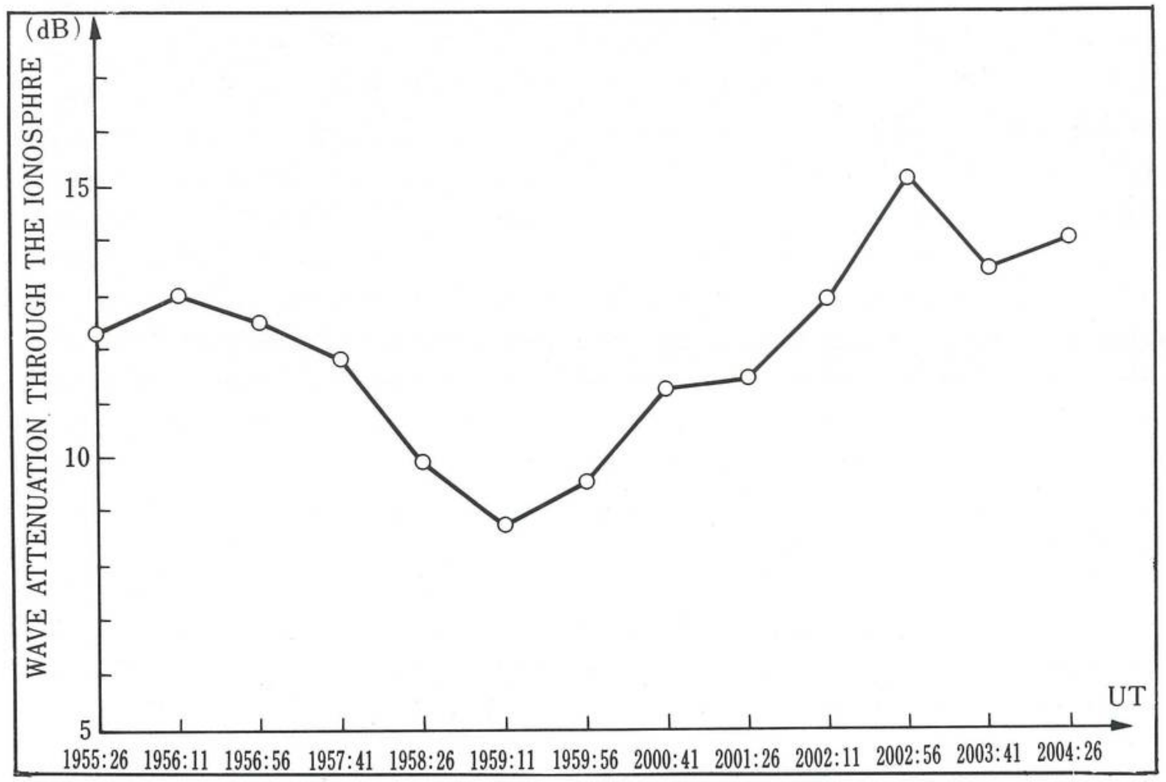
Item S/C	ISIS-I	ISIS-II	TD-1A
Launching	Jan. 30, 1969	Apr. 1, 1971	Mar. 12, 1972
Apogee (km)	3522	1428	518.8
Perigee (km)	574	1358	546.5
Inclination (deg)	88.4	88.1	97.5
Period (min)	128.3	113.6	95.1
Telemetry (TX No. I)			
Freq. (MHz)	136.080(401.750)	136.080(401.750)	136.050
Power (W)	4	4	0.6
B.W. (kHz)	100	100	1,700 bits/sec
Modulation	FM, PAM/FM	FM, PAM/FM	PCM/PM
Telemetry (TX No. III)			
Freq. (MHz)	136.590	136.590	137.740
Power (W)	2	3	3
B.W. (kHz)	50	50	30,600 bits/sec
Modulation	PCM/PM	PCM/PM	PCM/PM
Beacon			
Freq. (MHz)	136.410	136.410	136.050
Power (W)	0.1	0.1	0.6

MEASUREMENT OF TRANSPARENT HF WAVE FROM SATELLITE THROUGH THE IONOSPHERE

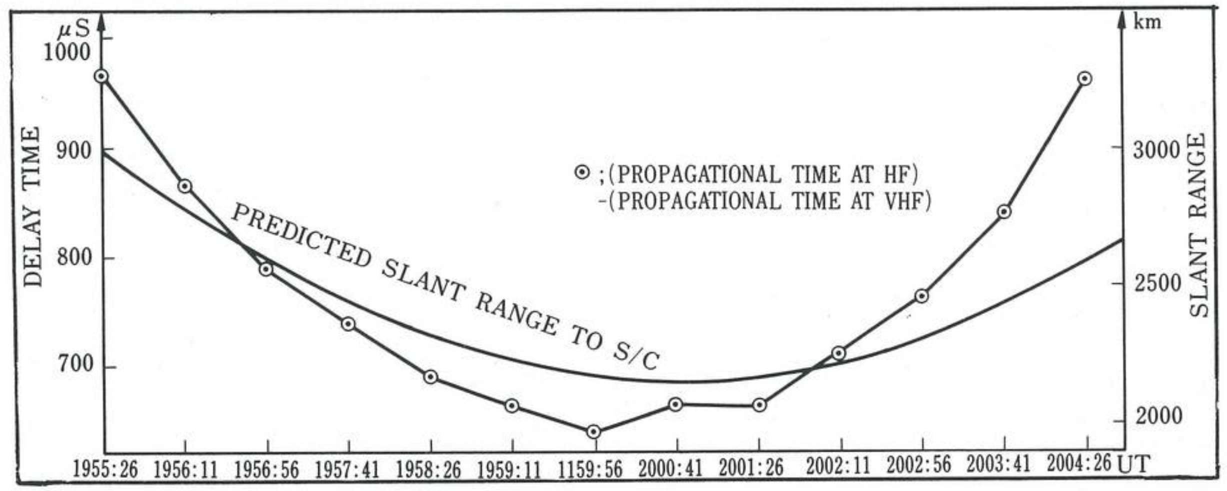
Measurements of various characteristics of the ionosphere have been continued up to the present. However, measurements of the transparent characteristics of HF waves through the whole ionosphere in the vicinity of the critical frequency have not yet been made in detail.

In 1972, Kashima earth station started an experiment for the purpose of measuring transparent HF wave attenuation through the ionosphere, using a fixed frequency signal 9.303 MHz from the ISIS-II. As an example of measurements made in this experiment, the attenuation through the ionosphere is shown in Figure (upper) and the difference of propagational delay time between VHF and HF is shown in Figure (lower).

As for the future plans, the following two objects should be studied. The first one is to make clear various phenomena obtained by this measurement and to investigate theoretically the wave attenuation through the ionosphere for appropriate ionosphere model. The second one is to make engineering researches for the improvement of accuracy of measurement and a signal detection and estimation, based on the detection and estimation theory, and the development of the technique of receiving the swept frequency sounder signals from ISIS-I/II and ISS.



Attenuation of 9.303 MHz waves through the ionosphere as a function of time



The difference of propagational delay time between VHF and HF as a function of time

STUDY ON THE RADIO ASTRONOMY

The first radio astronomical research started at Kashima earth station in February 1966 in cooperation with Tokyo Astronomical Observatory, with radio observations of galactic HII regions (=nebulae). For the bright nebulae, these observations were rewarded with good fruits in mapping the distribution of absorbing matter in interstellar space by comparison of the radio and the H (6563A) intensities. Since 1968, galactic radio survery were started with a view to finding out discrete sources and to analyzing the physical property of the galactic background radiation.

LINEAR POLARIZATION OF DISCRETE SOURCES

Observations of the linear polarization of radio sources began using the 26mϕ antenna in August 1971. We have made this kind of observation by two methods, one by tracking "on" and "off" position of the source, the other by drift scan. For the tracking method, we first track the source ("on" position), rotating the polarizer continuously either from 0° to 180°, or from 180° to 0° for three minutes, and then track the imaginary point where the source was located three minutes before ("off" position). By subtracting the intensity of "off" position from that of "on" position at each polarizer angle, we can obtain the curve for linear polarization. By the second method i.e. the drift scan, data were taken at a series of settings of the polarizer separated by intervals of 30° or 45° over a 180° range. Most sources were observed both east and west of the meridian at parallactic angles of +45° and –45°. At these positions the elevation and consequently the instrumental polarization was the same. Hence it was possible to obtain the instrumental polarization by addition and the source polarization by subtraction, of the two sets of measurements. The results of the measurement by drift scan are given in Table. (under). As a result of this survey, it became clear that the galactic background radiation was more non-thermal than expected. Besides the observations mentioned above, the following observational items have been coducted for the past few years and some are still being continued.

Linear polarization at 7.2 cm.

(1) Source Name	(2) Peak Flux Density (f.u.)	(3) Polarization Degree (%)	(4) Position Angle (°)
NRAO 150 *	7.7	3.5±0.6	172± 9
3C 120 *	10.6	1.8±0.6	22±19
3C 147	9.30	1.5±0.7	116±26
3C 161	7.5	5.1±1.2	149±14
4C 39.25 *	7.8	4.6±0.2	137± 3
3C 270	7.8	10.8±1.0	112± 5
3C 273 *	41.3	3.1±0.2	161± 3
3C 274 (Vir A)	78.5	1.1±0.2	172± 4
3C 279 *	13.0	3.7±0.3	159± 5
3C 345 *	10.7	1.0±0.4	9±24
3C 348(Her A)	14.7	7.0±0.5	23± 5
3C 353	22.7	3.5±0.3	95± 5
3C 454.3 *	11.5	4.8±0.5	5± 5

* Variable sources.

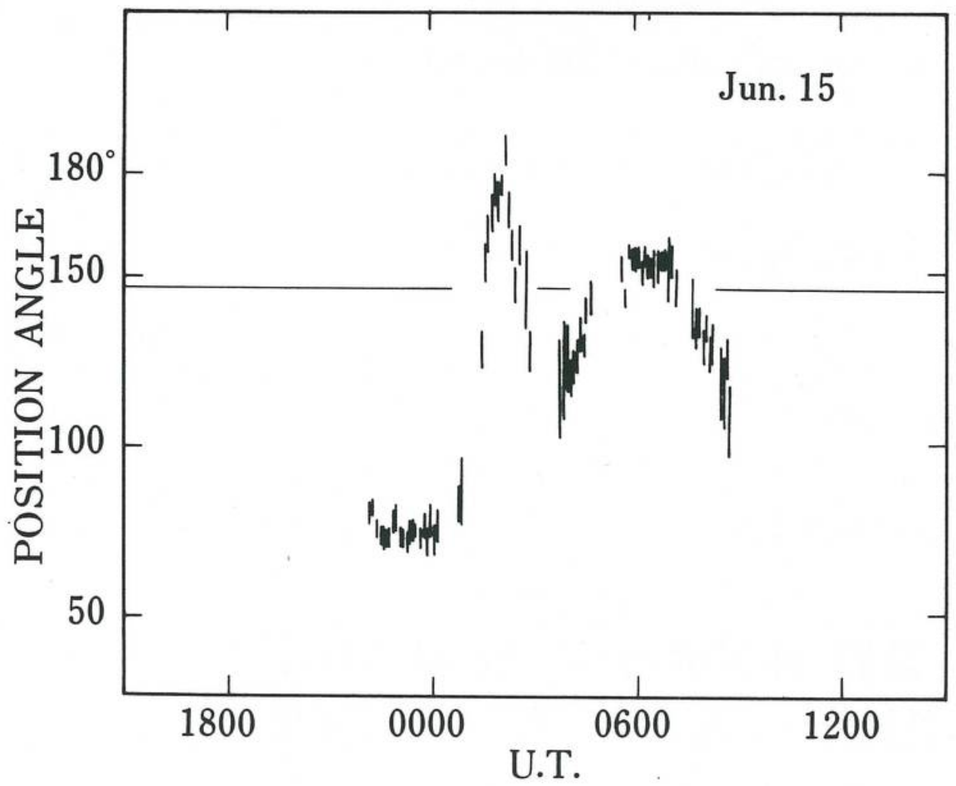
FARADAY ROTATION OF LINEARLY POLARIZED RADIO WAVES FROM THE CRAB NEBULA BY THE SOLAR CORONA

In June every year the occultation of the radio source Tau-A (Crab nebula) by the solar corona provides and opportunity of investigating the coronal electron density and magnetic field at a distance of 5→20 R from the sun. We observed the Faraday rotation of linearly polarized waves from tau-A, when they passed through the corona from June 8 to 21, 1971 inclusive.

The sun source distance varied from 20 R on June 3 to 5 R on June 15, the day of the closest approach. The observed position angles near the closest approach to the sun, on June 14 to 17, varied rather irregularly with a considerable amplitude. The irregular variations appear to have two distinct time scales of about 2 and 10 hours. A typical example to such a variation is seen in the results of June 15 (See Figure (under)).

Through the observation of the Faraday effect, it is concluded that a neutral sheet exists in a coronal streamer: the magnetic field direction on both sides of the sheet is reversed, and that the overall field configuration is nearly radial rather than of a dipole type.

The second Faraday rotation measurement has been made in 1973. This time, we observed at 6640 MHz, in addition to 4178 MHz of conventional frequency.



Preserved position angles of polarization of Tau A on June 1, 1971,

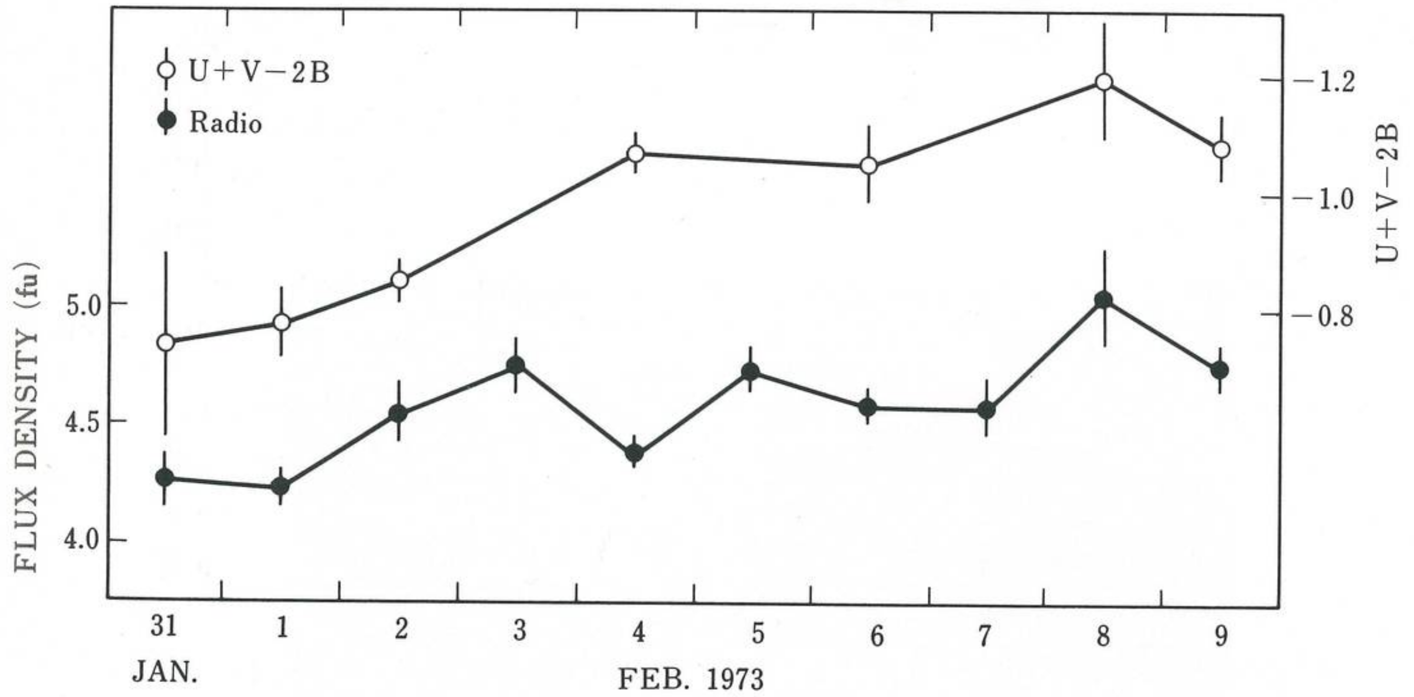
Each point shows a value determined from one set of observation. Lengths of the bars indicate probable errors

VARIATION OF FLUX DENSITIES OF VARIABLE SOURCES

Since the autumn of 1970, regular observations of variable sources, such as quasars and radio galaxies, have been made in order to make clear the variation of flux density for each source and to get information about the evolution of those types of sources. We have been observing some thirty sources every forty days or so.

Among those sources, there are sources varying very rapidly, e.g. OH287, BL Lac, 3C120. Above all OJ287 is the most mysterious one, by reason of its violent variation of flux density and the uncertainty of distance to that object. So we made simultaneous radio and optical observations of OJ287 in order to study on the correlation between radio and optical variabilities.

No definite correlation between radio flux density and optical brightness has been detected. However, it was found that the radio flux density related to a differential color index (U-B)–(B-V). Figure (under) shows the time variation of radio flux density and differential color index U+V-2B of OJ287, which were obtained at Dodaira Observatory, Tokyo Astronomical observatory.

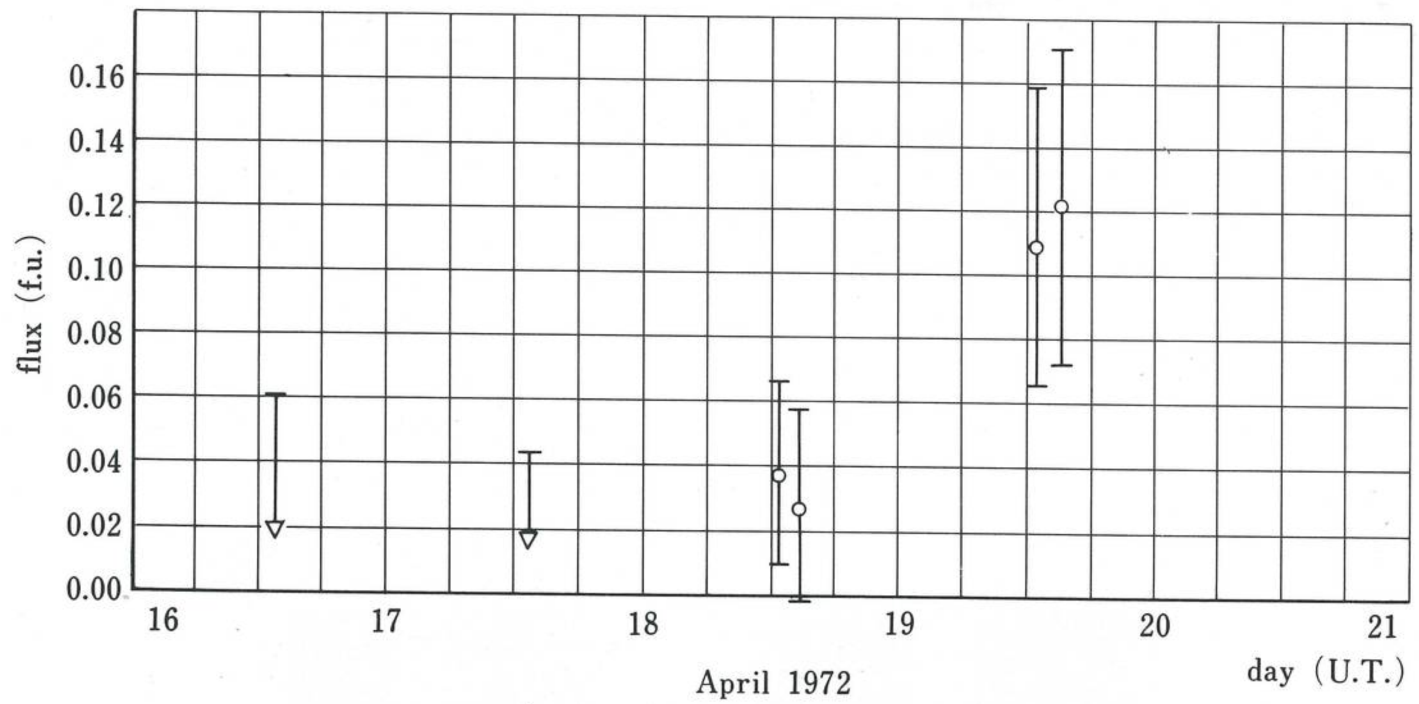


Time variation of radio flux density (filled circles) and differential color index U+V–2B(=(U-B)–(B-V)) open circles) of OJ 287.

X-RAY SOURCE SCO-X-1

For the past ten years, more than one hundred X-ray emission objects have been discovered in our galaxy. Among them, we have paid attention to Sco-X-I, which was the first detected X-ray source and was identified with optical object at Okayama Astrophysical Observatory.

In April from 1970 to 1972 we observed the radio emission of Sco-X-1, in cooperation with the Institute of Space and Aeronautical Observatory, both belonging to Tokyo University, who had made projects for the X-ray and optical observations of that object. Figure (under) shows the results of radio observation at Kashima from April 16 to 19, 1972. One can notice the violent increase from 0.03±0.02 f.u. on April 18 to 0.11±0.03 f.u. on April 19. Such increase suggests that the variation less than 10 hours occurred during these two days, and this flare-up is fairly large as compared with that which occurred in other observations made to date. The accuracy of the data on April 16 was smeared by artificial interference. Only the upper limits of 0.07 and 0.04 f.u. are given on April 16 and 17 in Figure. However, by further examination, these should probably be less than 0.04 and 0.02 f.u. respectively.



Daily variation of the radio intensity of Sco-X-l. An abrupt increase was found from April 18 to 19.

RESEARCH IN COMMUNICATION SYSTEM

RESEARCH IN RADIO DATA TRANSMISSION AND MODULATING SYSTEMS

For the selection of an error control technique, which is suitable for a radio data transmitting channel, we have to consider not only the average error rate but also the characteristics of error pattern, such as the "error-burst" and "error-free-run distribution". The error-free-run distribution is an important parameter for the modeling of digital channel as a Markov chain.

We are especially treating HF channel now, and the studies of error-free-run distribution error-burst and modeling of digital channel are in progress. Some computer simulation tests of ARQ and time-diversity systems were performed.

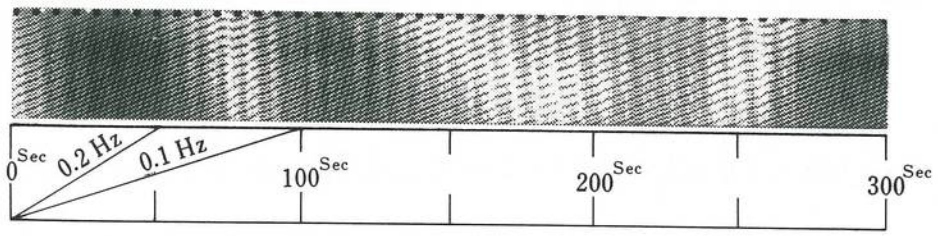
Also, we have a plan to study some kinds of modulating systems, such as delta modulating system, by computer simulation.

REMOTE SENSING OF OCEAN-WAVE BY BACKSCATTERED RADIO WAVE

The radio wave (wave length r) will be backscattered coherently by the ocean-wave which has a wave length of r/2. Theoretical value of the doppler shift of backscattered radio wave is $g/\pi r$, where g is the acceleration of gravity. The level of backscattered radio wave will become higher in proportion to the ocean-wave height.

These facts may be used for the remote sensing of the ocean-wave. So, we received backscattered radio wave of Loran A(1.85MHz) and got the expected doppler shift. Information of the ocean-wave height at the scattering area was limited, but we were able to see some correlations between the level of scattered radio wave and the ocean-wave height.

However, many more investigations are needed in order to show that this technique is useful for the remote sensing of the ocean-wave.



Doppler shift of backscatterd signal by ocean-wave (March 16, 1973,: theoretical doppler shift=0.135 Hz)

EXPERIMENT ON 10KHZ CHANNEL SPACING F3 SYSTEM

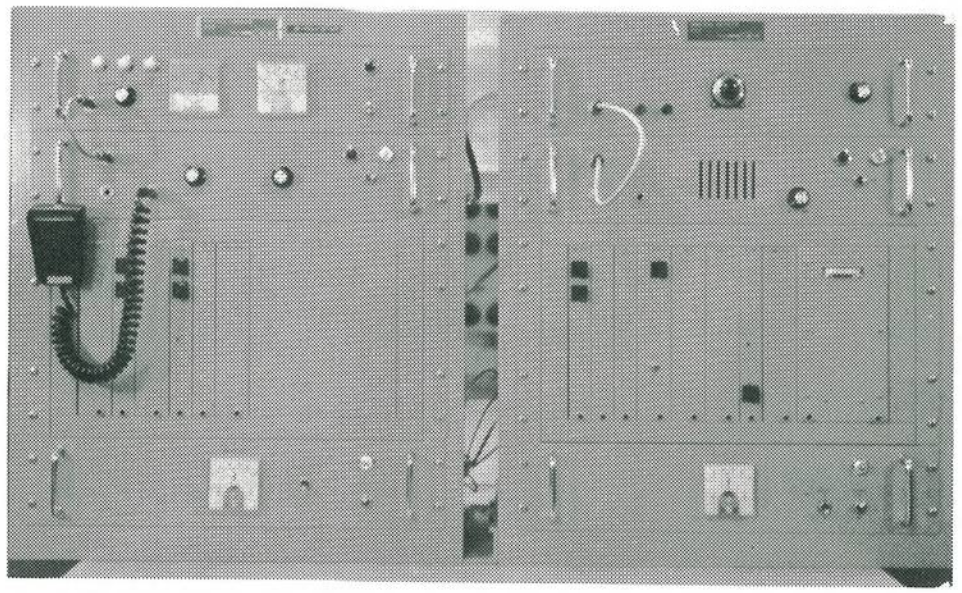
The vocal quality of output of the receiver in 10kHz split channel system, is almost as good as that in 20kHz channel spacing when frequency stability is better than 1kHz. However, it is necessary to have higher desired to undesired and carrier to noise ratios in order to get same quality in 20kHz channel spacing.

CONSTANT NET LOSS (OR LINCOMPEX) SSB SYSTEM

The CNL-SSB system for land mobile radiocommunications is constructed as the result of computer simulation. This system is shown in Figure (under).

Especially, attack and recovery times are as short as possible in order to increase the compression ratio and to keep the constant level of signal. Furthermore, frequency stability is less than 100Hz (6×10^{-7}).

For making use of this system in practical radiocommunications, it is scheduled to carry out the field test for this system.



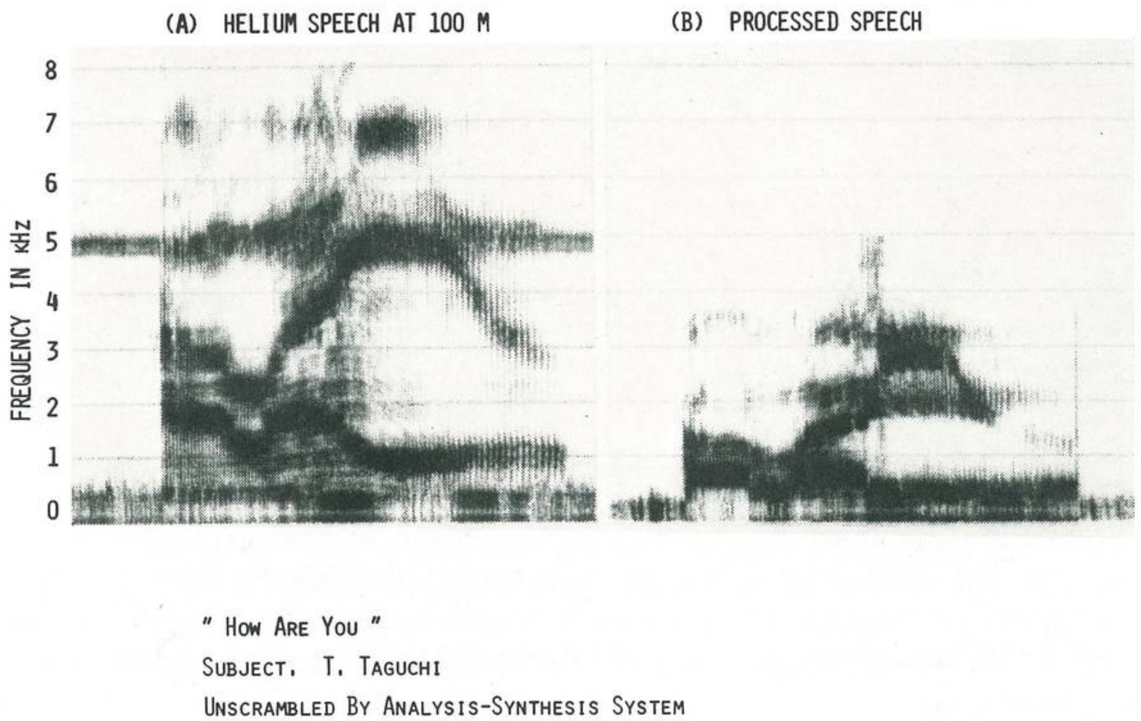
Transmitter Receiver

The CNL-SSB equipment for land mobile radiocommunications.

SPEECH COMMUNICATION

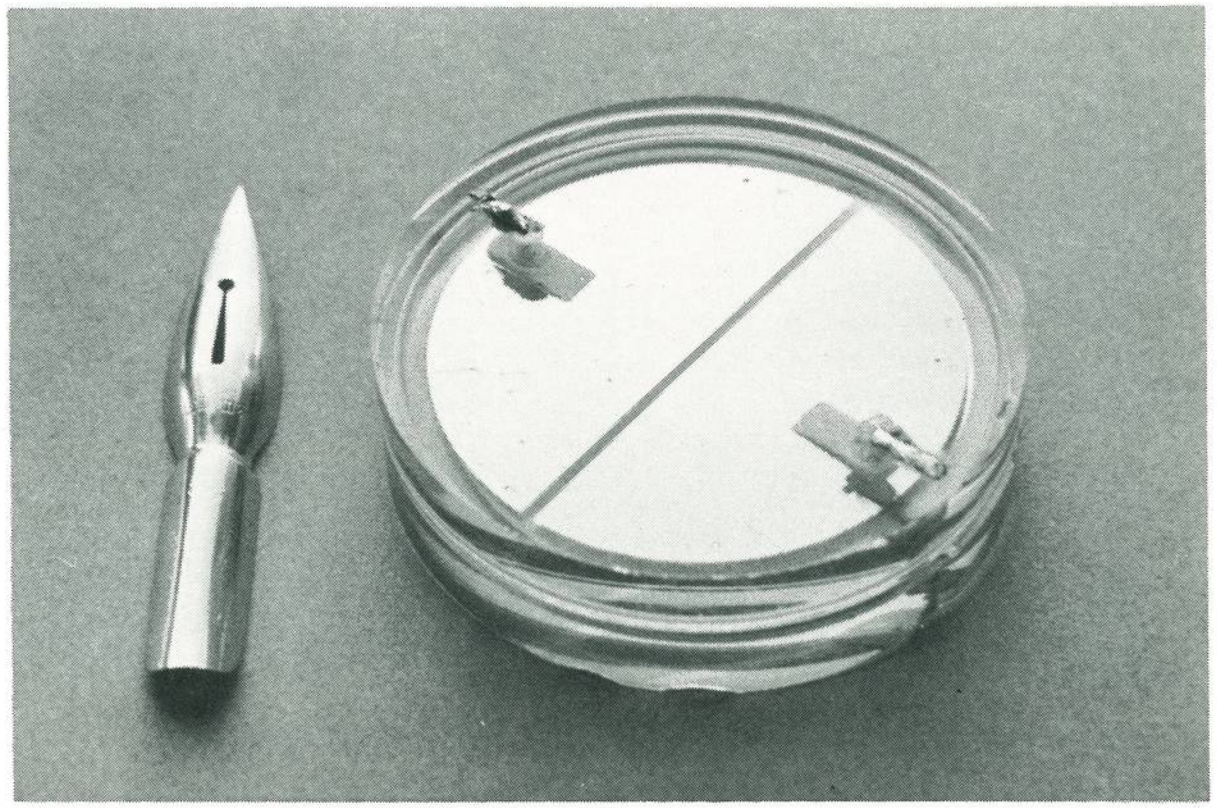
Emphasis in currently placed on the underwater speech communication, especially on helium speech produced in helium-oxygen mixture under pressure. The helium speech is so unintelligible that speech communication is hardly possible in the deep sea. Perceptual and physical analyses of helium speech are carried out. Two types of unscrambler are developed for improving the intelligibility of helium speech. One unscreambler is a simple one named SPREX (Segmentation Partial-Rejection and Expansion) and the other is a sophisticated analysis-synthesis system (modified formant vocoder).

Another emphasis is laid upon the studies on characteristics of glottal source and on the naturalness and individuality of speech. The voiced speech signal is decomposed into transfer function of the vocal tract and glottal waveform as the excitation source. Each characteristic is analyzed separately and then speech waveform is regenerated after processing. Present plans include (1) studies on characteristics of glottal source under various phonation; (2) analysis of pathological voice; (3) description of glottal excitation reserving naturalness and individuality; and (4) construction of formant vocoder with natural quality.



Spectrograms of helium speech and processed speech by analysis synthesis system

RESEARCHES IN HEGH-STABILITY CRYSTAL RESONATORS



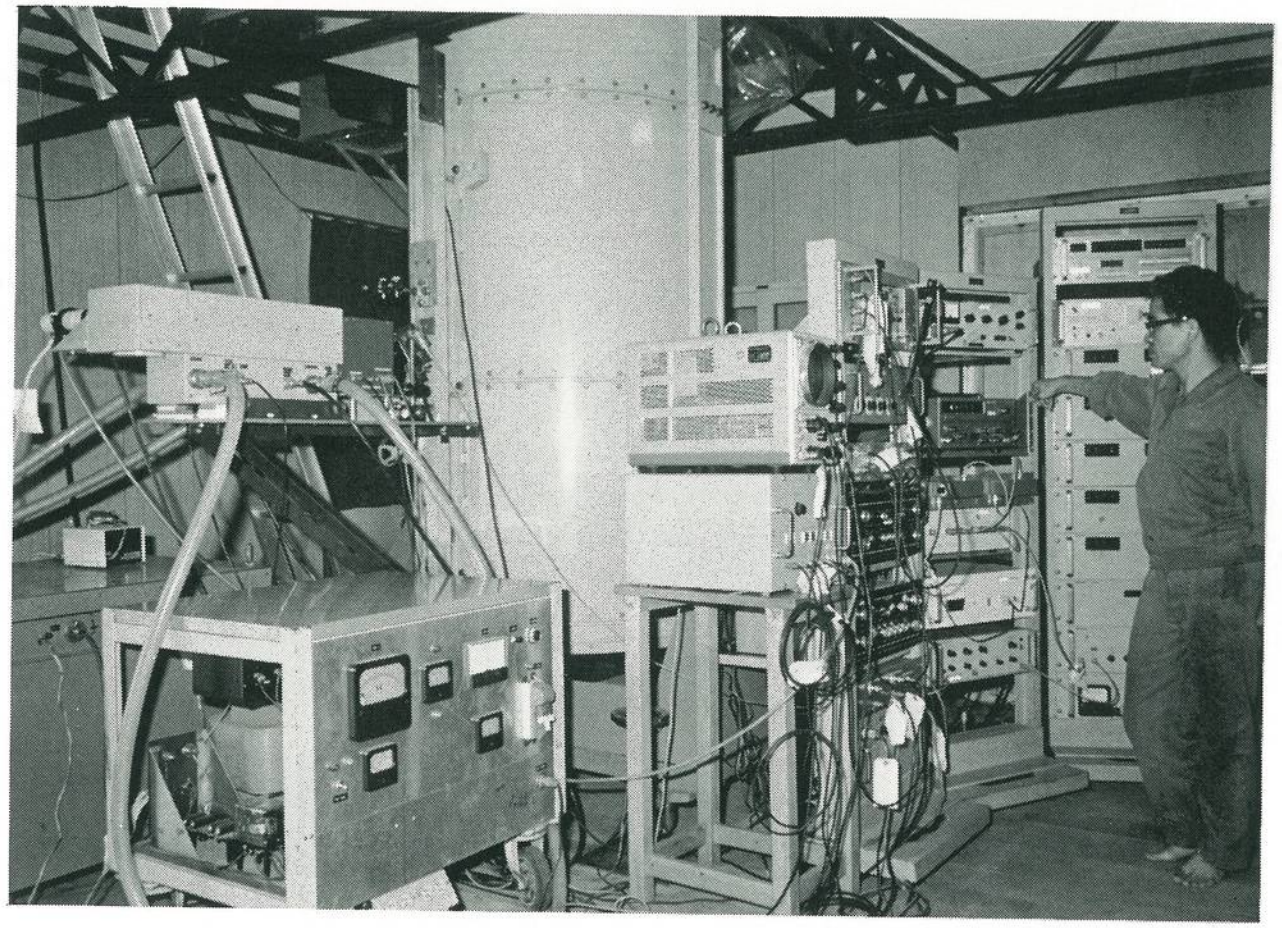
Superhigh Q 1 MHz AT—cut crystal resonator

In recent years many high-stability quartz oscillators of very easy handling have been produced, but in order to bring them into full play, the continuous operation for several weeks or months is required. In order that such defect may be overcome and a quartz oscillator may have much less difference of frequency variation between long and short periods of time, the RRL have entered into studies on the development of superhigh Q and high-stability crystal resonators. The photograph shows a 1 MHz AT—cut crystal resonator manufactured on trial at the RRL lately. It is small-sized and designed to be strong against mechanical or thermal shock. The Q (= $\omega L/R$) is approximately 2.2×10^7.

RESEARCH IN LASER

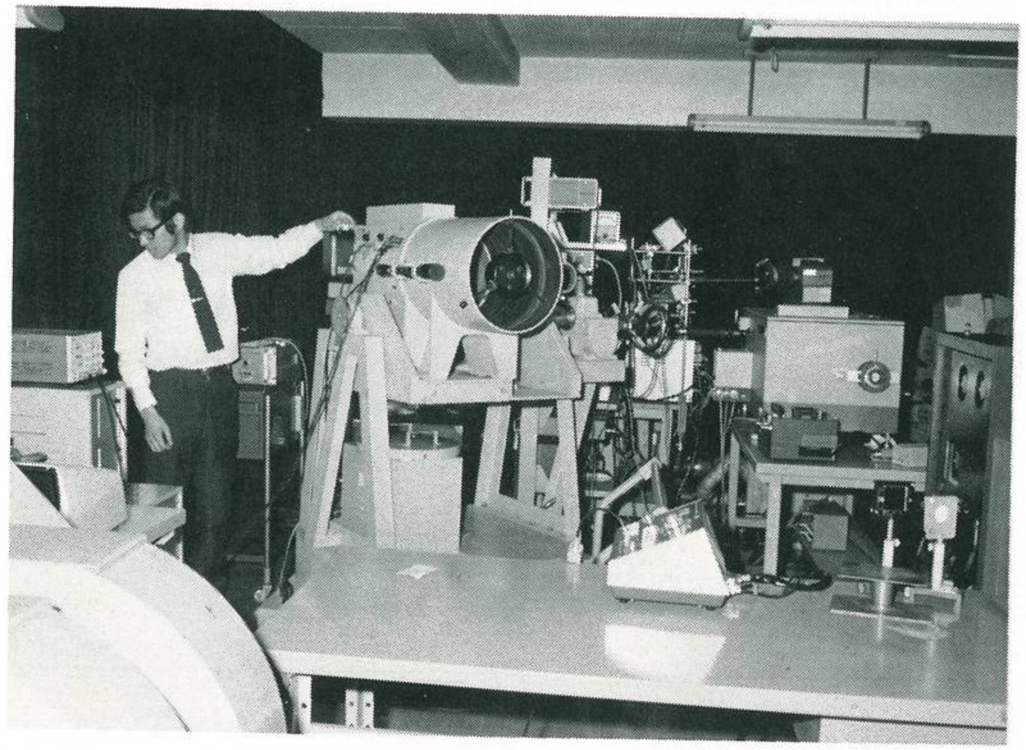
OBSERVATIONS ON STRATOSPHERIC AEROSOLS BY LASER RADAR

Our project of research is concerned with an application of laser radar for atmospheric studies. Observations on stratospheric aerosols have been made with a ruby laser radar since 1964. The observations show that the aerosol layer near 20 km exhibits temporal variation, and returned signal from the layer is approximately 1.4 times larger than that from molecular atmosphere.



Laser radar for stratospheric aerosol observations

DEVELOPMENT OF TECHNIQUES FOR MEASURING AIR POLLUTANTS BY USE OF A LASER RADAR



View of the laser radar for remote measurement of air pollutants

In order to clarify the process of photo-chemical smog occurrence, it is necessary to measure three dimensional distribution of air pollutants. New laser radar system using differential absorption method has been developed for detection of NO_2 and SO_2 gases and we have arrived at the stage that the system has an feasibility of measuring 0.1 ppm density with 50m resolution over 300m in the daytime.

We have also been developing a fluorescence technique.

Many pollution gases have their absorption spectrum in the infrared region but, at present, we can not arbitrarily select the wavelength of powerful laser in this region. Absorption lines of ozone gas are near 9.6μm and semi-tunable CO_2 laser can be used also near this region. We are trying to tune CO_2 laser wavelength to the exactly same one of ozone absorption lines.

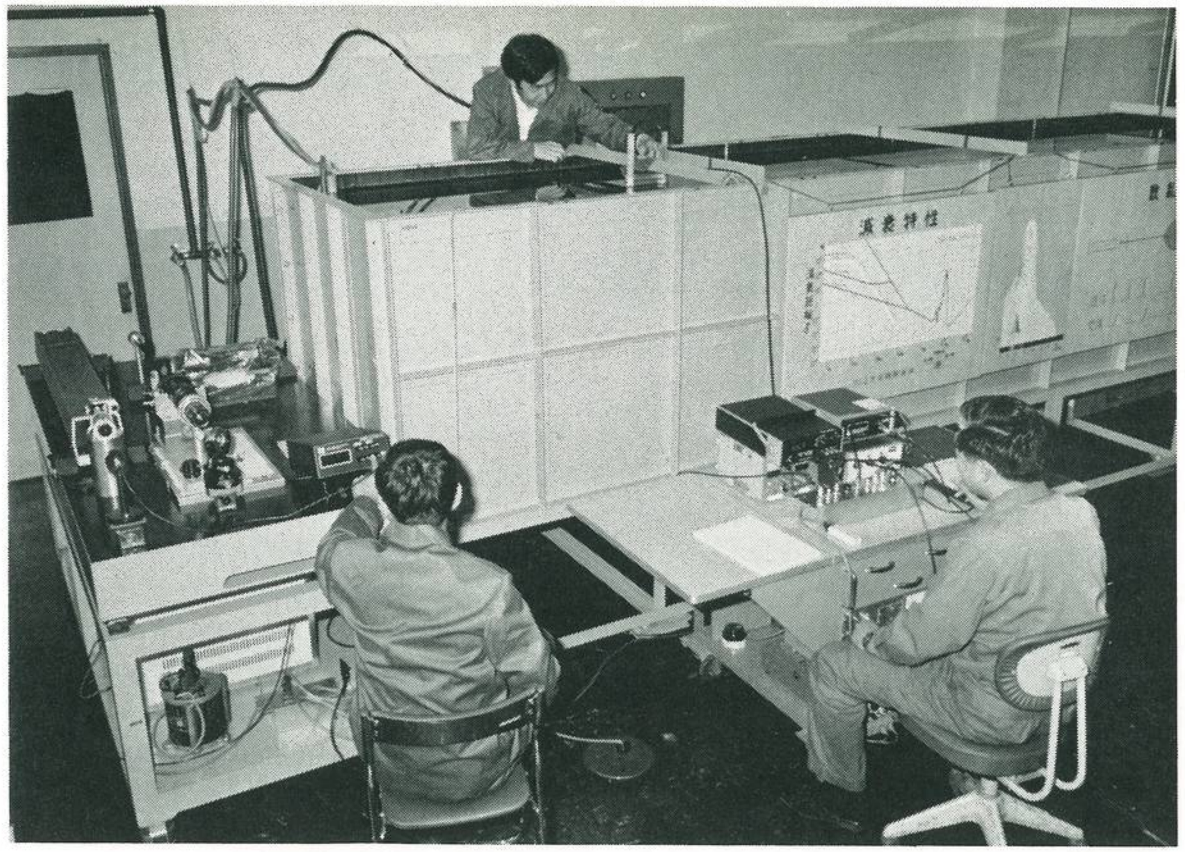
RESEARCH IN UNDERWATER INFORMATION TRANSMISSION BY LASER

The marine development requires the development of an effective underwater information transmission system, the transmitting capacity of which is larger than what VLF radio wave or acoustic wave carries, to transmit information of optical images and some control signals in water. The laser seems to satisfy this requirement (c.f. Figure (under)).

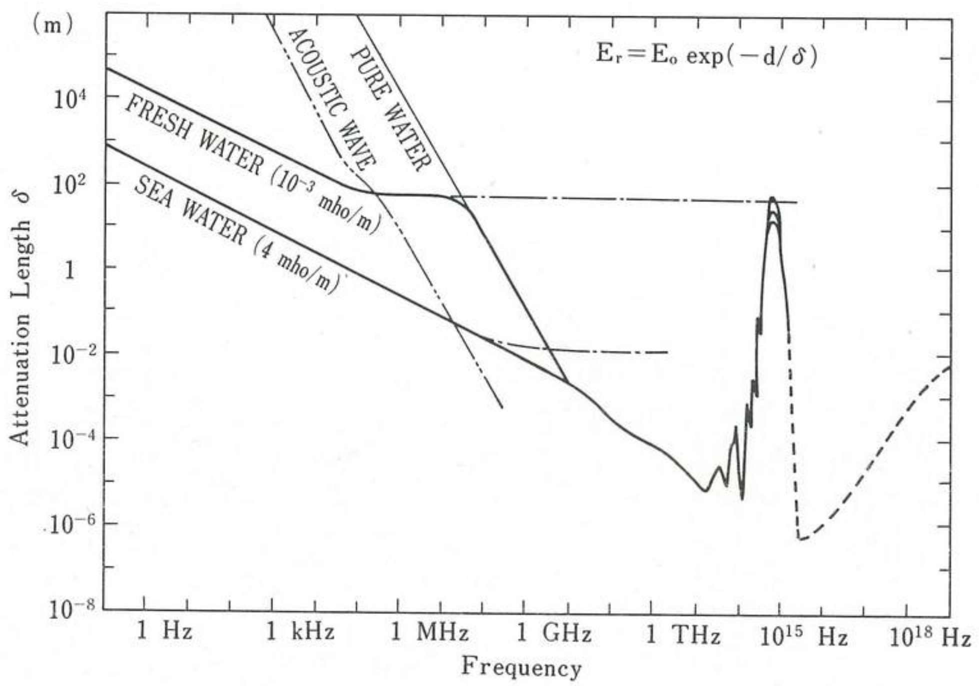
As the basic research, the attenuation characteristics and the divergent characteristics of a collimated beam of a green laser have been investigated in turbid water, as function of the propagation distance and the turbidity.

Besides, the development of the high-capacity underwater communication system is to be planned.

The development of a new powerful underwater observation equipment, called the laser scope or the laser viewer, is also in progress, as an applied technology, which adopts the range-gated system to reject backscattering of the illuminating laser light from scatterers suspended in water.



The water tank and experimental equipment for the laser propagation simulation



Dielectric absorption of pure, fresh and sea water as function of frequency

WORKING STANDARDS AND MEASUREMENTS

Studies on working standards necessary for calibration of radio measuring equipments and on the measurement of radio waves are being carried on.

For the establishment of the working standards, the Weston Cadmium Standard Cell and the Standard Resistance are maintained as the basic standards of the RRL. These basic standards are calibrated periodically by the Electro-Technical Laboratory, Ministry of International Trade and Industry. The working standards of various radio frequen-cies are derived from these DC standards by means of thermo-couple, barretter, calori-meter, phototransistor, etc., and being maintained with good accuracy. The working standards established in the R R L are as follows:

1. Power
2. Field Intensity
3. Voltage and Current on High Frequencies
4. Radio Frequencies
5. Occupied Frequency Bandwidth

Investigations on measurement devices and techniques are also being made and the results there of are applied to measurements of radio waves for radio regulation as well as type approval test, performance test and calibration.

TYPE APPROVAL TEST, CALIBRATION AND THE RESEARCH

Three kinds of technical public services concerning radio equipments are conducted for the purpose of making efficiency progress in the radio regulation. Those are type approval test, performance test, and calibration.

Type approval of radio equipments is conducted for maintaining the technical standard which is provided by the radio regulations. In case of radio equipments being installed at radio stations, it is legally required that the type of those equipments is approved by the Minister of Posts and Telecommunications.

Those equipments are divided into three groups.

The equipments belonging to the first group are those directly concerned with the security of human life and property, such as automatic alarm signal receivers, radio direction finders, radio apparatus for survival craft, aircraft transmitters and receivers. The equipments belonging to the second group are those installed at radio stations under legal obligation, such as frequency meters.

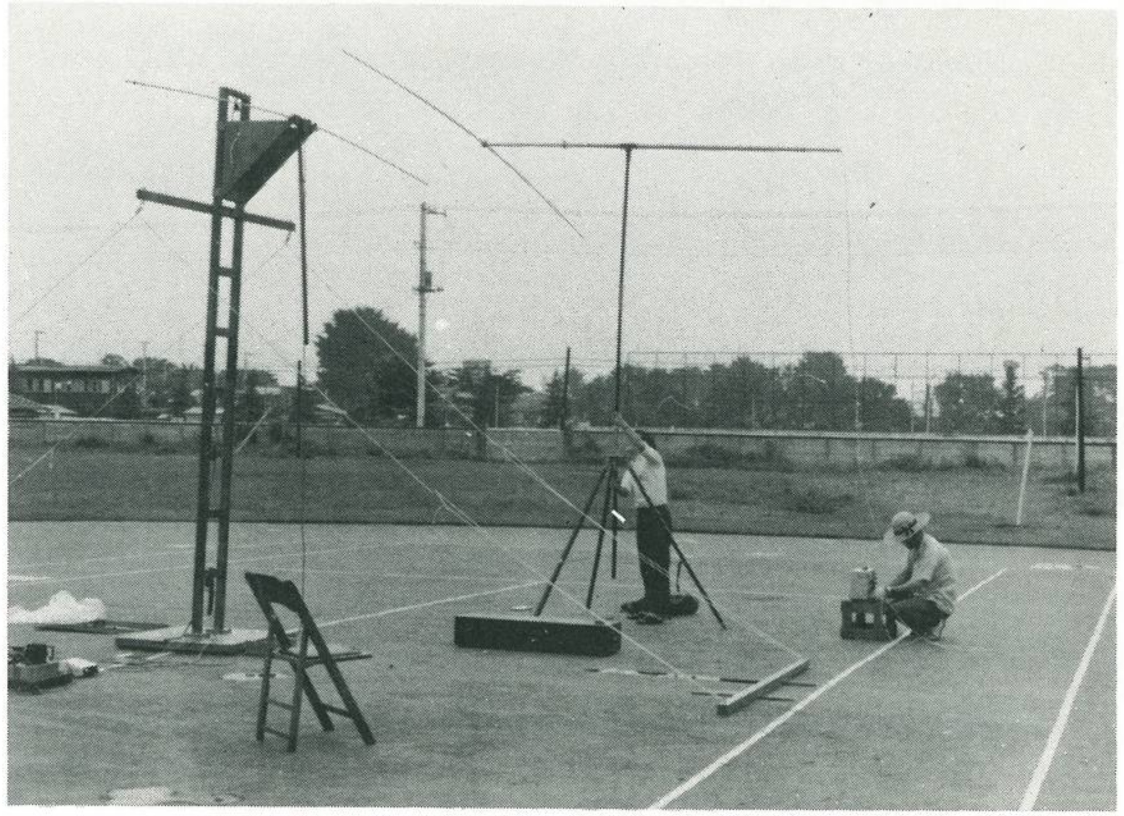
FM radio equipments, SSB radio equipments, simplified radio equipments, etc. belong to the third group. When certificated equipments are used at a radio station, procedures for licence or permission to be taken by the station are simplified.

Performance test is conducted one by one at the request of a manufacturer or an installer for required items about above-mentioned kinds of equipments, very low power transmitter, etc.

Calibration of measuring equipment for the radio regulations (standard signal generator, field intensity meter, radio wave power meter, etc.) is chiefly conducted for the measuring equipments used for inspection of a radio station, for type approval test, and for performance test. However, the calibration is also conducted in compliance with the request of an outsider.

In order to support above mentioned services, research and investigation concerning the method for type approval test and calibration are being conducted with the development of equipments for test and calibration.

Type approval testing equipment



Calibration of field strength meter

INFORMATION PROCESSING

COMPUTER FACILITIES

The medium-sized NEAC 2200/500 system has been installed and operated since 1968 as the main computer in the RRL. The field of utilization now spreads over the mathematical, physical, and engineering problems that arise in radio and laser propagation research, calculation of satellite orbits, image processing, speech analysis, and other scientific data handling.

The management of the system is being carried out on the openshop basis in programming and on the closedshop basis in computer operation. For processing a large amount of analogue data, and A–D/D–A conversion system with digital/analogue input/output channels controlled by a small computer has been ordered and installed since 1972.

The more powerful computer in the next stage is now being considered, including the data analysis for the ISS (Ionosphere Sounding Satellite) which is scheduled to be launched in the fiscal year, 1975.

Electronic computer NEAC 2200/500

Analog input-output processing equipment

AUTOMATIC PROCESSING OF VISUAL INFORMATION

Studies are in progress with regard to the visual information processing, especially the efficient coding of pictorial information and the automatic recognition of handwritten Chinese characters mainly by using the techniques of computer simulation. Also computer hardware and software are also developed in order to facilitate those research activities.

EFFICIENT PICTURE CODING

The necessity of image transmission is rapidly increasing in many fields, such as visual telephone, data communication, CATV as well as conventional television and facsimile. Since the images contain a large amount of information, and accordingly an excessive channel capacity is necessary to transmit them, it is desirable to reduce the capacity for using frequency spectrum efficiently, or reducing the cost of image transmission.

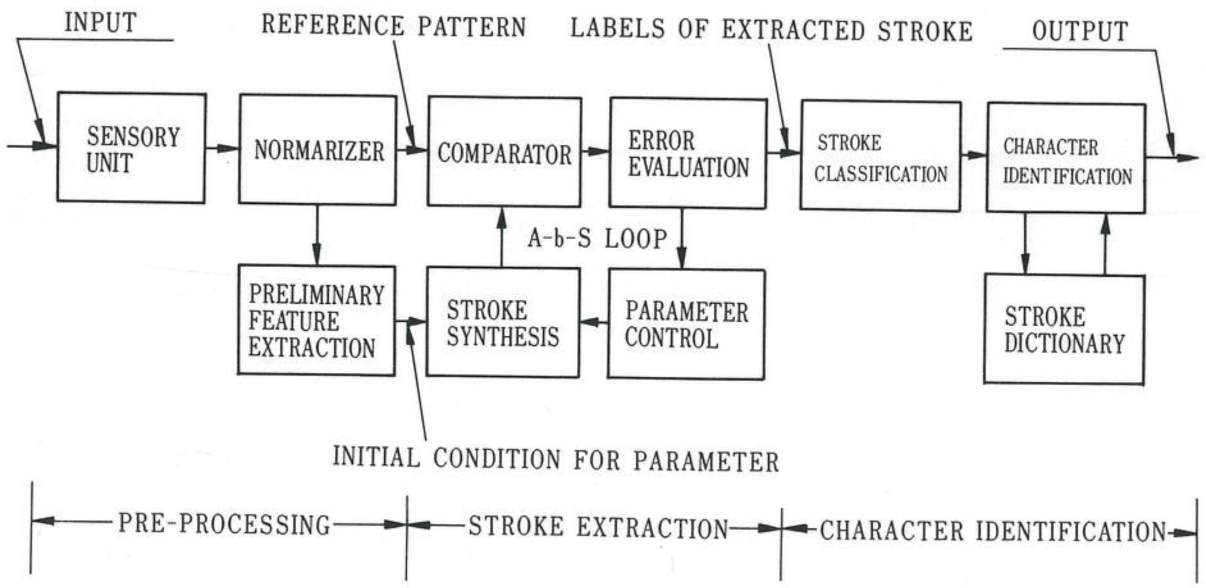
The facility for computer simulation consists of the slow scanning television system and the center computer NEAC 2200/500 with magnetic tapes, disks, etc. A programming system for picture processing was developed, by which efficient codings of simulation programs are easily made by Fortran.

Two coding schemes were investigated lately. One is a variant of orthogonal transform coding, in which brightness variations in blocks of 3 X 3 picture elements are approximated by quadratic expressions and only visually important coefficients are transmitted. The other is a Fourier transform coding, in which for higher frequency spectra, amplitudes are coarsely sampled and phases are coarsely quantized. Those schemes were applied to several photographs and compressed pictures of tolerable quality were obtained with compression ratios of 1 to 3.3–4.5, and 1 to 2–3 respectively.

STUDY OF HANDWRITTEN CHINESE CHARACTER RECOGNITION

Automatic recognition of handwritten Chinese character is one of the most important problems in the field of efficient transmission and automatic processing of information written in Japanese language. However, automatic recognition of Chinese character is still regarded as an extremely troublesome task for the existing information processing techniques, because of the multitudinousness and the complicated structure of the character patterns. In case of handwritten character recognition, there arises another laborious problem such as individual difference in addition to the above mentioned difficulties.

In order to find a clue for solving such a troublesome problem, our research attention has been paid to the facts that Chinese characters are drawn as sequences of a few types of fundamental stroke segments and that each stroke segment in handwritten characters can also be described by the terms of fairly simple model of penpoint movement in handwriting. Regarding these fundamental stroke segments as the primitive features for the recognition, a handwritten Chinese character recognition system by Analysis-by-Synthesis method was proposed.



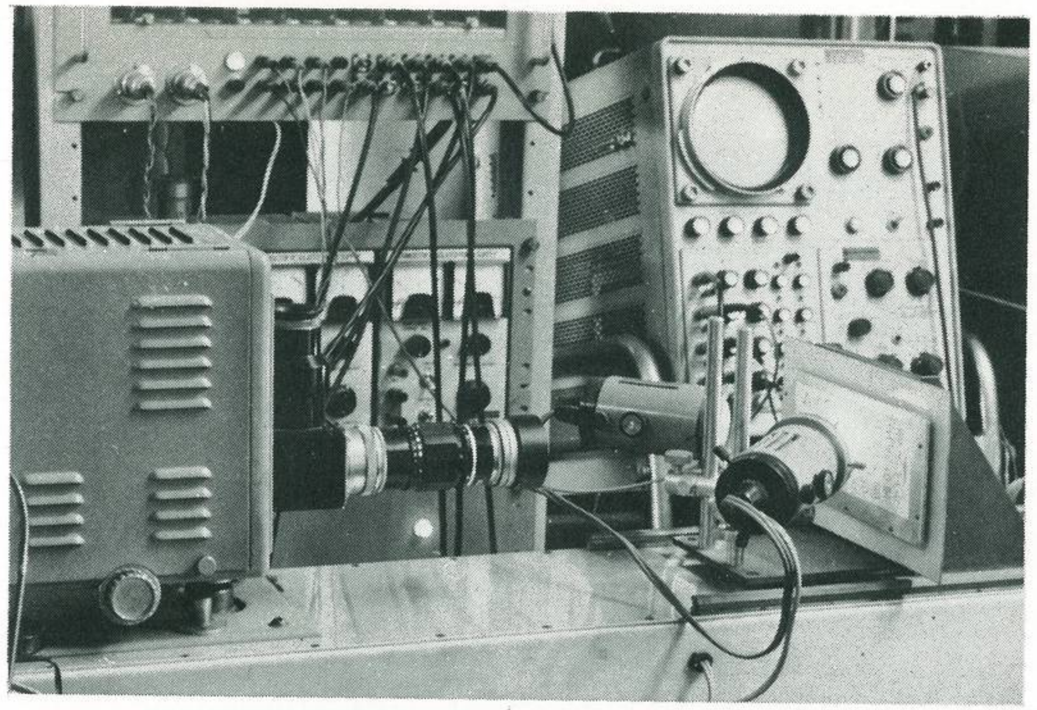
Handwritten Chinese character recognition system by A-b-S method.

The operation of the system can be divided into the following three categories.

(I) Preprocessing-scaling of character size and position, thinning of stroke width, and extraction of preliminary features.

(II) Extraction of fundamental stroke segments from the preprocessed character patterns by A-b-S method.

(III) Identification of character as an already known one by looking up the extracted stroke dictionary. The entire system is now being tested by computer simulation, gradually increasing the character classes to be recognized.



Character data sampling device

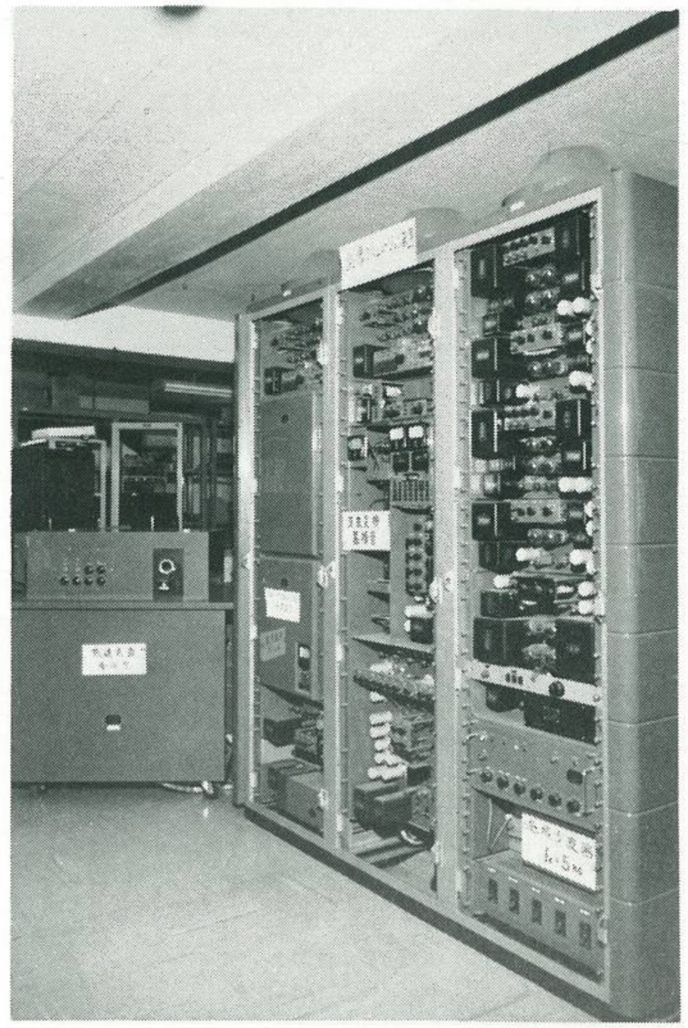


Image processing simulation equipment

ATOMIC FREQUENCY AND TIME STANDARDS

Hydrogen maser type atomic standards have been used as the primary standard of time and frequency since the autumn of 1966. Ever since we continued to study mainly on the coating method of 13 cm, 18 cm storage bulbs to improve the accuracy of the absolute value. We tried TFE and FEP Teflon coated in air and vacuum.

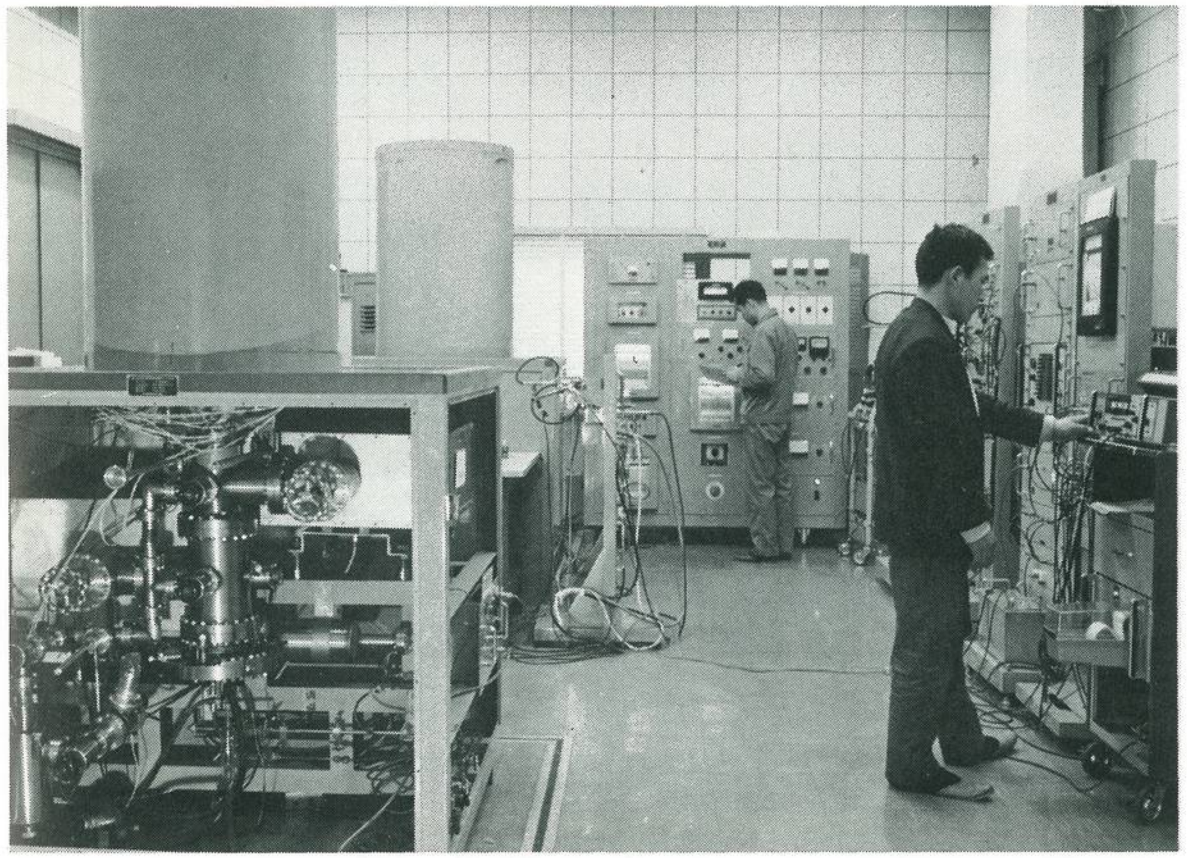
The international direct comparison of H-maser frequency with a specific bulb (FEP coating 15 cm) had been made between the RRL and NRC of Canada. The result showed remarkably good coincidence with 2×10^{-13}.

The automatic cavity tuning by pressure quenching have been completed since 1970. At present the resetabilities of two H-masers are within 1×10^{-13}.

We continue the study of H-maser physics and electronics for the improvement of the accuracy.

In 1967, we started the development of the Rb gas cell atomic frequency standard with fundamental experiments to obtain a much better working standard than crystal frequency standard, and in 1969 we completed a laboratory-type Rb atomic standard which was found to have an expected performance. We are now making research in the resonant frequency shift due to the spectrum of pumping light for Rb atoms with the device completed.

Other studies such as those on the generation of an accurate atomic time scale based on the frequency calibrations by the primary frequency standard and on the development of another type of an atomic frequency standard are being planned and examined.

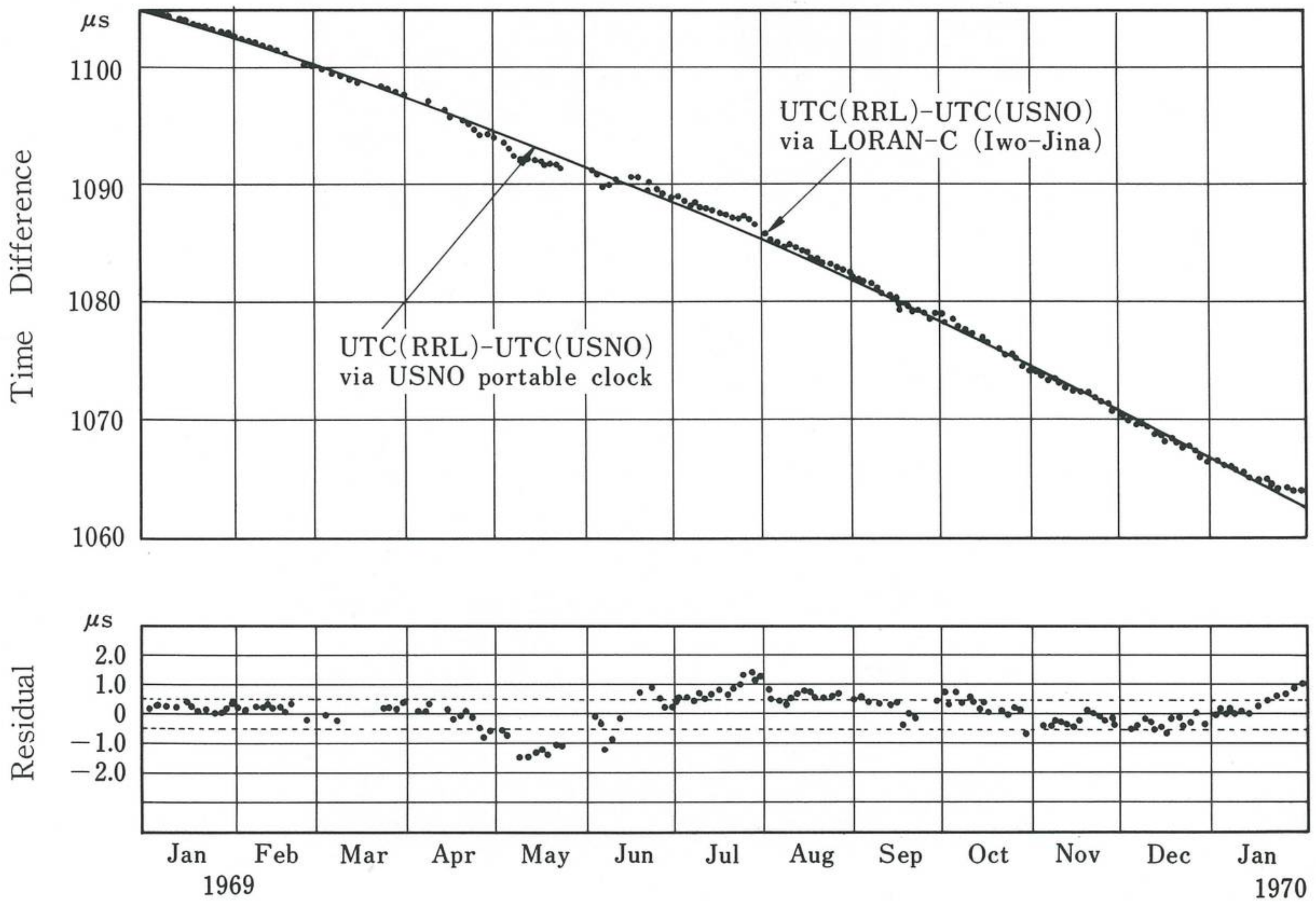


Hydrogen Maser

INTERNATIONAL COMPARISON OF ATOMIC TIME SCALE BY VLF AND LF

For the international comparison of atomic time scale, phase measurement of VLF and Loran-C transmission as received is now being done. As to the VLF, reception of the signal on 18.6 kHz from Station NLK (Jim Creek, Washington, USA) has been made since nearly ten years, and a receiving test on Omega emission from Hawaii and North Dakota has begun lately. Because of day-to-day variation of received phase on the order of μs, caused by that of D-layer's height, the precision is limited to a few parts in 10^{11} in 24-hour frequency comparison.

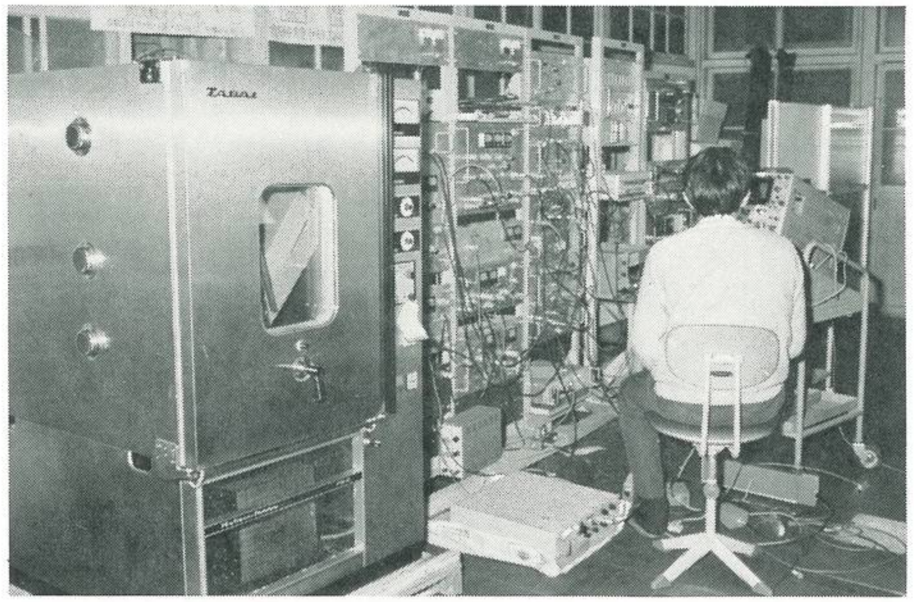
Measurement on Loran-C from Iwojima has been made regularly since 1969. By using a part of received pulse of 100 kHz, consisting only of ground wave for the phase comparison, variation of the phase as received is as small as 0.1 μs, hence the precision as high as a few parts in 10^{12} is obtainable in 24 hours. A result of the international time comparison via Loran-C between the RRL and the US Naval Observatory is illustrated by figure (under), showing that the precision of 0.5 μs is possible in the time comparison even in a long period.



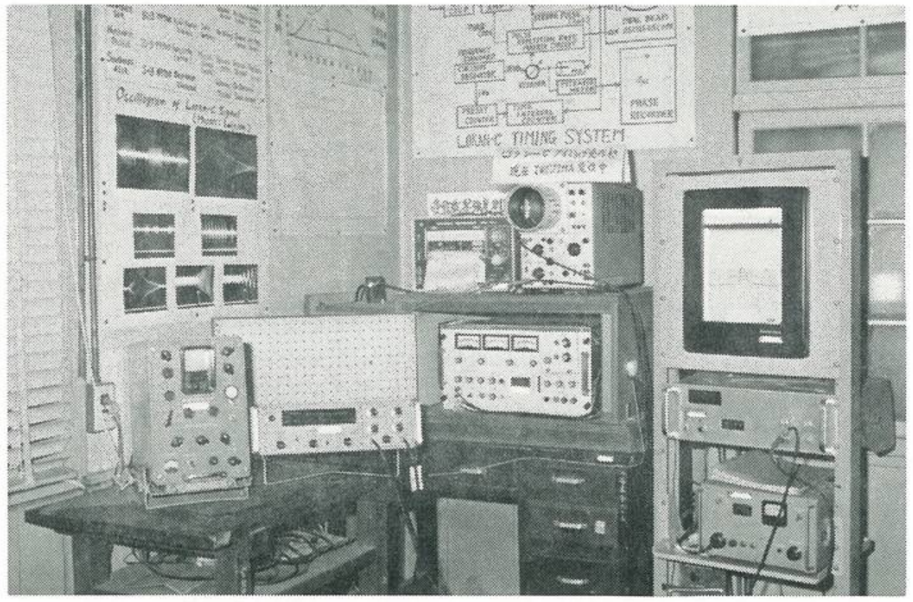
Time Comparison between UTC (RRL) and UTC (USNO) via Loran-C (Iwo-Jima)

PRECISION MEASUREMENT OF FREQUENCY

For the establishment of accurate and uniform atomic time scale and for appropriate application of standard frequency generators to various fields of precision science, study on the measurement of frequency stability, defined in terms of time and frequency domains, is now being carried on, in which emphasis is placed on data processing and analysis as well as on the improvement in the resolution of the measurement systems. Besides, for the study on noise from frequency synthesizers, measurement and analysis of noise in transistor amplifier and diode frequency mixer are now in progress.



System for precision frequency measurement



Loran–C receiving system

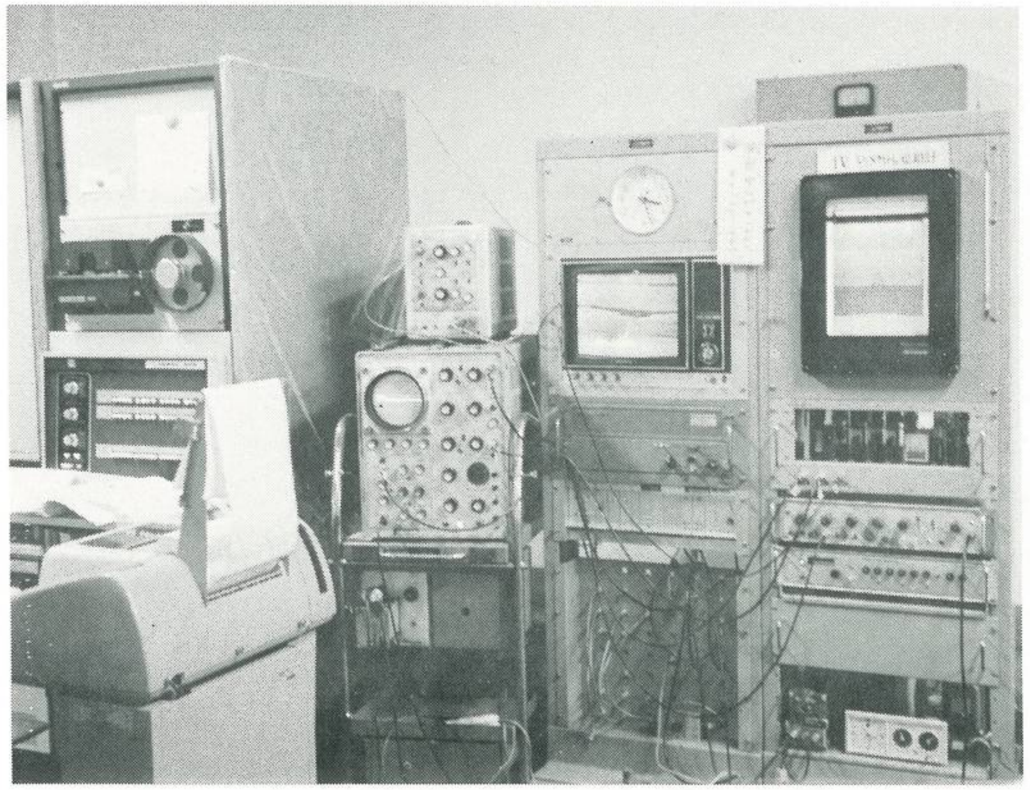
PRECISE COMPARISON OF TIME AND FREQUENCY BY MEANS OF TV SIGNALS

To investigate the utility of the method, the study was commenced in 1970. The reuslts show that the precision of frequency comparison via the relayed TV color subcarrier (3.58 MHz) stabilized by an atomic clock are 6.5×10^{-12} and 2.2×10^{-12} for averaging time of 10 and 60 minutes respectively.

As to the time comparison, the accuracy via the specified horizontal synchronizing pulse from the same TV transmitter is about 0.2 μs, and the delay time of microwave networks of 1400 km long, measured by the same method, is constant within 2 μs all the year around.

Since 1972, the clock intercomparison by TV signal has been made regularly among the organizations concerned with the precise time keeping.

The insertion of a pulse having a period of 1001 ms to the vertical blanking interval, as well as the stabilization of TV signals by an atomic clock, is considered as a simple and more useful method for the clock intercomparison in NTSC TV system, for which the necessary arrangements are now being made.



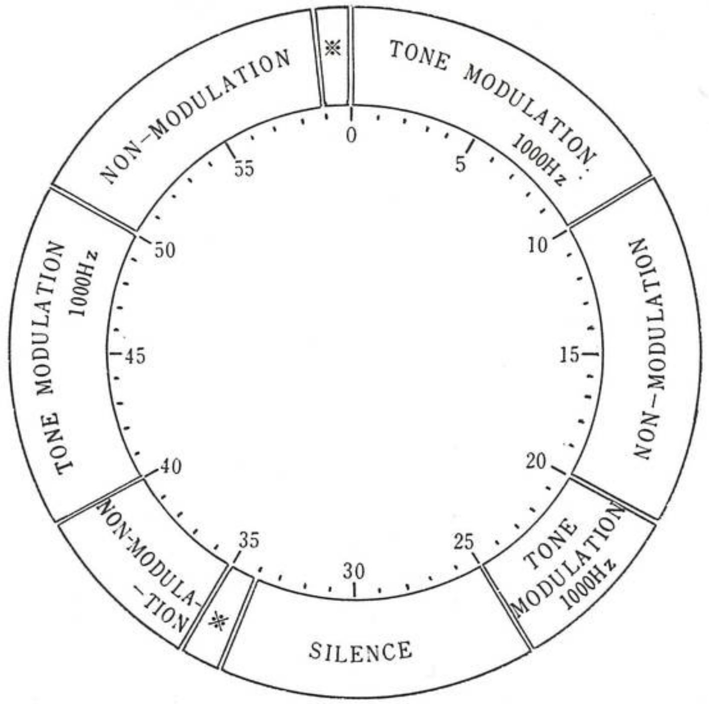
Precise frequency comparison measurement

STANDARD FREQUENCY AND TIME BROADCAST SERVICE

The time signals and the standard frequencies are broadcast from JJY with very high accuracy and stability for users in many fields.

The frequencies are maintained with $\pm 5 \times 10^{-11}$ with respect to the value determined by the definition of second.

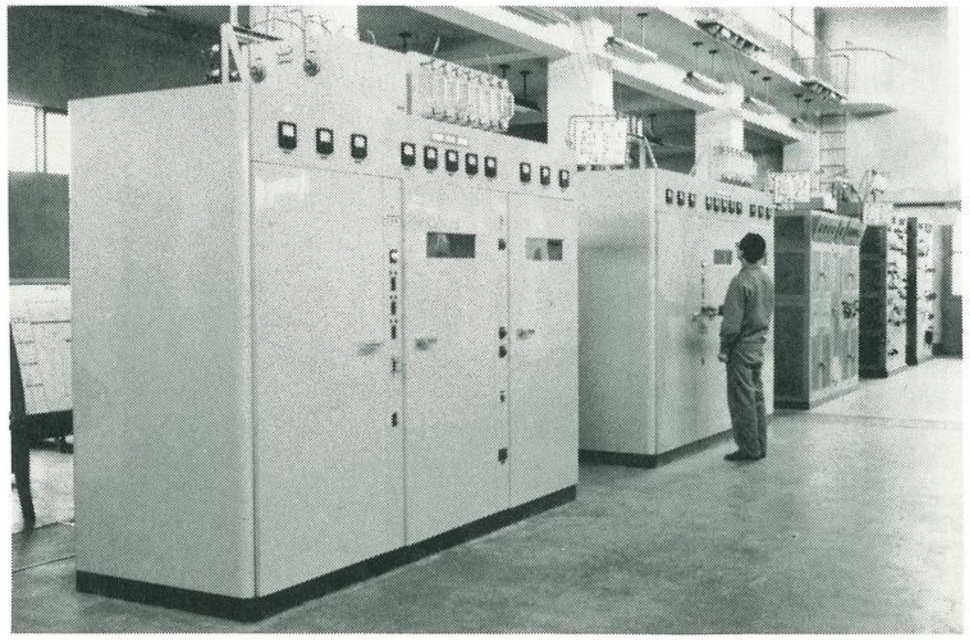
The JJY time signals are based on the UTC system and are synchronized internationally within ± 1 ms.



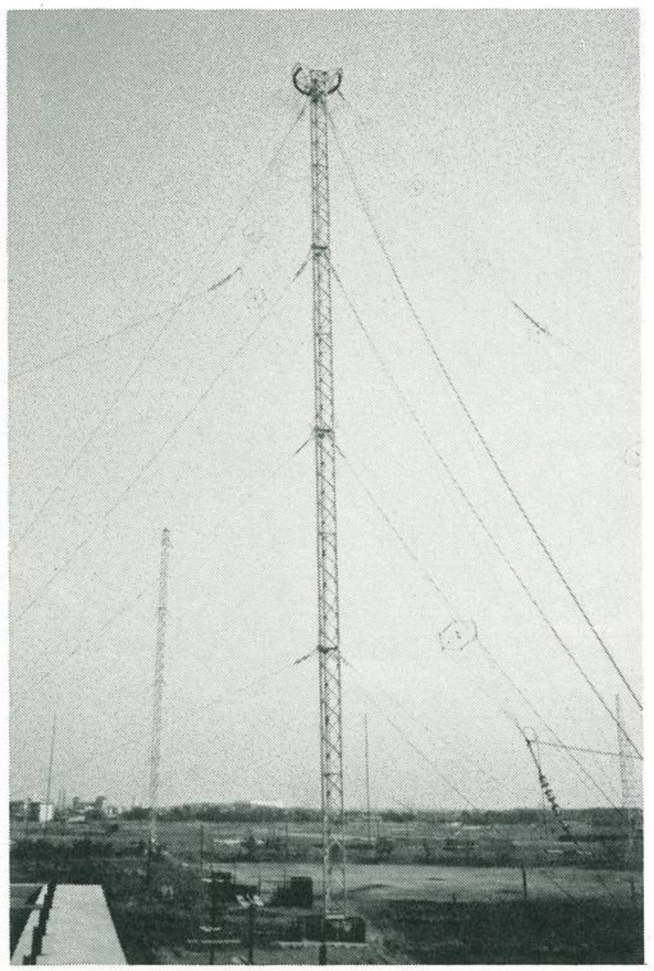
The hourly broadcasting schedule of JJY
*Station announcement

Service station and experimental stations for standard frequencies

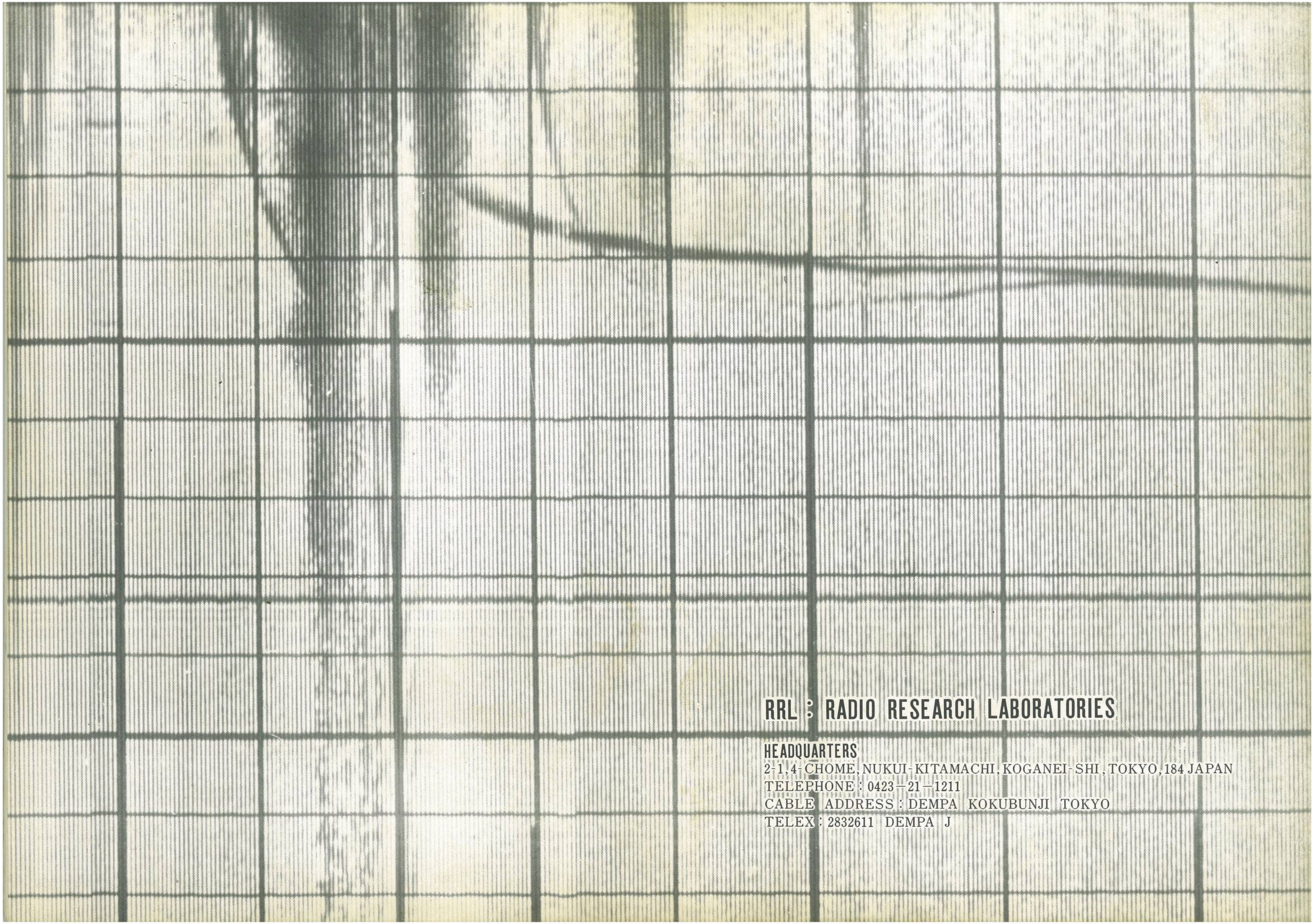
	SERVICE STATION				
CALL SIGN	JJY	JG2AE	JG2AQ	JG2AR	JG2AS
FREQUENCIES	2.5 MHz, 5 MHz 10 MHz, 15 MHz	8 MHz	16.2 kHz	20.0 kHz	40.0 kHz
OUTPUT POWER	2 kW	0.5 kW	3 kW	3 kW	10 kW
OPERATION HOURS	24	05 : 59~ 19 : 59	OCCASIONALLY	14 : 30~16 : 30 EXCEPT ON EVERY SATURDAY AND SUNDAY	04 : 00~15 : 00 EXCEPT ON EVERY SATURDAY AND SUNDAY
SECONDS PULSES	USUALLY	USUALLY	USUALLY	USUALLY	NONE
ACCURACY	± 0.5 ~~±3~~ $\times 10^{-10}$	± 0.5 ~~±3~~ $\times 10^{-10}$	± 0.5 ~~±3~~ $\times 10^{-10}$	± 0.5 ~~±3~~ $\times 10^{-10}$	$\pm 0.5 \times 10^{-10}$
LOCATION	KOGANEI, TOKYO	KOGANEI, TOKYO	KOGANEI, TOKYO	KOGANEI, TOKYO	KEMIGAWA, CHIBA PREFECTURE



JJY transmitter room (Koganei station)



LF 40 kHz transmitting antenna (Kemigawa station)



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As of Apr. 1, 1974

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Deputy Director Dr. Hiroo Yuhara

Principal Research Officer Mr. K.Kawakami

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Special Research Section for Precision Quartz Resonators	Dr. Y.Hiruta

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Wakkanai Radio Wave Observatory	Mr. T.Koizumi
Akita Radio Wave Observatory	Mr. Y.Takenoshita
Inubo Radio Wave Observatory	Mr. C.Ouchi
Yamagawa Radio Wave Observatory	Mr. M.Nakajima
Okinawa Radio Wave Observatory	Mr. S.Watanabe