RADIO RESEARCH LABORATORIES

MINISTRY OF POSTS AND TELECOMMUNICATIONS

1977

CONTENTS

BIRD'S-EYE VIEW OF THE RADIO RESEARCH LABORATORIES

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REGULAR PERSONNEL 463

OUTLINE OF THE RADIO RESEARCH LABORATORIES

It is only less than a century since the mankind set about making use of radio waves. During those years there has been a remarkable development in the field of radio science and its application. Since the utilization of radio waves covers various fields, such as communication, broadcasting, remote control, remote sensing, etc., the radio wave is at present an indispensable factor for the formation of modern society. Moreover, the demand for radio waves is now on the increase with the complication of social life and the promotion of international exchange.

For this reason it may safely be said that the mission of the Radio Research Laboratories, an auxiliary organ of the Ministry of Posts and Telecommunications, is to conduct researches aiming at effective utilization of radio waves on the one hand, and on the other hand, prepare fundamental data necessary for making the most of radio waves that are limited resources for the national welfare.

In order to assure the efficient performance of radio communication, it is required to study the radio propagation in each frequency band and make clear the fitness of each frequency band according to the purposes. It is also necessary to issue forecasts for the short-wave propagation and forewarnings for the propagation disturbance by making observations and studies of the ionosphere. The main field of radio research covers not only a new development of available frequency band but also that of communication, communication system, data processing system, etc. for making the best use of frequency spectrum.

The space development has been taken up as a project of national importance. Since the space development cannot be considered without radio wave, the part played by the Radio Research Laboratories is extremely important and among the space development projects already fixed in Japan are indeed four artificial satellites in which the Radio Research Laboratories is directly concerned, namely, ISS (Ionosphere Sounding Satellite), CS (Medium-capacity Communications Satellite for Experimental Purposes), BSE (Medium-scale Broadcasting Satellite for Experimental Purposes), and ECS (Experimental Communications Satellite).

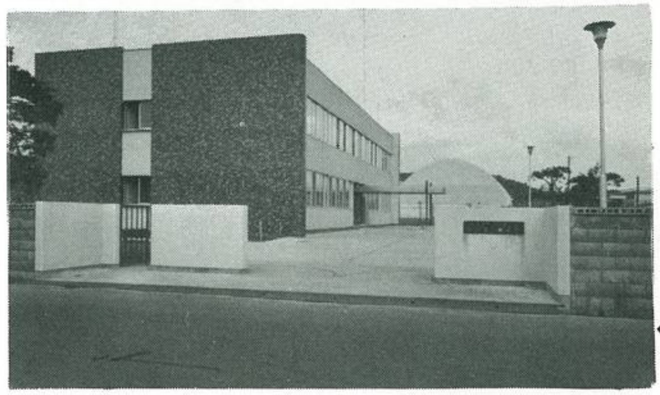
As for the marine developments, researches have been prosecuted into an undersea communication system by laser and a new system of high-efficiency underwater television using laser, and examinations are well under way on a comprehensive marine communication system.

One of the primary utilizations of radio waves other than communication is the measurement of the earth's environment. Observations of the ionosphere have been carried out for many years as a link in the chain of the world observation network. Through intensified observations which are being made as part of the International Magnetospheric Study (IMS 1976–1978), our natural environment is expected to be made clear more in detail. The Radio Research Laboratories is engaged not only in the monitoring of cosmical space but also, to meet the requirements of the times, in the technical development of remote sensing of different phenomena occurring near the surface of the earth, such as ocean waves and distribution condition in space of air pollutants, expecting that the radio wave and its related techniques will be of use to the national welfare.

It is one of the principal services of the Radio Research Laboratories to determine the frequency standard value and broadcast the standard frequencies as the measure of radio waves and thereby make the announcement of the standard time. On the other hand, the type approval test services of radio apparatus and devices are also of great importance from a national point of view. It is essential to strengthen such services for the promotion of effective utilization of radio waves in Japan.

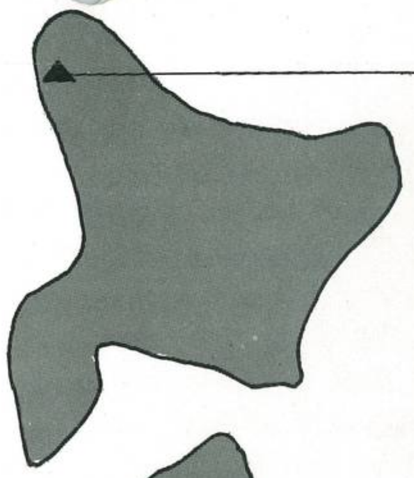
LOCATION OF THE RADIO RESEARCH LABORATORIES

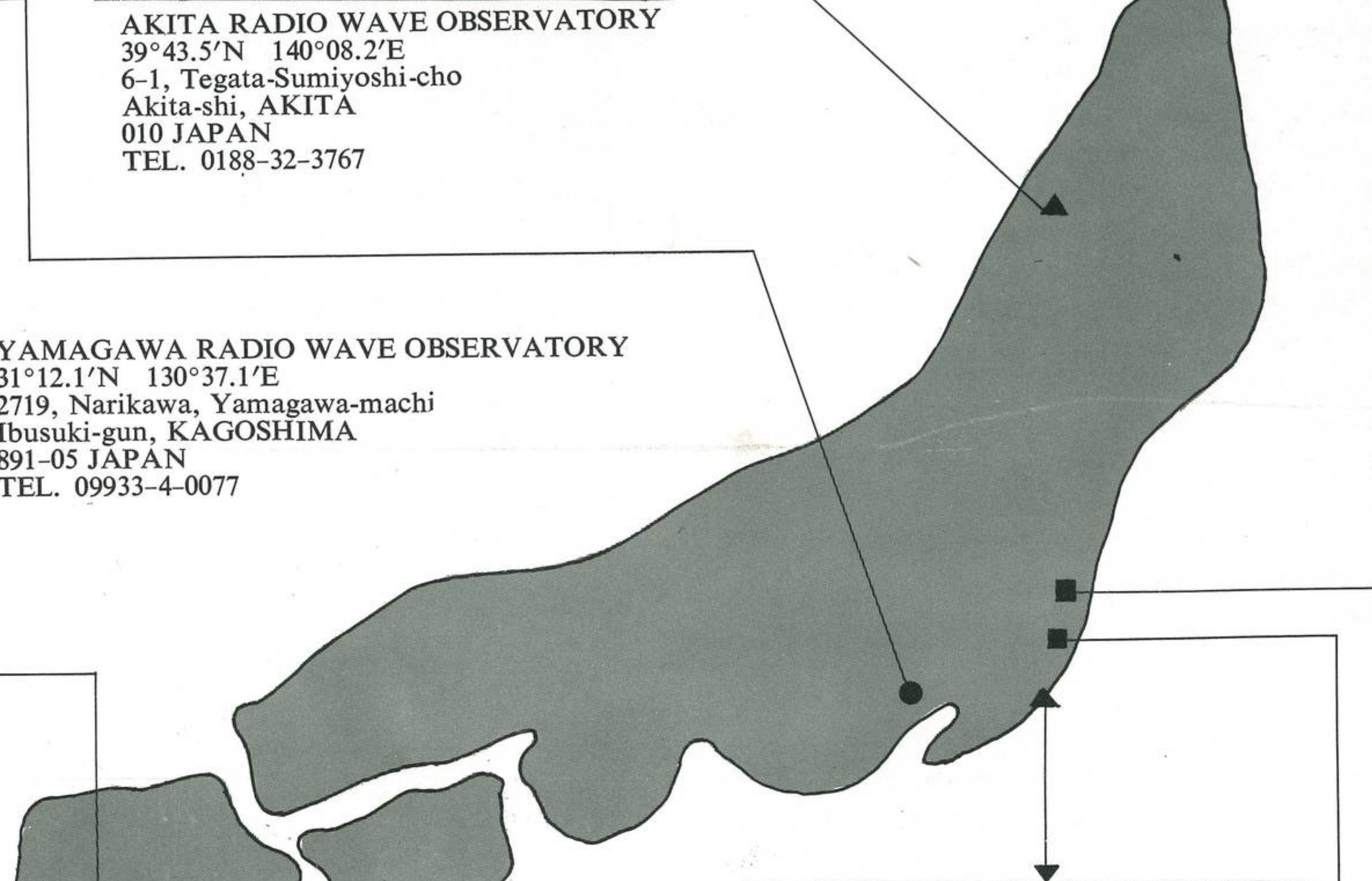
HEADQUARTERS
35°42.4′N 139°29.3′E
2-1, Nukui-Kitamachi 4 chome
Koganei-shi, TOKYO
184 JAPAN
TEL. 0423-21-1211
TLX. 2832611 DEMPA J
Cable DEMPA KOKUBUNJI TOKYO

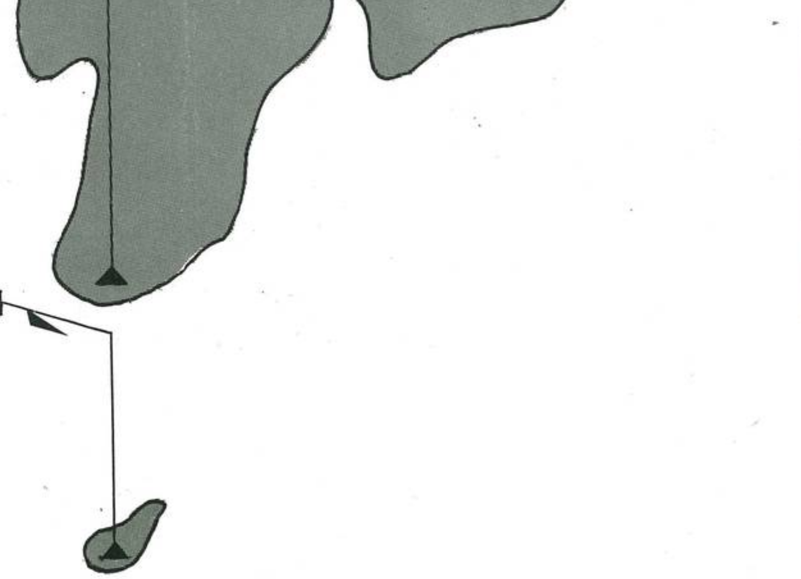


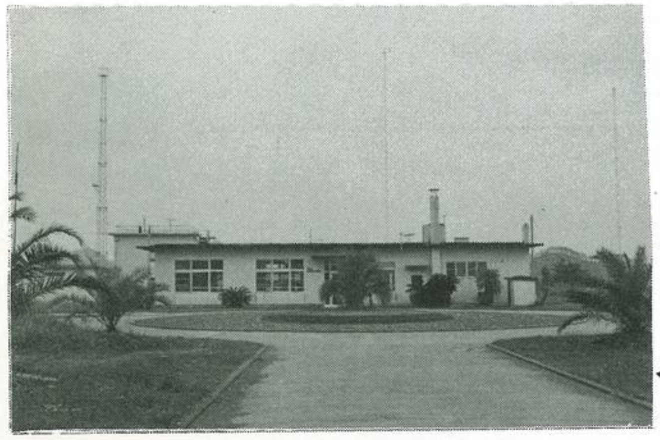
AKITA RADIO WAVE OBSERVATORY
39°43.5′N 140°08.2′E
6-1, Tegata-Sumiyoshi-cho
Akita-shi, AKITA
010 JAPAN
TEL. 0188-32-3767

WAKKANAI RADIO WAVE OBSERVATORY
45°23.6′N 141°41.1′E
3-20, Midori 2 chome
Wakkanai-shi, HOKKAIDO
097 JAPAN
TEL. 01622-3-3386



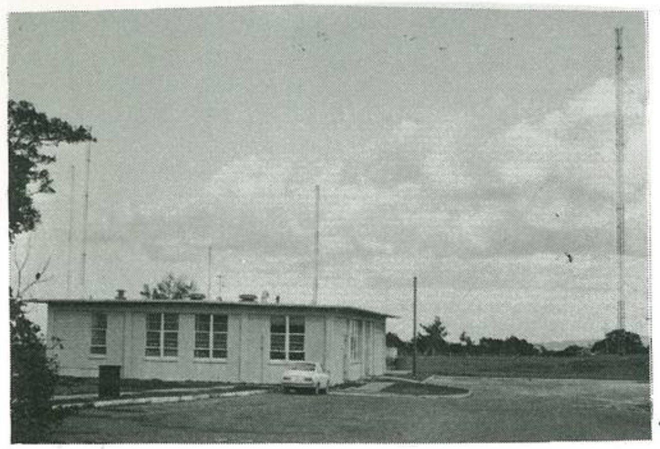




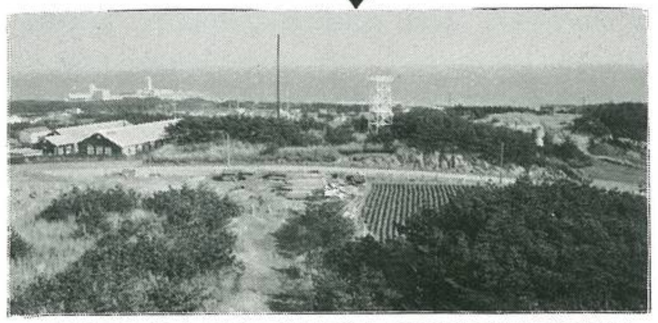


YAMAGAWA RADIO WAVE OBSERVATORY
31°12.1′N 130°37.1′E
2719, Narikawa, Yamagawa-machi
Ibusuki-gun, KAGOSHIMA
891-05 JAPAN
TEL. 09933-4-0077

HIRAISO BRANCH
36°22.0′N 140°37.5′E
3601, Isozaki-machi
Nakaminato-shi, IBARAKI
311-12 JAPAN
TEL. 02926-5-7121



OKINAWA RADIO WAVE OBSERVATORY
26°16.9′N 127°48.4′E
Kuba, Nakagusuku-son
Nakagami-gun, OKINAWA
901-24 JAPAN
TEL. 09893-8-0045



INUBO RADIO WAVE OBSERVATORY
35°42.2′N 140°51.5′E
9912, Tennodai
Choshi-shi, CHIBA
288 JAPAN
TEL. 0479-22-0871

KASHIMA BRANCH
35°57.2′N 140°40.0′E
Hirai, Kashima-machi
Kashima-gun, IBARAKI
314 JAPAN
TEL. 02998-2-1211
TLX. 3658901 COMKAS J

ORGANIZATION OF THE RADIO RESEARCH LABORATORIES

Director
Deputy Director   Principal Research Officer

HEADQUARTERS

Administrative Division
- General Affairs Section
- Accounts Section

Planning and Support Division
- Project Support Section
- Technical Service Section

Technical Consulting Division
- International Radio Affairs Research Section
- Frequency Utilization Research Section
- Radio Application Research Section
- Communication System Advisory Section

Information Processing Division
- Information Processing Research Section
- Computer Applications Research Section
- Computer System Research and Service Section
- Satellite Data Research Section

Radio Wave Division
- Radio Propagation Research Section
- Ionospheric Radio Prediction Section
- Space Physics Section
- Radio Meteorology Section

Artificial Satellite Research Division
- Communication Satellite Research Section
- Ionospheric Satellite Research Section
- Data Acquisition System Research Section

Communication System and Apparatus Division
- Communication Systems Section
- Speech Processing Research Section
- System Performance Research Section
- Standards and Measurements Research Section
- Applied Radio Physics Section
- Marine Communication Research Section
- Communication Apparatus Section

Frequency Standard Division
- Atomic Standards Research Section
- Standard Frequency and Time Research Section
- Standard Frequency and Time Dissemination Section

Special Research Section for Space Physics
Special Research Section for Atmospheric Radio Science
Special Research Section for Radio Physics
Special Research Section for Electromagnetic Compatibility

REGIONAL BRANCHES AND OBSERVATORIES

Kashima Branch
- Space Communication Section
- Space Research Section
- Satellite Control Section
- Administration Section

Hiraiso Branch
- Upper Atmosphere Research Section
- Solar Radio Research Section

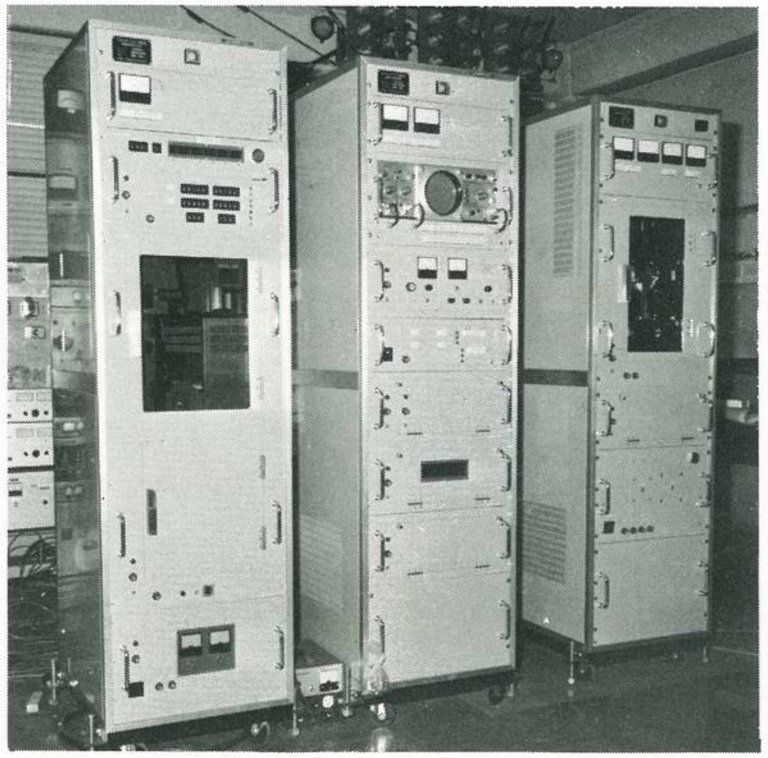
Wakkanai Radio Wave Observatory
Akita Radio Wave Observatory
Inubo Radio Wave Observatory
Yamagawa Radio Wave Observatory
Okinawa Radio Wave Observatory

IONOSPHERIC OBSERVATIONS

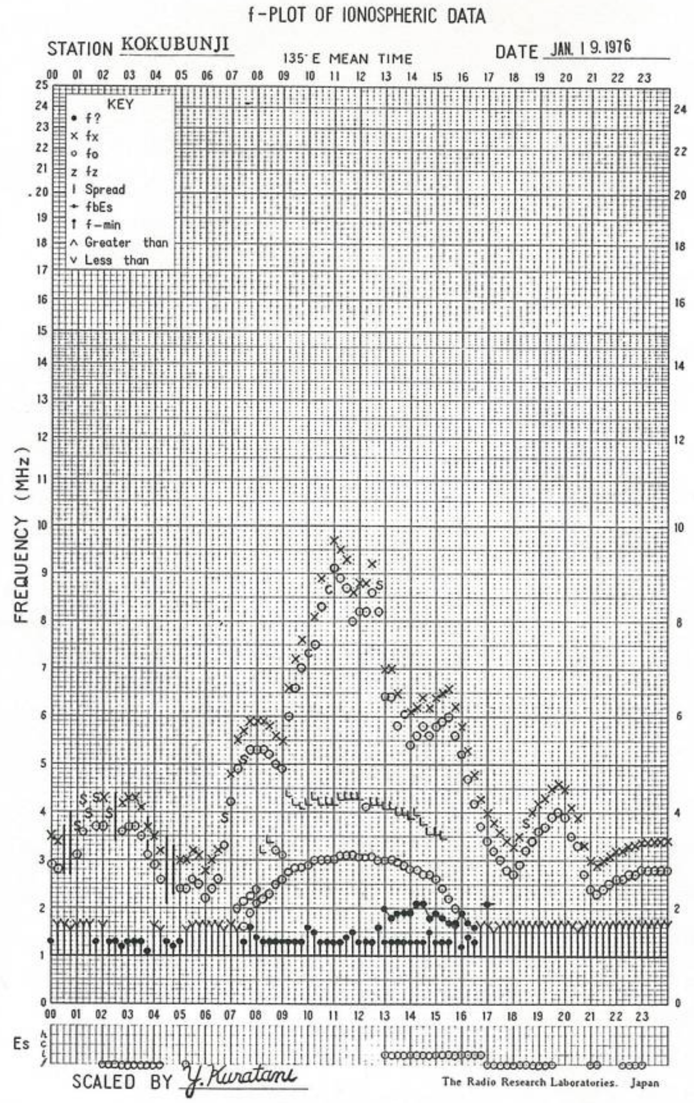
Observations of the ionosphere by means of vertical sounding technique are being made at the five Radio Wave Observatories of Wakkanai, Akita, Kokubunji (Tokyo), Yamagawa and Okinawa located, from north to south, at intervals of about five degrees of latitude along the 135° E meridian, in order to "Monitor the Solar Earth Environment" (MONSEE) on a permanent basis, in cooperation with activities of the international scientific communities. It should particularly be mentioned that ionospheric soundings in the Tokyo district started in 1932 at about the same time as in the U.S.A. (Washington D.C.) and England (Slough).

The observational results of the ionosphere give not only the most important information 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.

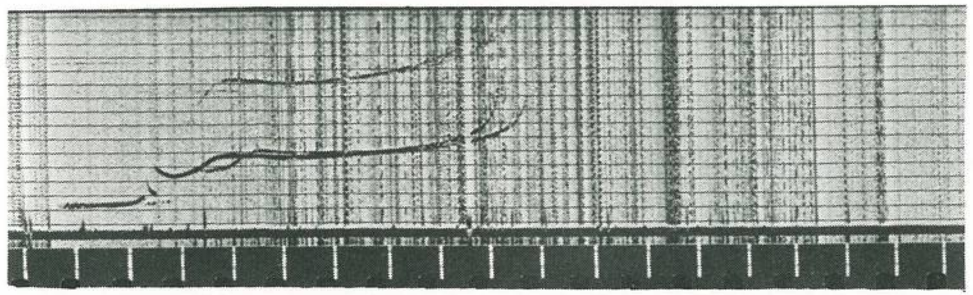
According to the URSI rules, ionospheric observatories are requested to make soundings normally every 15 minutes on a routine basis. Ionospheric parameters obtained at the five Japanese sounding stations are published monthly in the "Ionospheric Data in Japan" for distribution among the World Data Centers as well as domestic and foreign agencies concerned.



Ionosonde (Type-9)



f-plot of ionospheric data

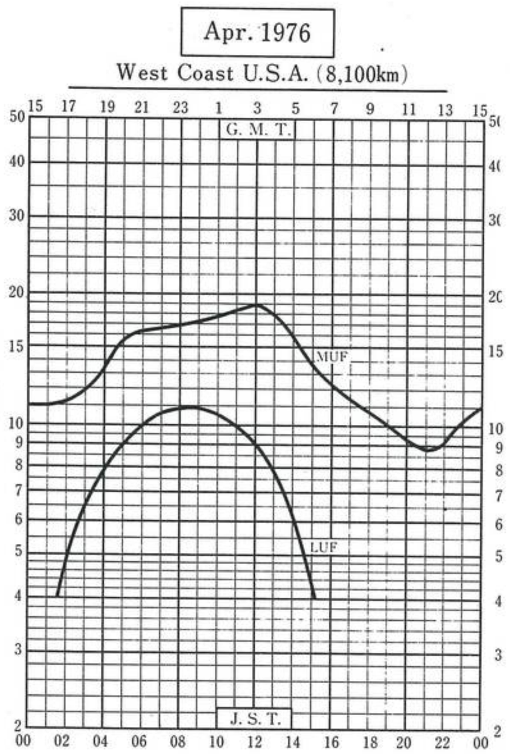


A record of ionospheric vertical sounding (ionogram)

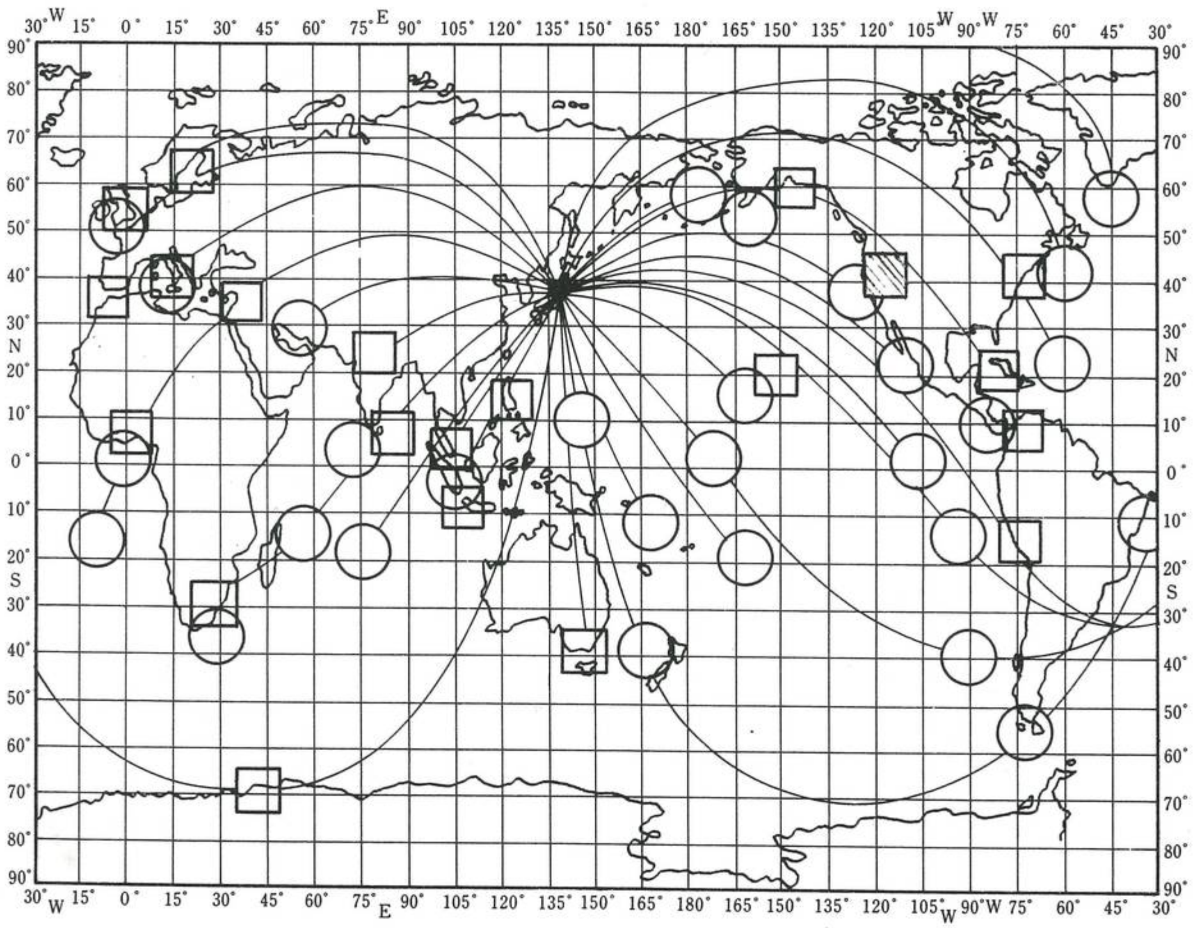
HF RADIO PROPAGATION PREDICTION

The Radio Research Laboratories issues three months in advance the HF radio propagation prediction which covers communication circuits between Tokyo and each of several principal districts as well as the waters in which merchant or fishing vessels are on voyage.

The prediction diagram prepared by the full use of electronic computer gives an idea of operational frequencies usable for communications between the two places at a given time.



An example of radio propagation prediction (MUF: maximum usable frequency; LUF: lowest useful frequency)



Service area of radio propagation prediction
○···waters □···principal districts ▩···west coast U.S.A.

WORLD DATA CENTER C2 FOR IONOSPHERE

The World Data Centers were established by the Special Committee for the IGY (International Geophysical Year) under the ICSU (International Council of Scientific Unions), with a view to collecting and keeping observational data obtained during the IGY. The World Data Centers are as follows:

Center A:	All disciplines	U.S.A.
Center B:	All disciplines	U.S.S.R.
Center C:	Single discipline	Several nations

Since 1958, the World Data Center C2 for Ionosphere under the Radio Research Laboratories has been continuing to collect, exchange and keep all the data obtained from the organizations or ionospheric stations participating in world-wide scientific cooperation. At present this Center has a large quantity of ionospheric data (6900 copies in paper sheet or book, 16350 rolls in film) received from sixty-seven 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 for Solar-Terrestrial Physics
Soviet Geophysical Committee
Academy of Sciences of the U.S.S.R.
Molodezhnaya 3, Moscow 117296
U.S.S.R.

World Data Center C1 for Ionosphere
Appleton Laboratory, Science Research Council
Ditton Park, Slough SL3 9JX
Bucks, U.K

World Data Center C2 for Ionosphere

RADIO DISTURBANCE WARNINGS

The ionosphere is mainly influenced by the solar activities, changing with the season and local time, and is sometimes disturbed in association with solar eruptions and magnetic storms. Consequently, HF radiocommunication in particular meets with considerable difficulties. Therefore, radio disturbance warnings are required to predict accurately the time of occurrence and degree of disturbances. For warning against radiocommunication hindrance, the Hiraiso Branch of the Radio Research Laboratories is collecting through the Regional Warning Centers for International URSIGRAM and World Days Service, a variety of information on field intensities of HF signals in long-distance propagation, ionosphere, geomagnetism and solar activity, in addition to observational data sent from the domestic observatories.

The Hiraiso Branch is responsible for the issue of both radio disturbance warnings for domestic communication engineers and the geoalert (a solar-geophysical disturbance message) for the other Regional Warning Centers (refer to IUWDS on page 9). Such radio disturbance warnings are disseminated to general users by the standard frequency (JJY) broadcasting and to specified agencies by telephone, telex or mail.

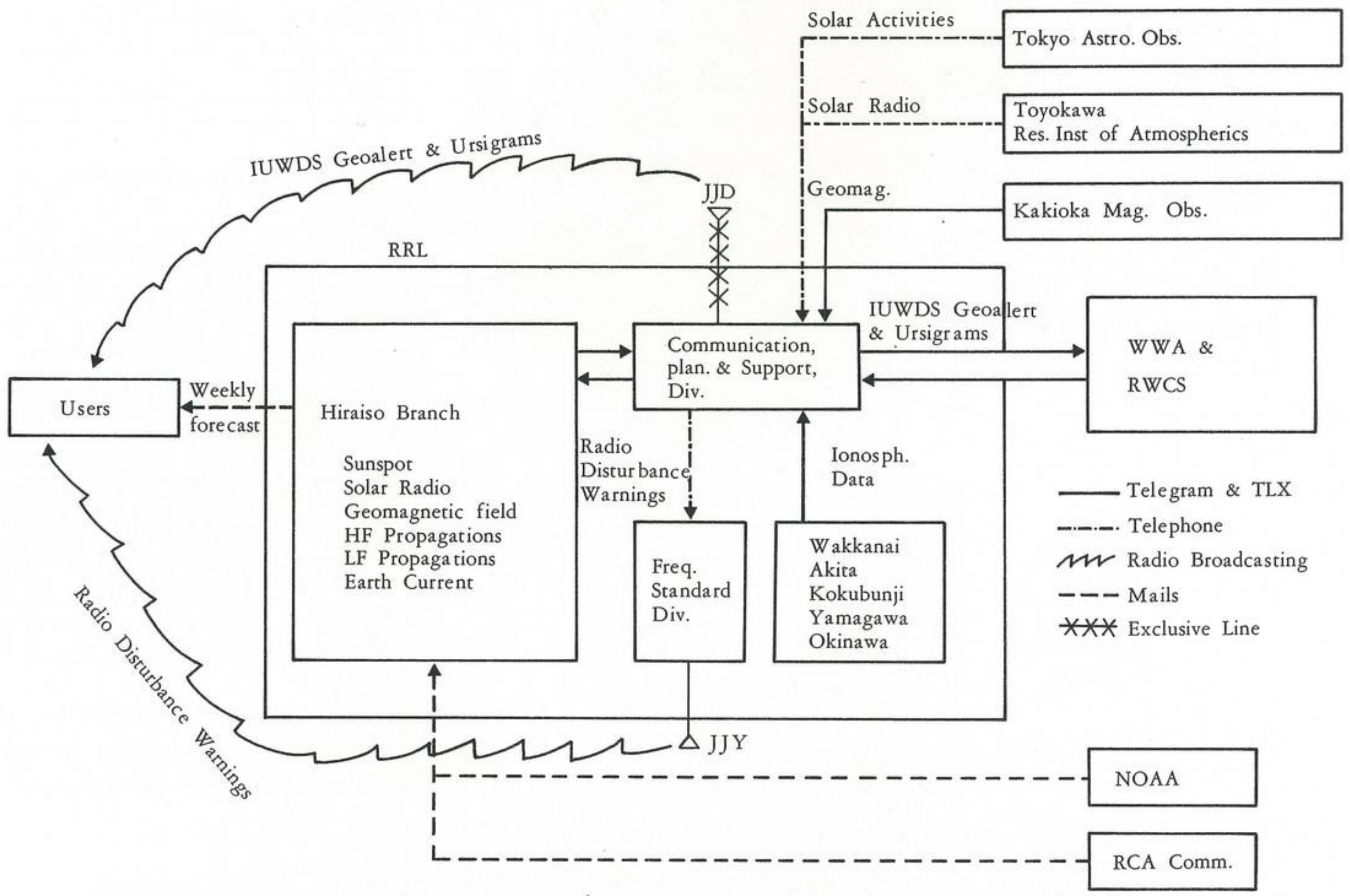
Recently, an electronic computer system, named RADWIS (Radio Disturbance Warning Issuance System) was introduced for the automatic processing of relevant information and the improvement in service.

RADIO DISTURBANCE WARNING SERVICES

Type	Title	Content	Forecast Period	Frequency of Issuance	Distribution (Medium)
World Days Service	GEOALERT	Solar-Terrestrial Disturbances	1 day	Daily	Radiocommunication Facilities (JJD) WWA & RWC (TLX)
Actual Conditions Report	URANJ USIDS		......		
Short-term Forecast	WARNING	HF Propagation Disturbances	12 hrs	Occasionally	Radiocommunication Facilities (JJY)
Weekly Forecast	WEEKLY FORECAST ADJ--		1 week	Weekly (Tues. & Fri.)	Radiocommunication Facilities (Mail) WWA & RWC (TLX)
Message Commanding Special Ionosphere Observations		Ionospheric Conditions	Several days	Occasionally	Radio Wave Observatories (TLX)

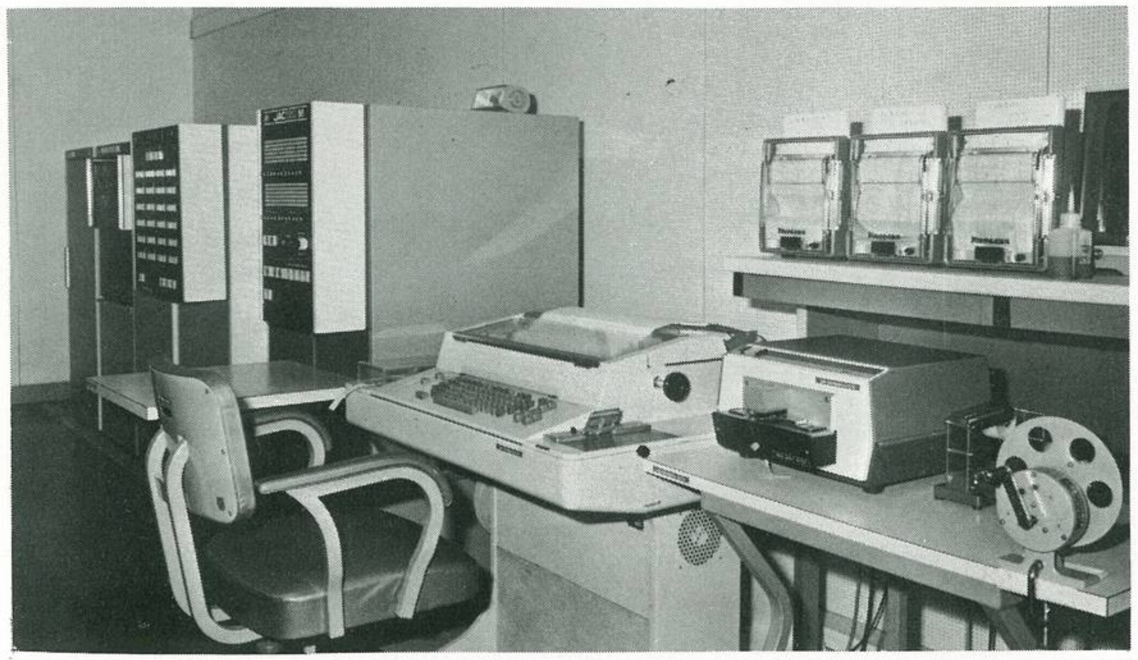
KINDS OF IONOSPHERIC DISTURBANCES

Type	Region of Occurrence	Delay Time after Flare	Duration	Causes Identified	Ground-based Sensors
Sudden Ionospheric Disturbance (SID)	Sunlit Hemisphere	8 mins	0.5-3 hrs	Solar X-ray	Ionosphere Observations HF-VLF Radio Propagations
Polar Cap Disturbance (PCD)	Polar Regions	1-2 hrs	1-10 days	Solar High-Energy Protons and Electrons	Riometer Ionosonde
Ionospheric Storm	World-wide	2-3 days	2-3 days	Solar Plasma Cloud	Ionosphere Observations (Geomagnetism Observations)
Recurrent Ionospheric Storm		27-day period independent of Flare	Several days		



System of radio disturbance warning services and flow of solar and geophysical data

System of radio disturbance warning services



RADWIS, an electronic computer system for radio disturbance warnings

INTERNATIONAL URSIGRAM AND WORLD DAYS SERVICE

The International Ursigram and World Days Service network has been effectively operated since the IGY for the rapid exchange of solar and geophysical data for researchers and observatories. In general, the IUWDS message, the so-called URSIGRAM, contains two kinds of information; one is the solar and geophysical data such as solar activity, geomagnetism, cosmic rays, ionosphere, etc., and the other is "PRESTO" (prompt report of major events), "GEOALERT" (Geophysical Alert), etc. These messages coded in five-digit numbers are defined in the code booklet released by the IUWDS Committee.

The IUWDS has assigned the five regions of the world, each of which having a Regional Warning Center (RWC). The Western Hemisphere RWC at Boulder, U.S.A. serves as the IUWDS World Warning Agency.

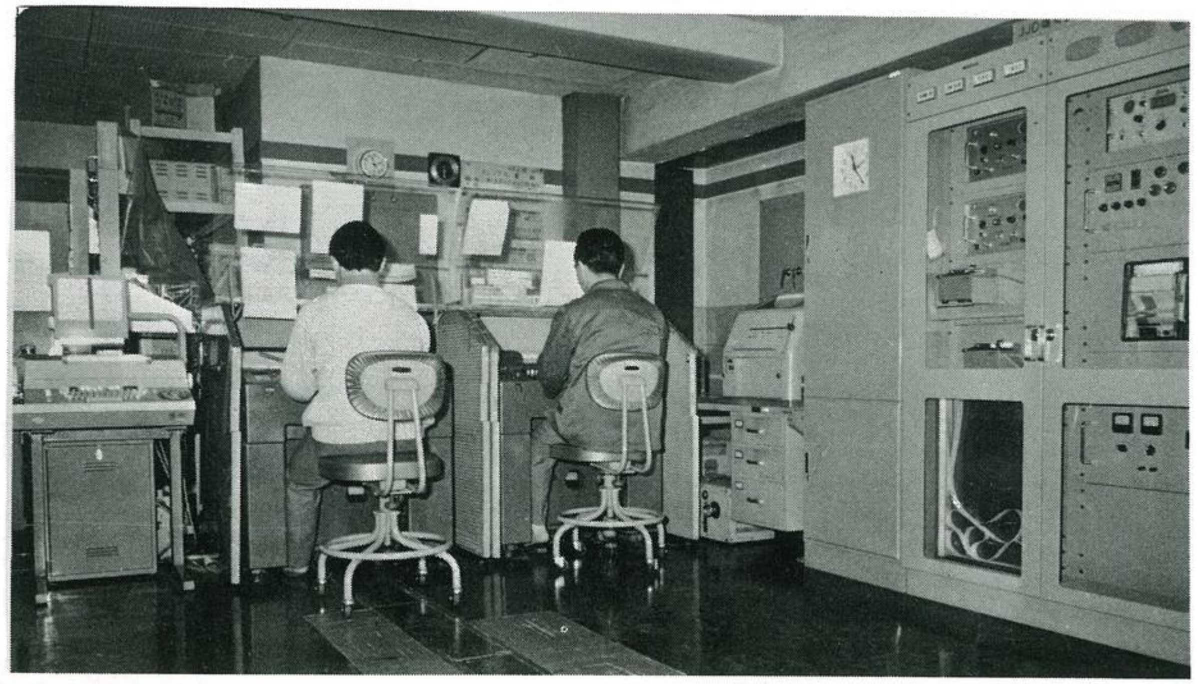
The RRL has taken on the services of the Western Pacific RWC since the establishment of the International Geophysical Year (IGY) in 1957, and the URSIGRAM has been exchanged with the four other RWC's (Boulder, U.S.A.; Moscow, U.S.S.R.; Paris, France; Sydney, Australia).

The URSIGRAM broadcasting is outlined as follows:

Communication center: RRL, Koganei, Tokyo
Transmitting station: Usui, Chiba
(35° 43.7′ N, 140° 12.2′ E: about 60 km east of the RRL)

Current broadcasting schedule:

Call Sign	Frequency (kHz)	Class of Emission	Time (UT)	Power (kW)	Antenna
JJD	10,415	A1	08:00	5	Non-directional
JJD2	15,950	A1	08:00	5	Non-directional



Communication center

OBSERVATION OF THE SOLAR RADIO EMISSIONS

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

The enhancement of emission usually occurs in association with a solar optical flare, known as a burst, and is classified into several types according to its variation and spectrum. The type IV burst is a useful information for the prediction of geomagnetic storms and polar cap absorption events. The data are published monthly in the "Ionospheric Data in Japan".

Parabolic antennas for solar radio observation

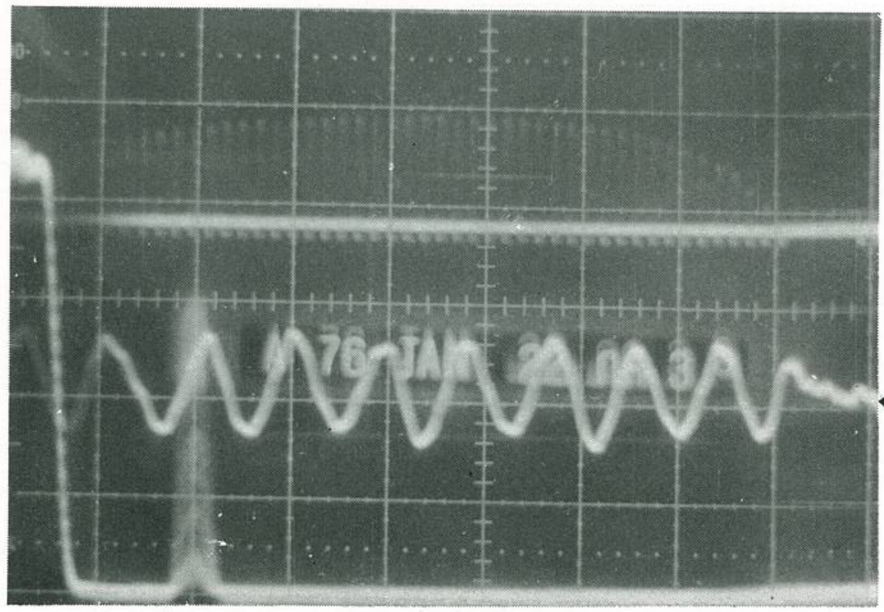
HF RADIO WAVE PROPAGATION

The JJY standard frequency waves have been received at the Wakkanai and Akita Radio Wave Observatories for researches in HF wave propagation over short distance through the ionosphere, especially the Es-layer. On the other hand, the data on long distance propagation of WWV (Colorado, U.S.A.) and WWVH (Hawaii) standard frequency waves at 15 MHz have been obtained since 1962 at the Hiraiso Branch operating as an international key station, and have been published monthly in "Ionospheric Data in Japan" and also reported to the CCIR.

OBSERVATION OF THE LOWER THERMOSPHERE BY A METEOR RADAR

Observations of the wind and density of the neutral atmosphere in the meteor region (80–100 km) are being carried out with a meteor radar to study the dynamics in the lower thermosphere. Special emphasis is placed on the URSI-IAGA Coordinated Observations of Tides in the Lower Thermosphere Project in forming observation schedules.

A 5-element Yagi antenna rotatable in azimuth and elevation —Akita Radio Wave Observatory—



Successive echo amplitude separated by 3.3 ms.

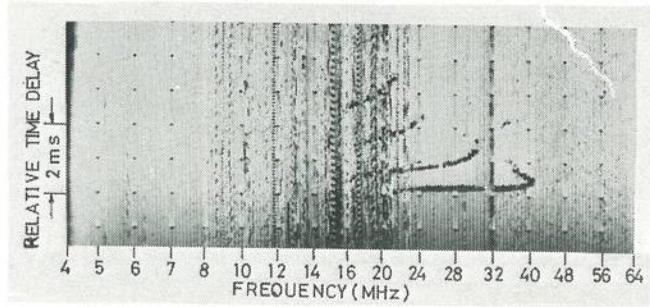
Doppler shifts Sweep time: 20 ms/div.

An echo displayed on A-scope Sweep time: 333 μs/div.

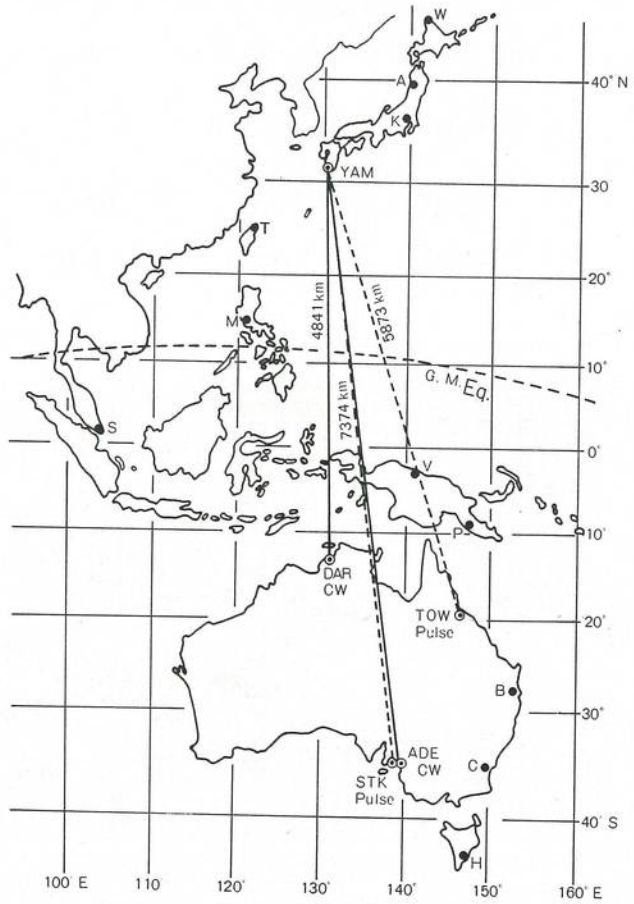
An example of the meteor radar records

TRANS-EQUATORIAL RADIO PROPAGATION

Long range propagation experiments in VHF band have been conducted under joint efforts between Japan and Australia over the trans-equatorial path as shown in the map, to clarify the ionospheric propagation mechanism of VHF waves. For the study of trans-equatorial propagation (TEP), the step-frequency pulsed sounders have been operated and the oblique ionograms shown in the figure have been obtained in addition to the fixed-frequency CW transmitters. Moreover, the measurement of beacon signals from artificial satellite has recently started at the Yamagawa Radio Wave Observatory to investigate the correlation between scintillation of the signals and the trans-equatorial waves.



An example of oblique ionogram

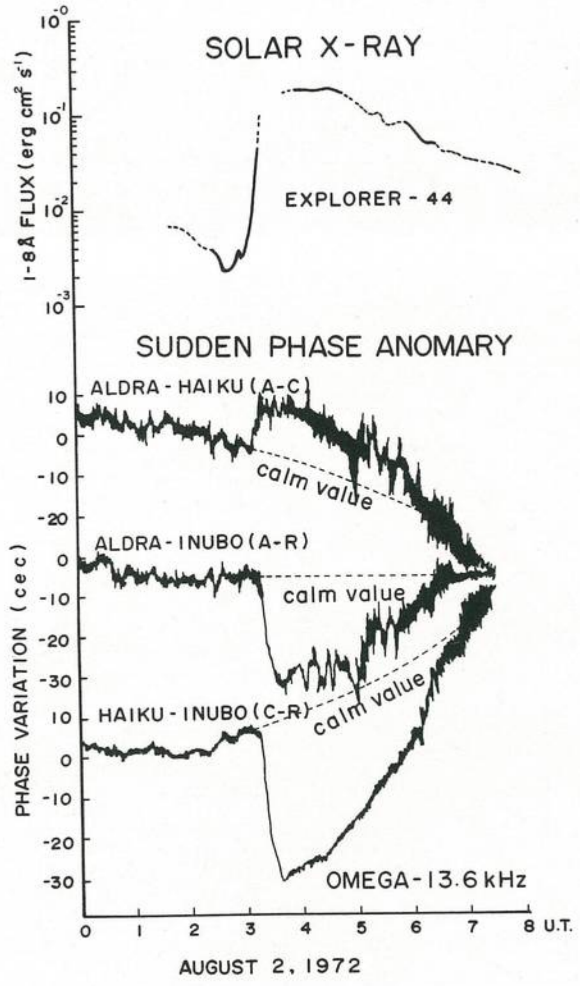


Map of the TEP paths

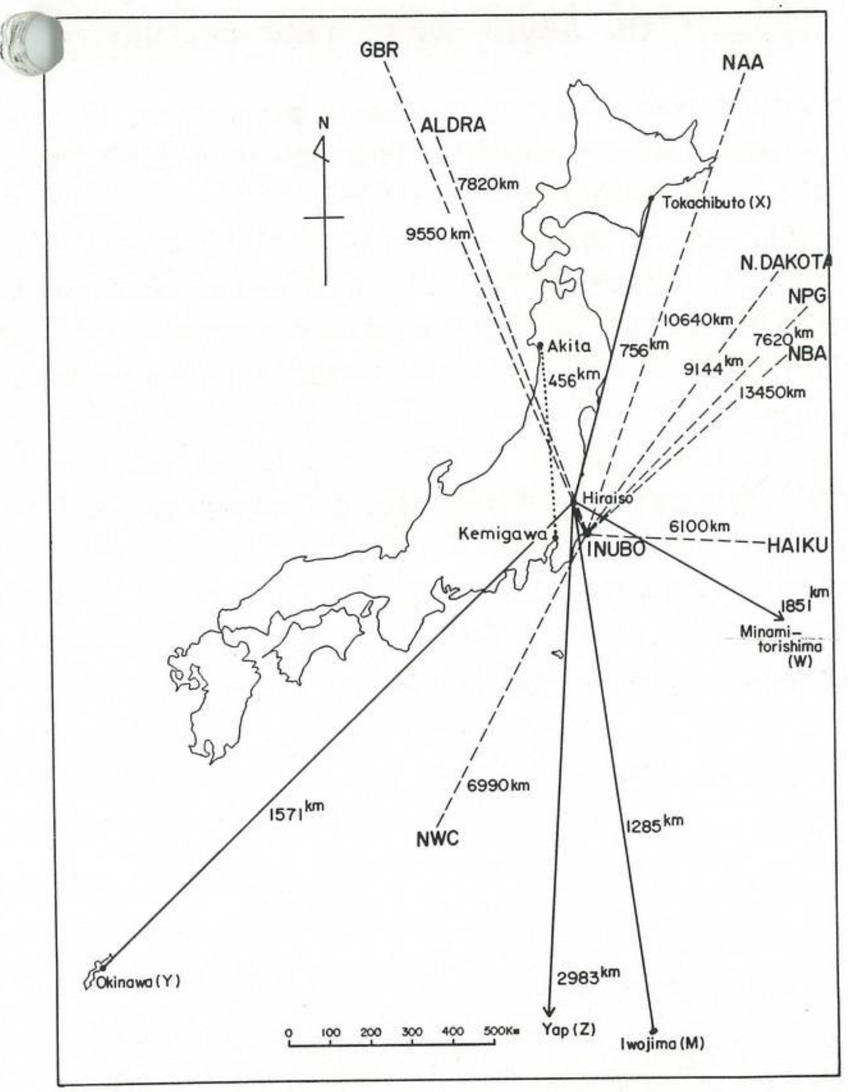
VLF AND LF RADIO PROPAGATION

The VLF and LF waves are commonly utilized as services for transmission of the standard frequencies and navigation, since these waves propagate very stably up to long distances. When a solar flare occurs, however, the intense X-ray and protons are emitted from the sun. During these periods, the lower ionosphere, through which the LF or VLF waves propagate, is much influenced and greatly disturbed. Consequently, the LF and VLF waves demonstrate complicated variations in both the field strength and the phase such as Sudden Field Anomaly (SFA) and Sudden Phase Anomaly (SPA). These phenomena are called collectively the Sudden Ionospheric Disturbance (SID), and the Polar Cap Disturbance (PCD).

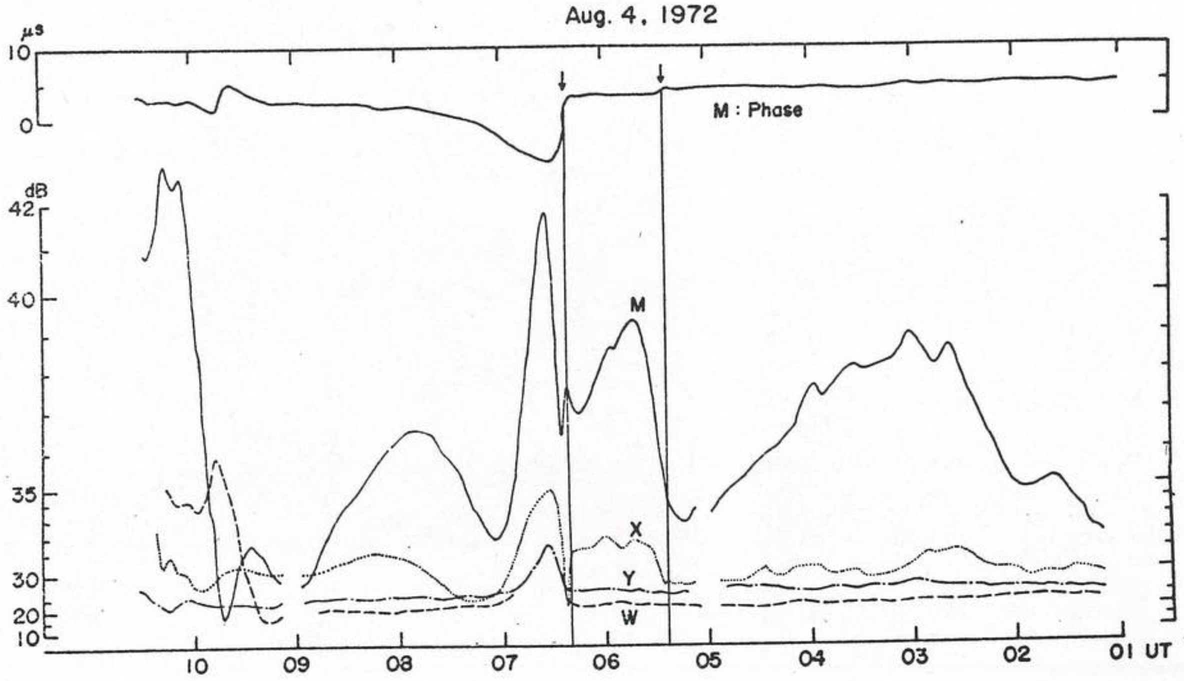
At the Inubo Radio Wave Observatory, several VLF radio waves, including Omega waves, have been monitored, while at the Hiraiso Branch, Loran-A (MF) and Loran-C (LF) waves have been received, in order to investigate propagational condition during SID, PCD and Stratospheric Warming Events.



An example of SID recorded at Inubo



Geographical disposition of LF radio wave circuits received at Hiraiso (Loran-C, 100 kHz) and Akita (Standard frequency, 40 kHz) and VLF radio wave circuits at Inubo



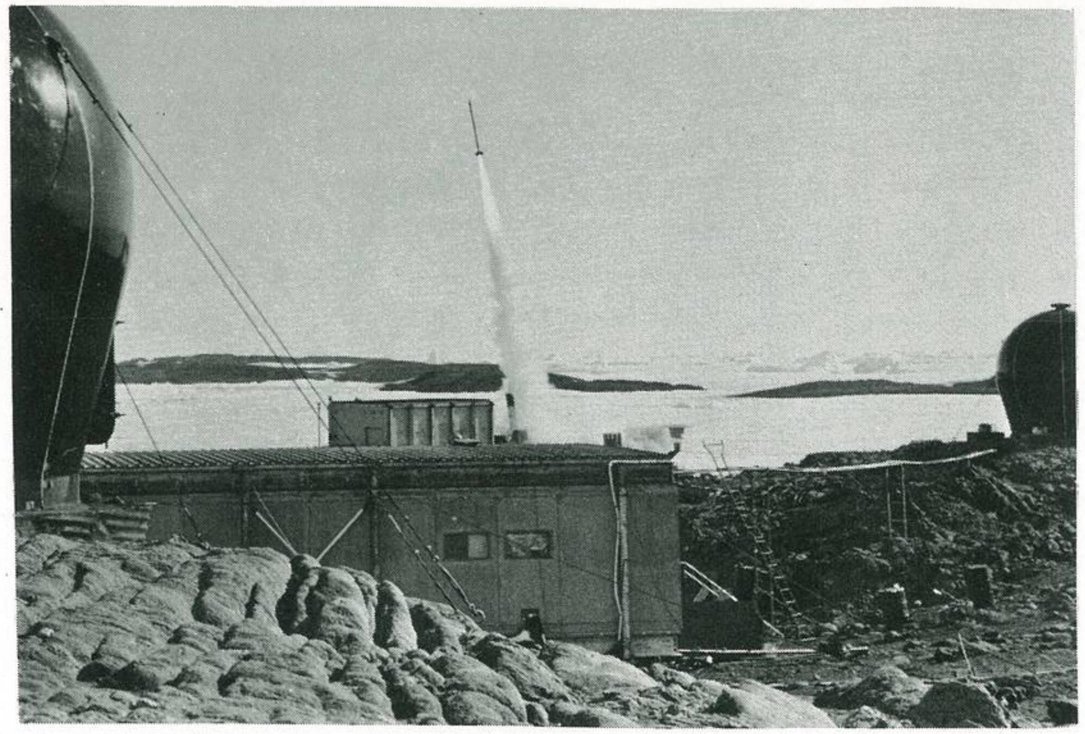
An example of SPA (upper) and SFA (lower) phenomena recorded at Hiraiso

IONOSPHERIC OBSERVATIONS IN THE ANTARCTICA

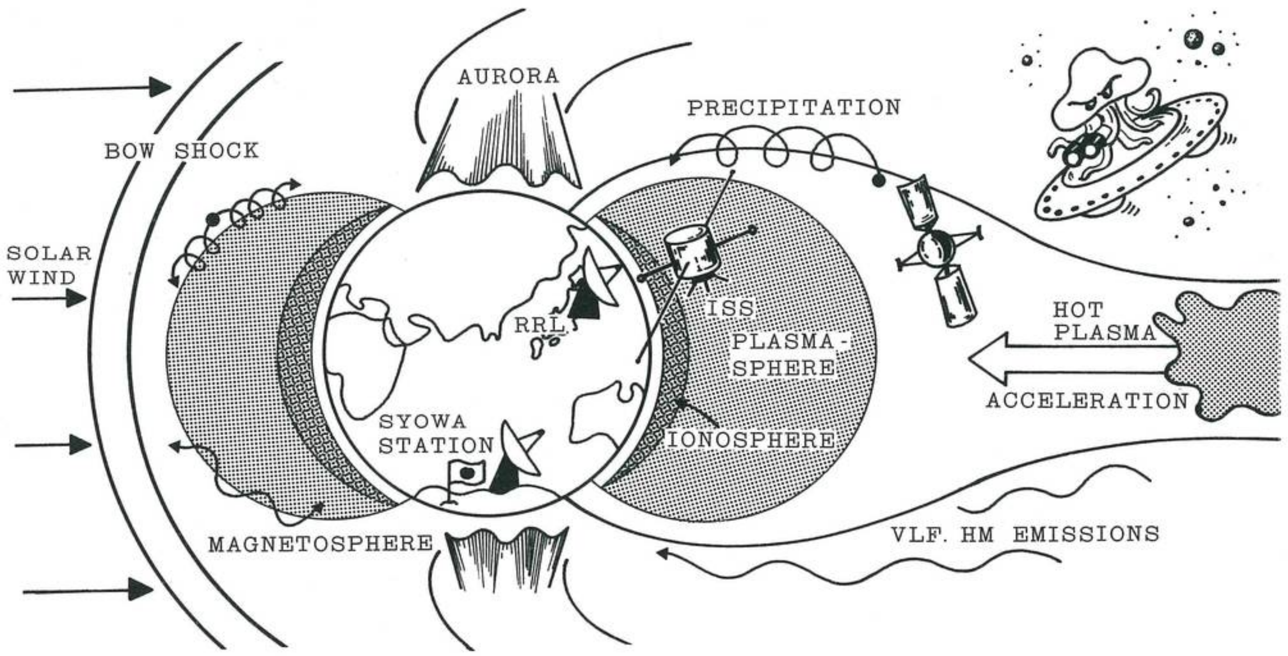
Since the IGY, observations of the ionosphere have been carried out at the Syowa Station, located at 69.0°S, 39.6°E in the Antarctica, under the project of the Japanese Antarctic Research.

Items of the ionospheric observations for which the RRL is responsible are ionospheric soundings, measurements of ionospheric absorptions with riometers, observations of radio aurora in VHF band and reception of VLF signals. Sometimes, intensified observations by rocket with various sensors, such as electron density probe, high energetic particle detector and radio receivers, are made in order to clarify the mechanism of various polar phenomena including aurora, ionospheric sporadic E layer, geomagnetic disturbances, VLF emissions, etc.

The data on the observations are summarized and released by the Radio Research Laboratories (data on ionospheric soundings) and the National Institute of Polar Research (other data) to those who are interested in the polar aeronomy as well as trans-polar radio propagations.



Observation by rocket

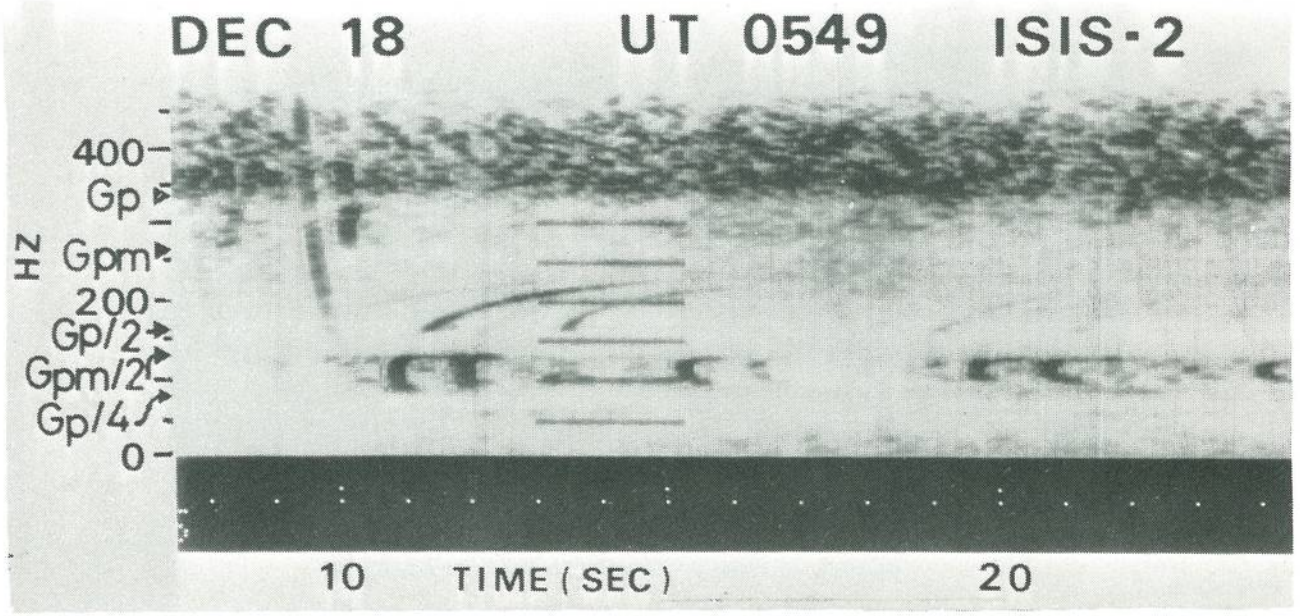


INTERNATIONAL MAGNETOSPHERIC STUDIES (IMS)

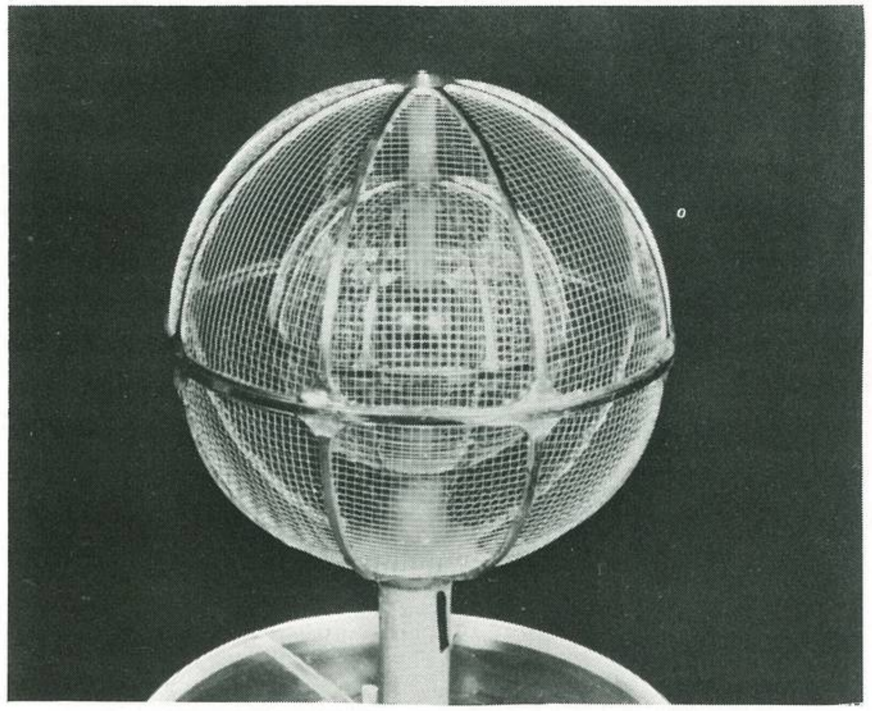
Since January 1976, the international cooperation in magnetospheric observation has been made by satellites as well as at ground stations. The Radio Research Laboratories has also the magnetospheric exploration programs, such as magnetospheric sounding, observations of HF-VLF radio noises, ion compositions, and plasma temperature by the ISS and ISIS satellites, and the ground-based observation of VLF hiss and whistler at the Wakkanai and Okinawa Radio Wave Observatories. Observations of the ionospheric vertical sounding, auroral radar, riometer, and VLF radio waves at the Syowa Station, Antarctica, have been reinforced by the wintering party members sent from the Radio Research Laboratories during the IMS.

STUDIES ON VLF EMISSIONS AND WHISTLERS

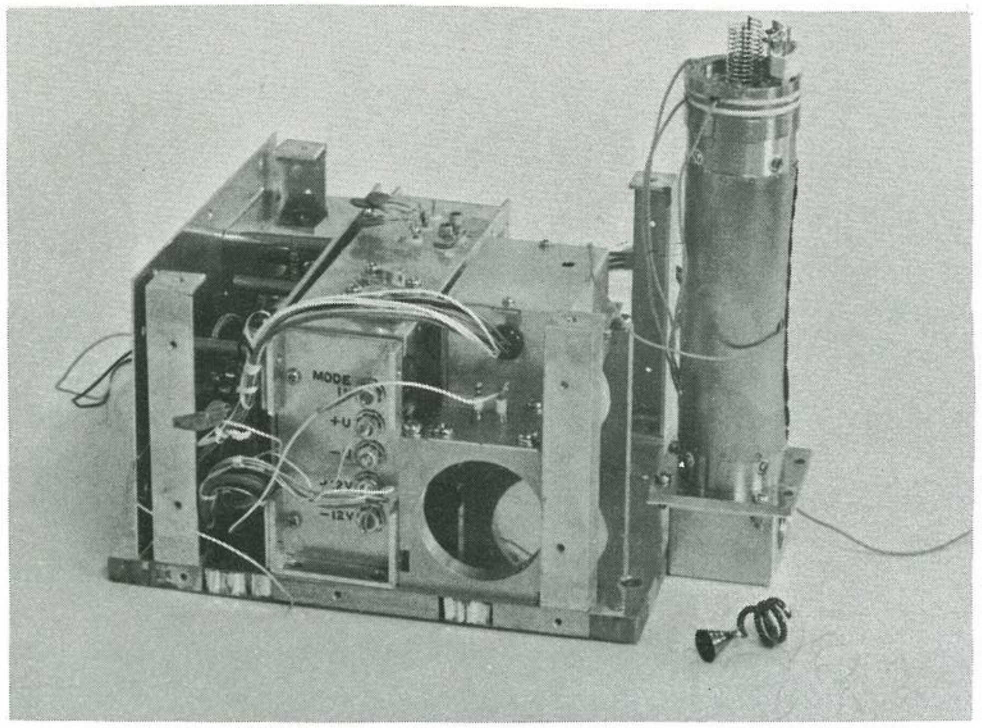
VLF emissions and whistlers are observed on a routine basis at the Wakkanai and Okinawa Radio Wave Observatories respectively, in order to investigate characteristics of mid-latitude hiss generated near the plasmapause, and of low-latitude limit of whistlers. In addition, the spectrum analysis of ISIS-VLF data received at the Kashima Branch is conducted by Space Physics Section, Radio Wave Division. The picture below shows examples of the deuteron whistlers ($G_{pm}/2-G_p/4$), trans-equatorial proton whistlers ($G_{pm}-G_p/2$), and an electron whistler of falling trace, where G_p is the proton gyrofrequency and G_{pm} the minimum (equatorial) proton gyrofrequency along the geomagnetic field line passing through the satellite. The deuteron whistlers are often observed in the low-latitude topside ionosphere.



Deuteron cyclotron whistler observed by ISIS-2



Retarding potential trap



Quadrupole type mass spectrometer

SPACE RESEARCH BY ARTIFICIAL SATELLITES

Various plasma probes have been developed during the past fifteen years, for example, radio frequency resonance probe and electrostatic probes including the retarding potential analyzer. The effectiveness of these probes for ionospheric observations has been proved by a number of rocket experiments made at the Kagoshima Space Center of the University of Tokyo, and at the Syowa Station in the Antarctica.

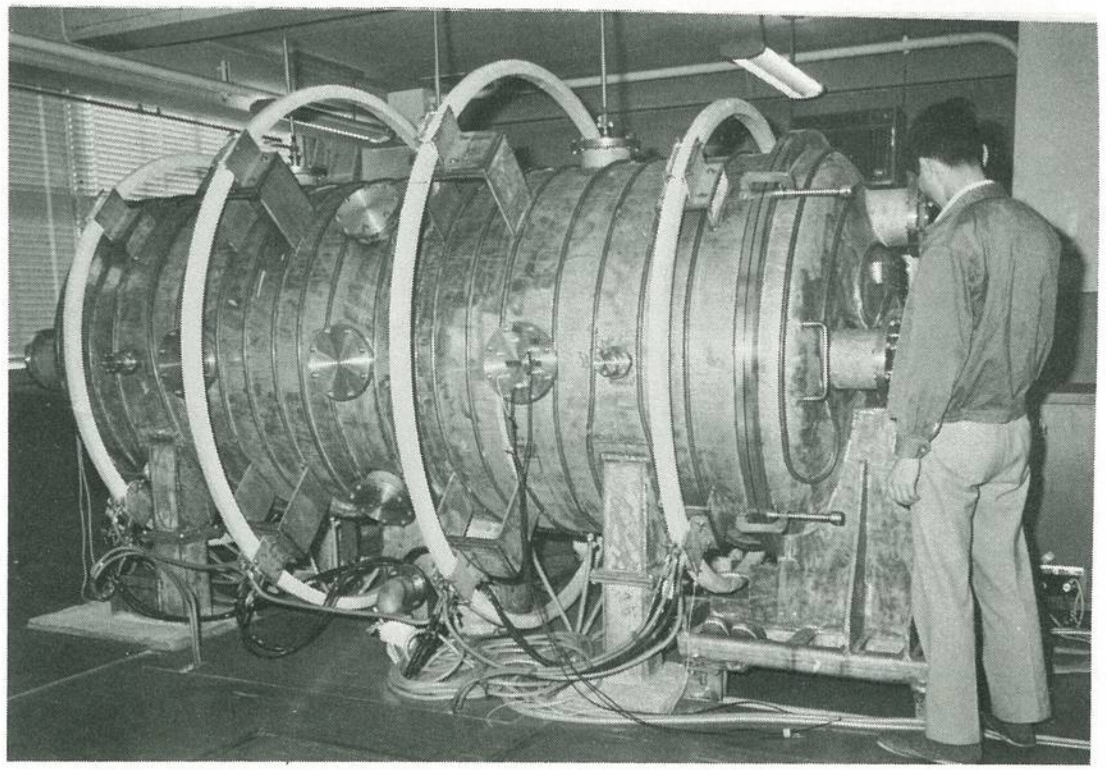
Emphasis has recently been placed on researches in mechanism of excitation, maintenance and energy transfer processes of plasma waves.

In addition to the *in situ* measurements of the upper atmosphere by sounding rockets and satellites, the laboratory experiment for studying the characteristics of the upper atmospheric plasma has been made by means of the space plasma chamber in the Radio Research Laboratories.

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

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

A future plan for the ISS series is under way in parallel with the development of new-type space-borne instruments.



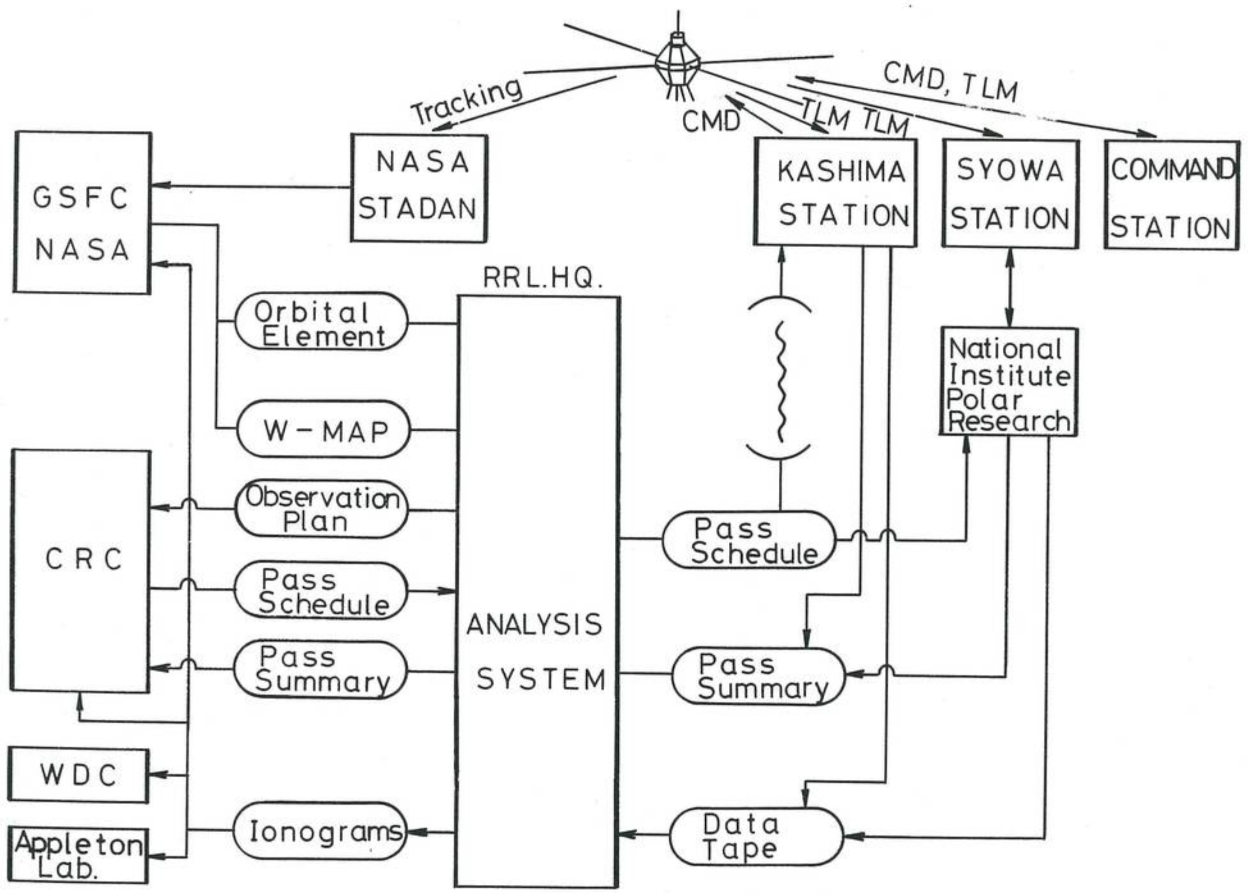
Space plasma chamber

ACQUISITI( ) AND ANALYSIS OF DATA ON THE INTERNATI( )L SATELLITES FOR IONOSPHERIC STUDIES (ISIS)

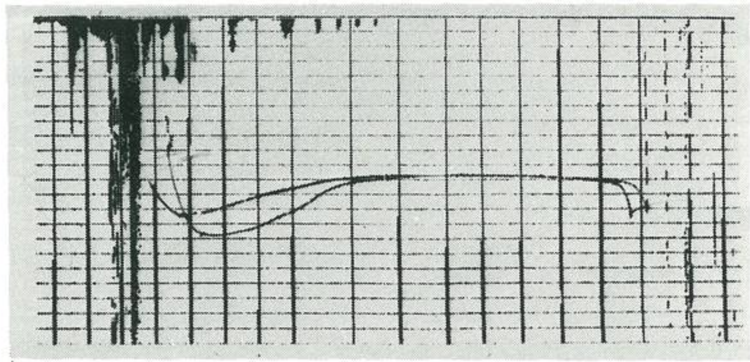
The Radio Research Laboratories joined the ISIS Working Group in August 1965, and commenced the telemetry of Alouette-1 and Alouette-2 at the Kashima Station in August 1966. Since then the telemetry of Alouette-1 (till November 1968), Alouette-2 (till November 1971), ISIS-1 (since July 1970) and ISIS-2 (since May 1971) has been performed at the Kashima Station. The command operation to the ISIS satellites started in November 1972. The Computer System for Satellite Control (CSSC) capable of automatically carrying out tracking, telemetry and command has been in operation since April 1975.

The telemetry of ISIS satellites at the Japanese Antarctic Base, Syowa (69°00′S, 39°35′E) started in April 1976 in cooperation with the National Institute of Polar Research.

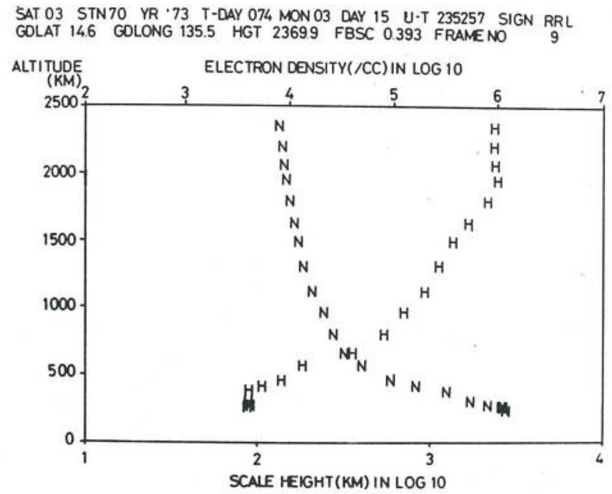
The ISIS data recorded at Kashima on magnetic tapes are transferred to the RRL Headquarters so as to be processed and analyzed. The topside ionograms obtained are distributed to the CRC in Canada, and the World Date Centers at GSFC and NOAA in the U. S. A. and at Appleton Laboratory in the U. K. The topside sounder data are used for studying the structure of the topside ionosphere with the aid of On-Line Ionogram Processor, and are published in the date book "Data on Topside Ionosphere". The VLF data are used for the study of the whistlers and the characteristics of VLF emissions.



Data Flow for ISIS Project



Topside Ionogram (ISIS-1) 15 March 1973 Rev. No. 16890 23h52m57s UT (14.6°N, 135.5°E) Satellite Height 2369.9 km



Profile of electron density and scale height reduced by the on-line ionogram processor

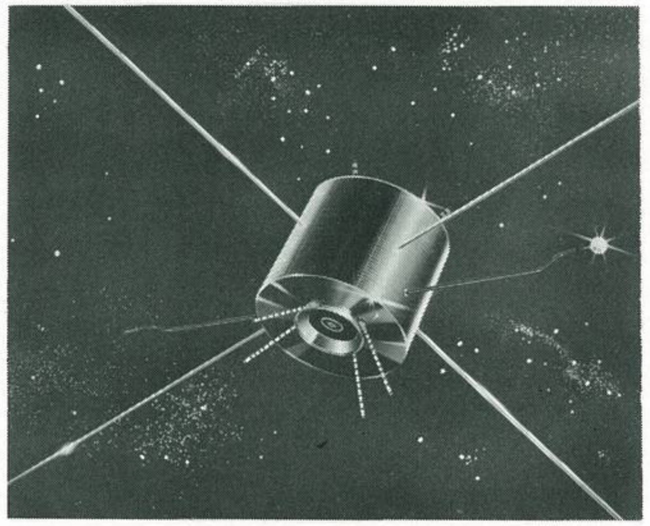
IONOSPHERE SOUNDING SATELLITE

The object of the Ionosphere Sounding Satellite (ISS) project is to carry out the following four missions in order to obtain the world map of the ionosphere necessary for improvement in radio propagation forecast of HF communication channels:

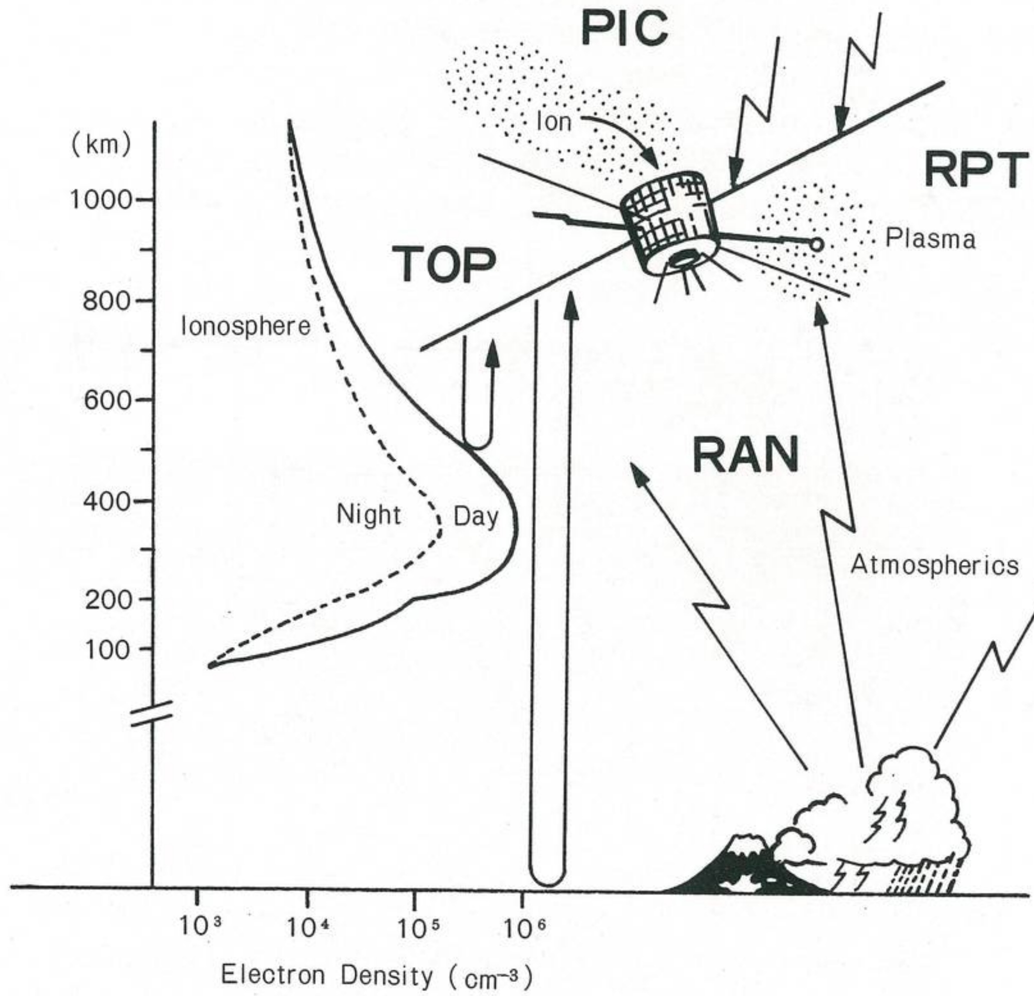
1. Observation of a world-wide distribution of ionospheric critical frequencies and the virtual height vs. frequency characteristics.
2. Observation of world-wide distributions of average radio noise intensities and occurrence frequency of atmospherics.
3. Observation of plasma parameters: density and temperature of electron and ions surrounding the satellite.
4. Observation of compositive ions surrounding the satellite.

Outline of observation

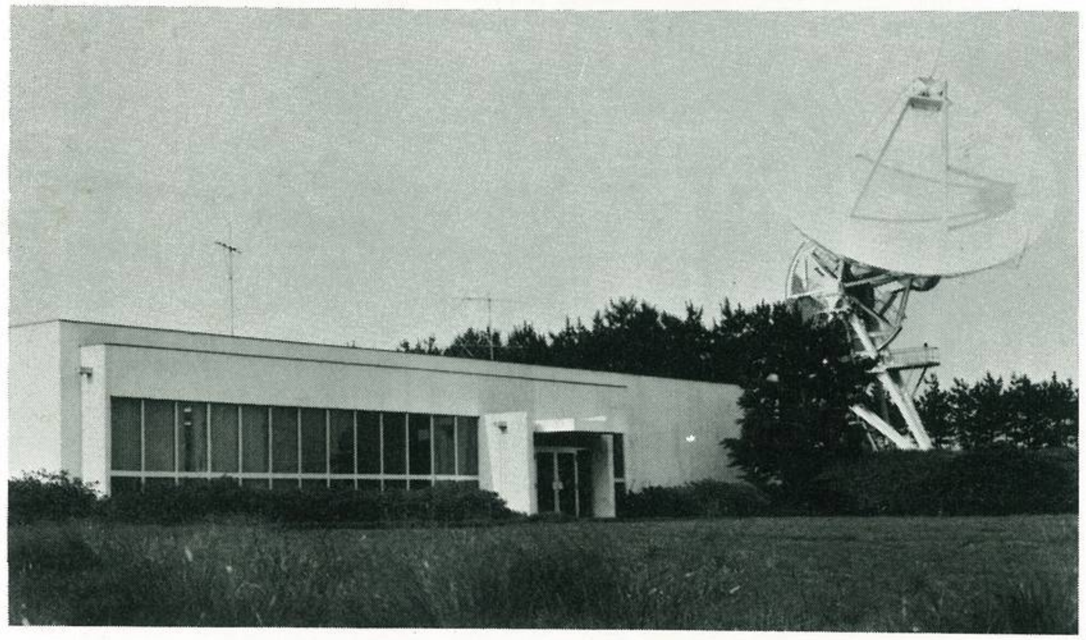
Topside Sounder (TOP)		Frequency range : 0.5 to 15 MHz
		Frequency step : 100 kHz
		Transmitter power : 100 W
		Pulse width : 280 μsec
	TOP-A	Detection of ionospheric critical frequency
	TOP-B	Observation of d′-f characteristics
		d′ : Virtual height
		f : Observation frequency
Radio Noise Meter (RAN)		Observation of average intensity of radio atmospheric noise and occurrence frequency of impulsive radio noise
		Observation frequency: 2.5 MHz, 5 MHz, 10 MHz and 25 MHz
Retarding Potential Analyzer (RPT)		Electron and ion density : 10^3 to 10^6 cm^{-3}
		Electron and ion temperature : 1,000 to 5,000 K
Postitive Ion Mass Spectrometer (PIC)		Mass of positive ion : 1 to 24 AMU
		Density of ion species : 10^2 to 10^6 cm^{-3}
Aspect Sensor (AS)		3-axis magnetometer
		Solar aspect sensor
		Earth aspect sensor
		Total detection error: within ±2.5°
House Keeping Monitor (HK)		Temperatures of inner and outer surface of spacecraft
		Voltages and currents of power supplies
		Working condition of each subsystem, etc.



ISS

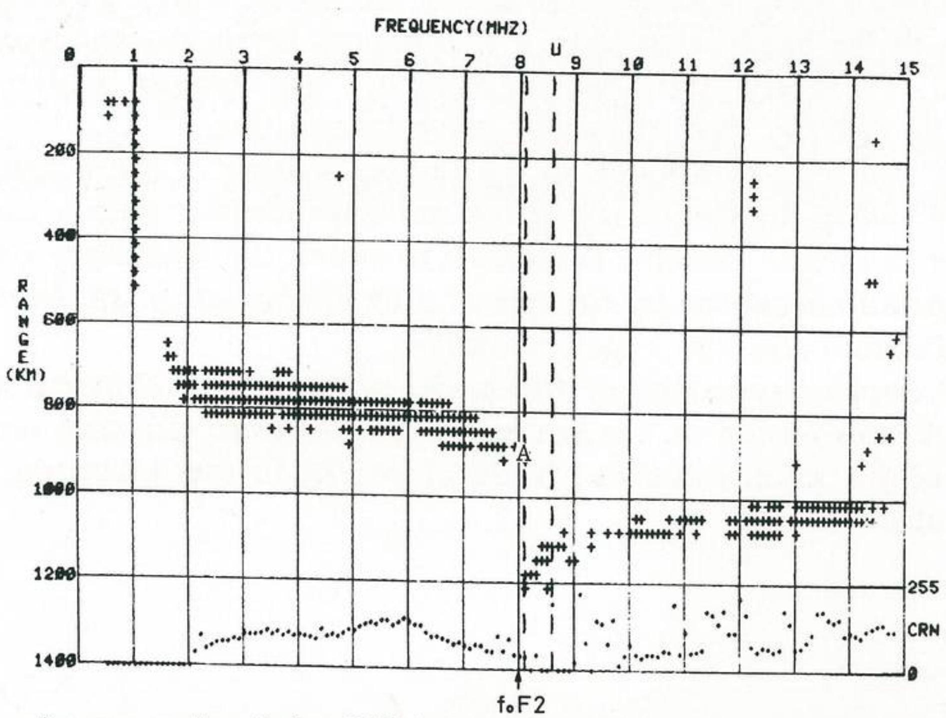


ISS mission description

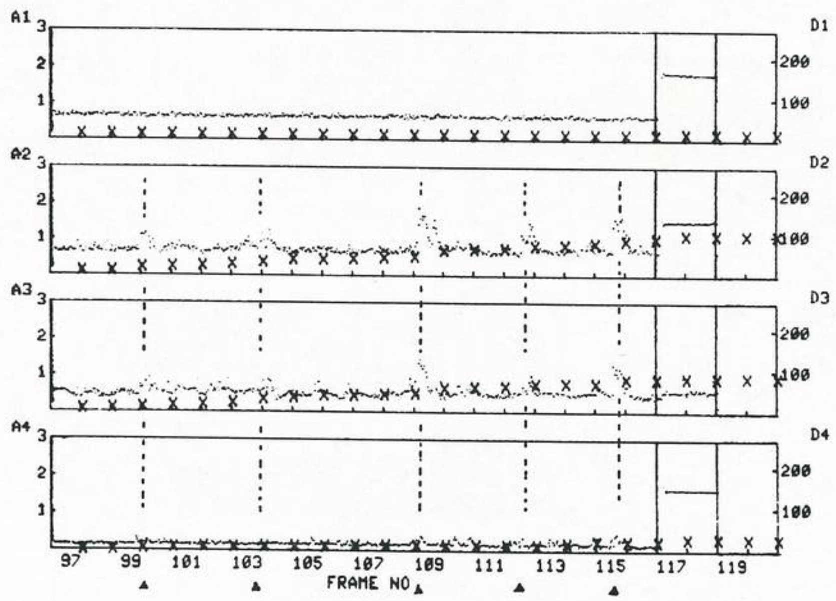


Control building and 18 mϕ telemetry antenna

Facilities for satellite data processing and analysis



An example of the ISS ionogram observed over the Syowa Base, Antarctica. The critical frequency of the F region, f_oF2, detected by TOP-A is 8.1 MHz is consistent with that determined from the d′-f characteristic (TOP-B).



Examples of Atmospheric Radio Noise Measurement (RAN) showing the occurrence of lightning flashes.

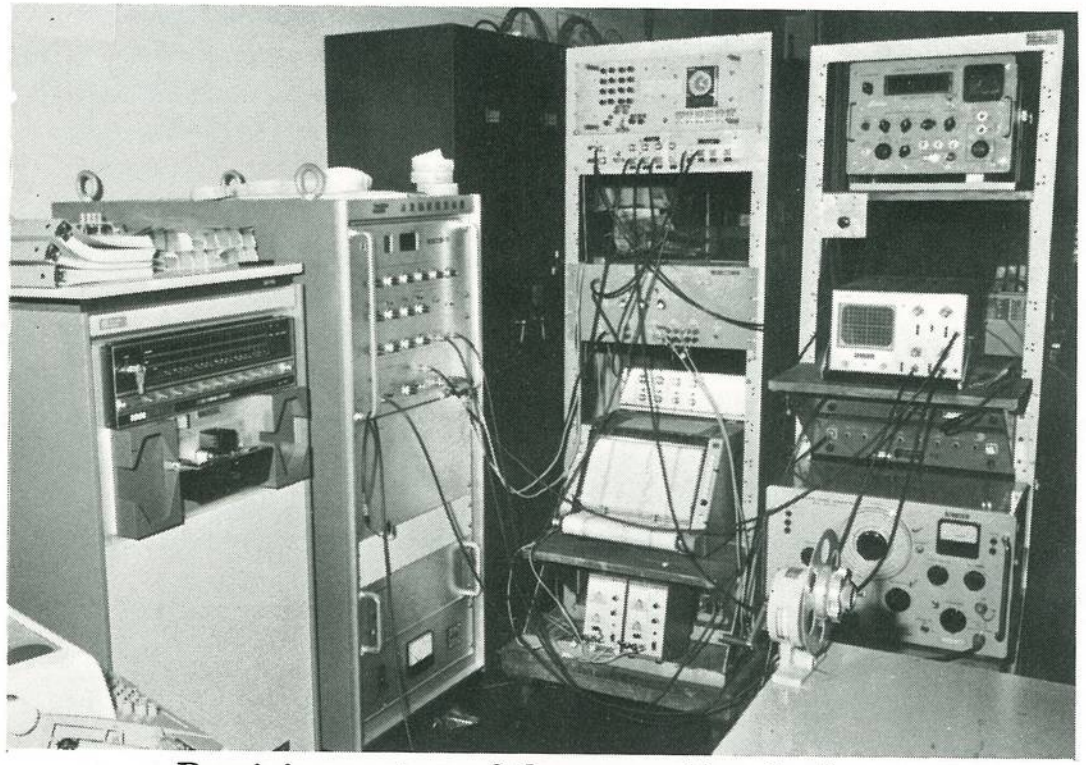
These were observed above the Pacific Ocean, at a distance of about 1000 km south of Tokyo. Ch2 (5 MHz), Ch3 (10 MHz) and Ch4 (25 MHz) show the same impulsive patterns.

REMOTE SENSING OF OCEAN WAVE BY BACKSCATTERED RADIO WAVE

The radio wave is backscattered by the ocean waves, and the dominant contribution to the backscattered echo is produced by such ocean waves, having a wavelength of exactly half the radio wave's wavelength, which are advancing of receding radially from the radio wave transmitter.

This fact may be applied to the remote sensing of the ocean wave spectrum, if we can sweep the frequency of the radio transmitter over a correspondingly wide frequency range. Since it is difficult to sweep the frequency over the wide range, the limitations caused by the use of a fixed-frequency transmitter were evaluated both theoretically and experimentally.

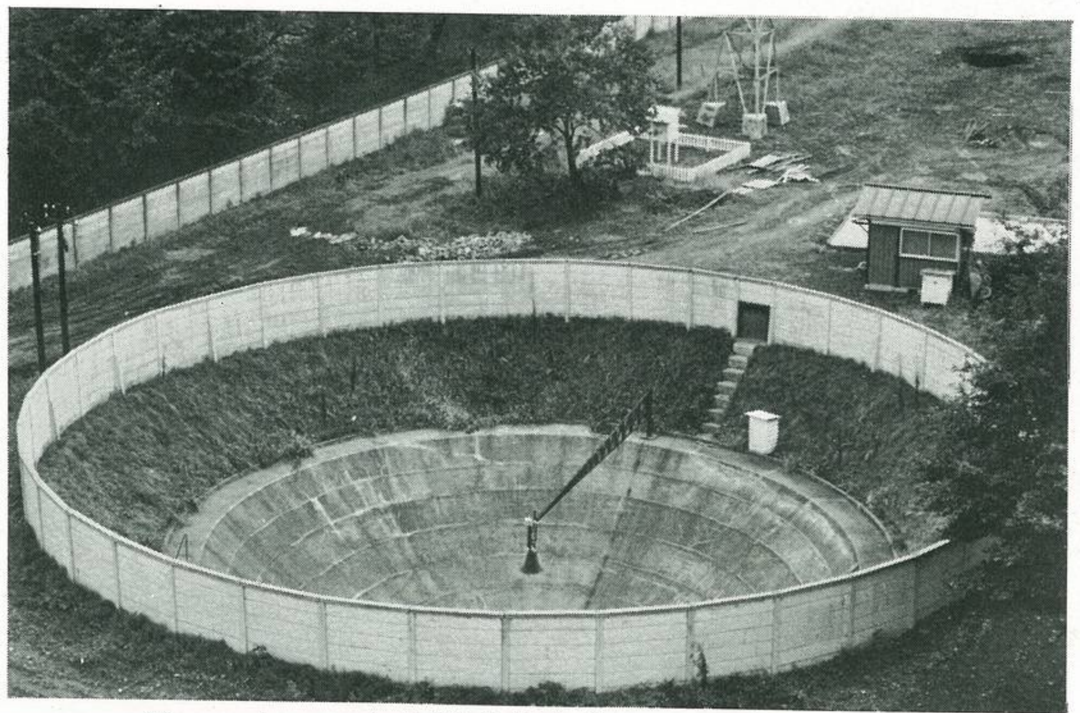
The doppler spectrum of the backscattered echo contains some pieces of important information on the ocean wave, and more effective remote sensing technique of the ocean wave may be developed by further investigations of the doppler spectrum.



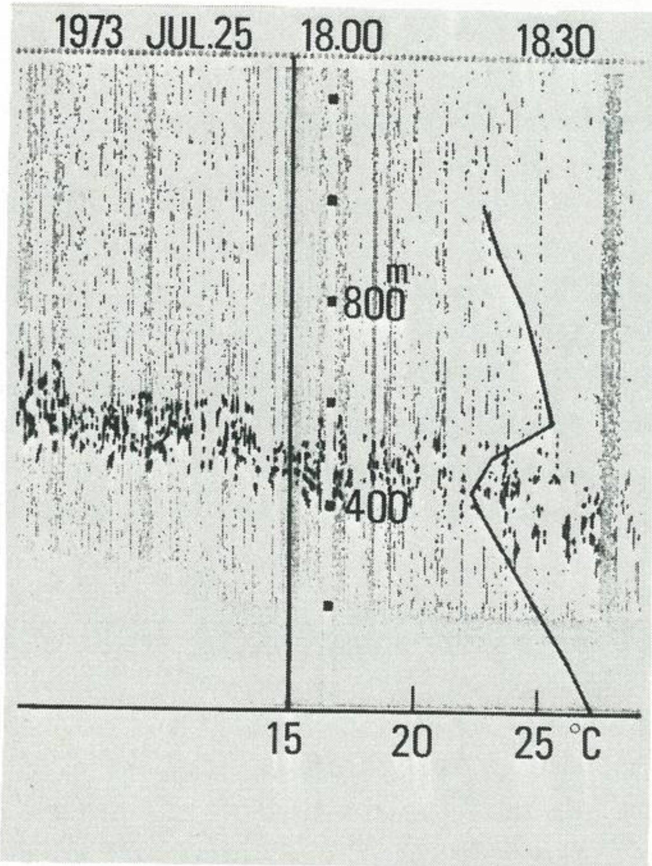
Receiving system of the sea-scattered echo

ACOUSTIC SOUNDING OF THE LOWER TROPOSPHERE

The structure of the lower troposphere has been studied since 1970 in a series of observations utilizing the method of acoustic wave backscattering for the purpose of increasing the knowledge of radio wave propagation and air pollution prediction. These observations using the well-designed equipment system for acoustic sounding have yielded useful results including the characteristics of inversion layers, turbulent layers, thermal plumes, and internal gravity waves found in the atmospheric boundary layer. At the same time the development of new techniques is in progress for more sophisticated soundings.



Concrete paraboloidal dish for acoustic sounding

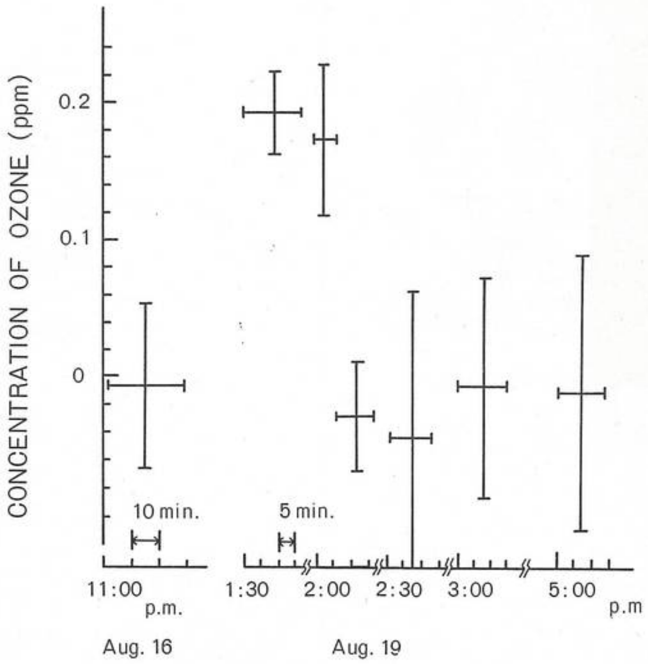


An example of Sodar (Sound detection and ranging) echo compared with simultaneously observed atmospheric temperature profile which indicates a remarkable inversion at a height of 400–500 m.

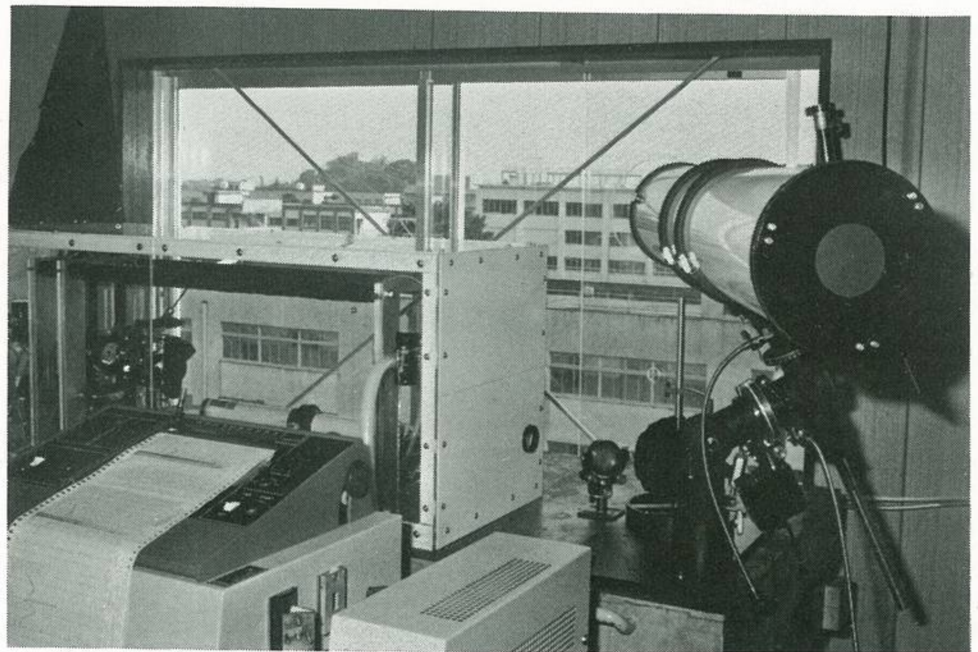
Acoustic radar

MONITORING OF AIR POLLUTION WITH LASER RADAR

For the detection and monitoring of air pollutants, the optical methods using laser have an advantage over the wet chemical ones now in use, because the former can be used for remote sensing and measuring on real-time. The long-path absorption using CO_2 laser is useful for monitoring of ozone which is a main component of oxidant. The study of practical application is in progress at the Radio Research Laboratories.



Experimental results measured in photochemical smog

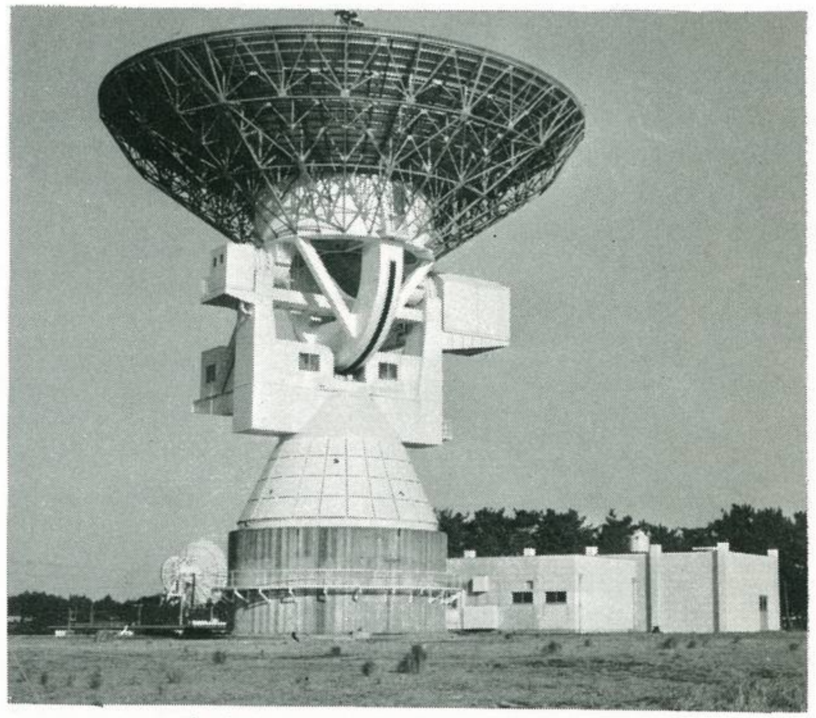


Laser radar monitoring system of air pollution

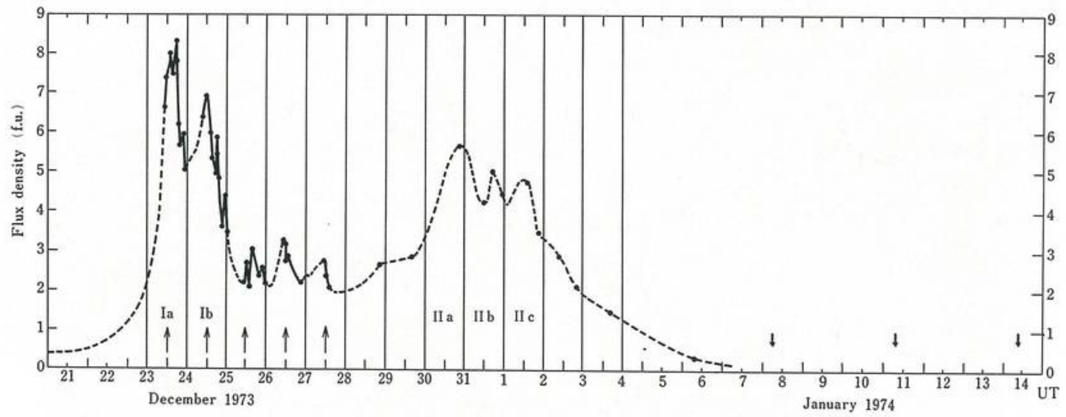
RADIO ASTRONOMICAL RESEARCHES AND VERY LONG BASELINE INTERFEROMETRY (VLBI)

At the Kashima Branch, we have been making many kinds of radio astronomical observations by the use of a 26 m antenna which is the only large paraboloidal antenna for cosmic microwave researches in Japan. The objects of observation are as follows: X-ray stars such as Cyg-X-3 and Sco-X-1; time variable sources of flux intensity and polarization; Faraday rotations of linearly polarized radio wave from Crab nebula; and radio observations of optically compact galaxies. From the amount of Faraday rotations, we estimate the structures and intensities of solar coronal magnetic fields and plasma densities.

On the other hand, concerning VLBI experiments which are an application of radio astronomical technology, we are now planning small-scale VLBI experiments with a baseline of about 100 km, and are examining the basic technology for apparatus to be used, and the data-reduction procedure, preparing for the future intercontinental VLBI experiments.



A 26 m paraboloidal antenna

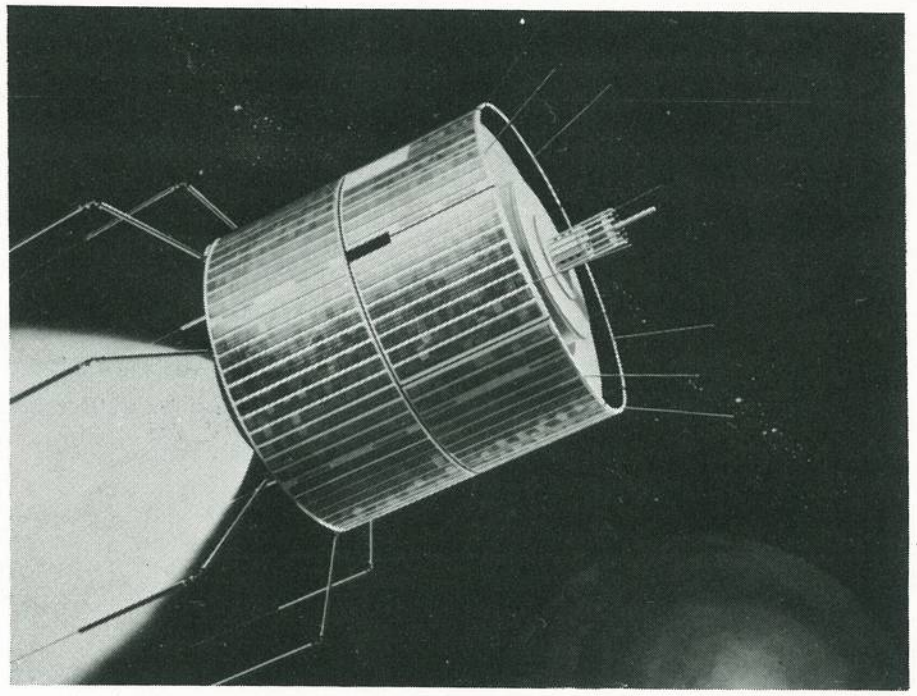


An example of a large radio burst
in Cyg-X-3 observed by a 26 m antenna

SPACE COMMUNICATIONS

The Radio Research Laboratories took up the study of space communications in 1960, and established the Space Communication Section at its headquarters in April 1961. With the completion of a 30 mϕ paraboloidal antenna and space communication facilities, the Kashima Branch was founded in Ibaraki Prefecture in May 1964 and started various communication experiments using the Relay Satellite.

On the occassion of the Tokyo Olympiad in October 1964, the Kashima Earth Station contributed to the success in the first international relay of Olympic TV programs via Syncom-III. In December of the same year, the Radio Research Laboratories officially announced its participation in the Applications Technology Satellite (ATS) Program of the U. S. A., and really entered into the joint space communication experiments via ATS-1 Satellite at the end of 1966. In October 1968, another 26 mϕ paraboloidal antenna was constructed to meet the requirements for higher performance of the antenna system.



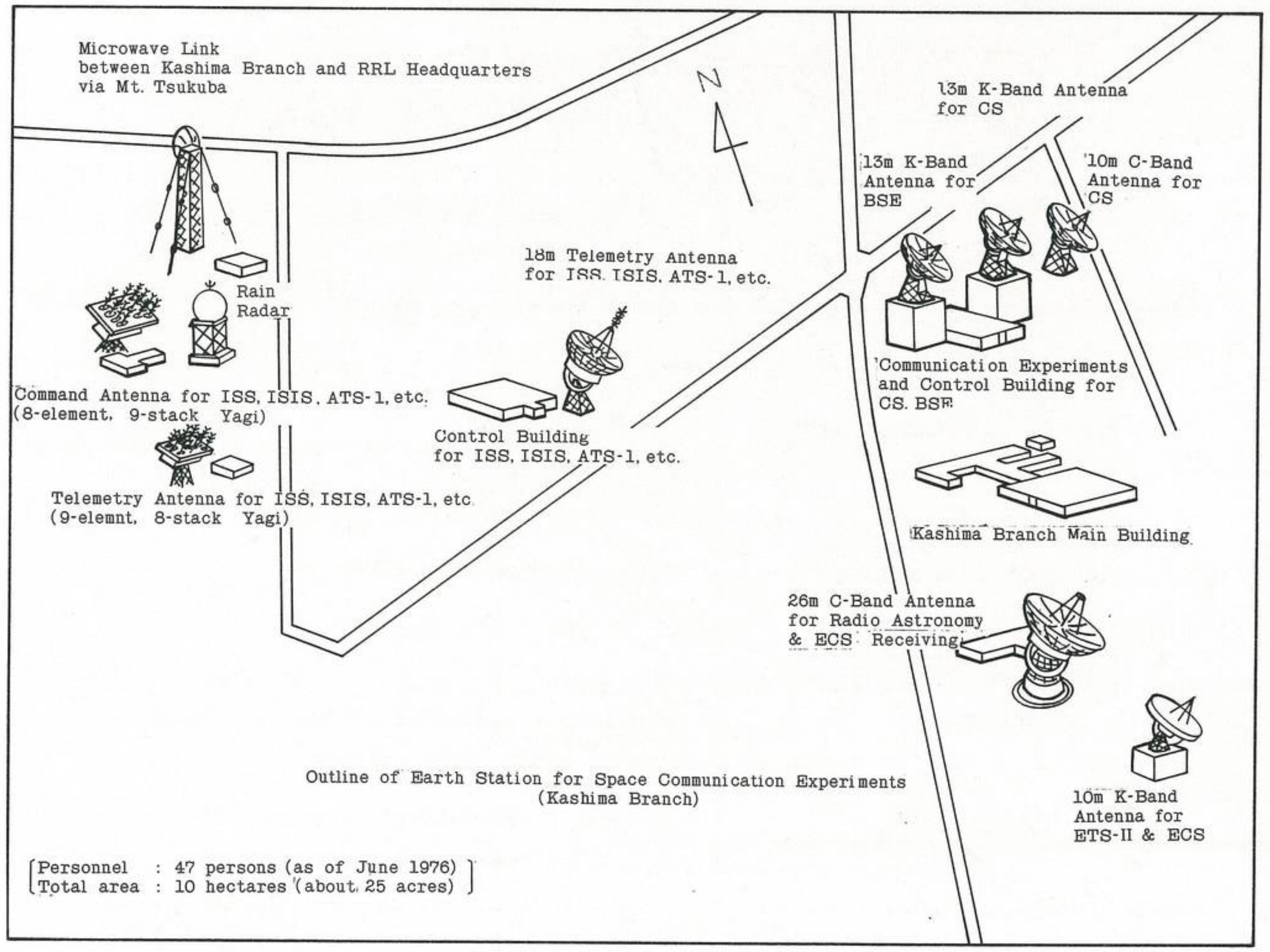
ATS-1

JAPAN-U.S. JOINT RESEARCHES IN ATS-1 PROGRAMS

The Kashima Earth Station has supported NASA by performing the trackings of ATS-1 through ATS-5 in their launch phase. Especially, when ATS-1 was geostationary-orbited within the field of vision from the station, various experiments were conducted via this satellite. Through the AST-1 experiments, a great contribution has been made to the development of space communications in this country. The primary items of experiment are as follows:

Items of Experiment

Item	Period
1. Measurement of Range & Range Rate	from 1967 to December 1975
2. Experiment on PCM/TDMA system	from February 1967 to December 1968
3. Experiment on SSB/PM system	from May 1969 to January 1971
4. Experiment on SSRA system and SSRR system	from October 1971 to December 1975
5. Experiment on TV signal transmission	from December 1966 to August 1971
6. Experiment on satellite control of ATS-1	from August 1974 to July 1976



Outline of Earth Station for Space Communication Experiments
(Kashima Branch)

[Personnel : 47 persons (as of June 1976)
Total area : 10 hectares (about 25 acres)]

PROJECT OF MEDIUM-CAPACITY COMMUNICATIONS SATELLITE FOR EXPERIMENTAL PURPOSES (CS)

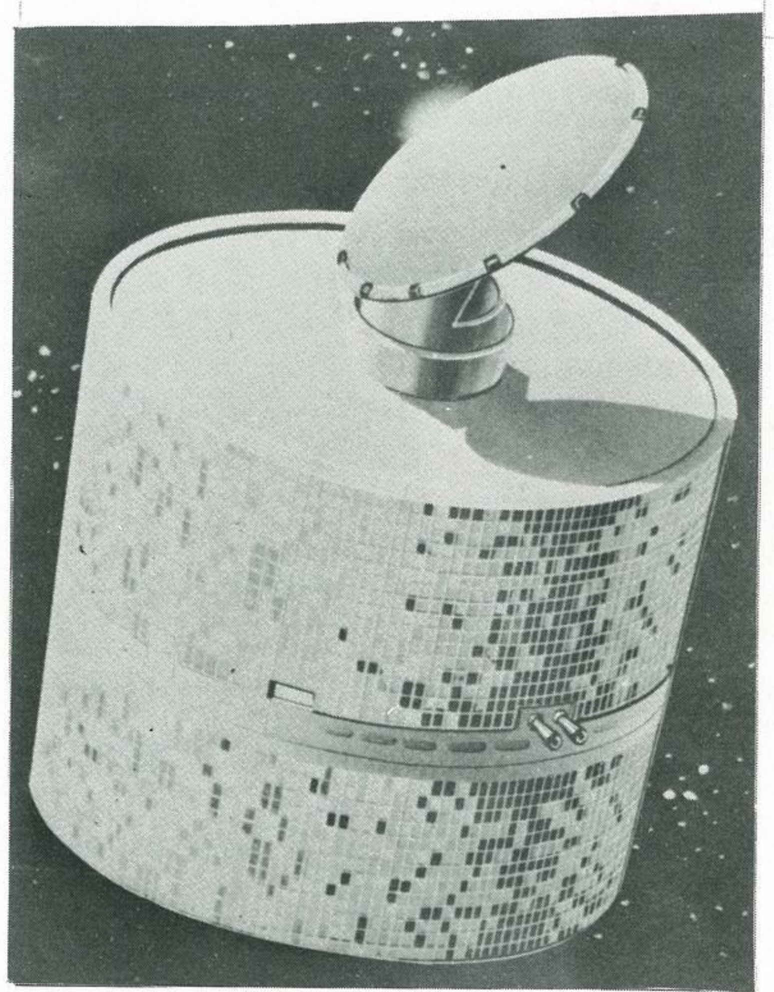
The purposes of this satellite are to conduct various technical experiments such as satellite communication experiments using quasi-millimetric waves and micro waves which are necessary for the future operational satellite development in order to cope with the presumable increase in communication demand. The CS is expected to be launched in November 1977.

The ground facilities of the CS project are composed of Main Fixed Earth Station, Mobile Earth Stations and Transportable Earth Stations. The Main Fixed Earth Station which is now under construction at the Kashima Branch will have the functions of telecommunication experiments and satellite operational control. With these facilities to be installed throughout Japan, various satellite telecommunication experiments will be made for about three years after the launching. The main experimental items are as follows:

1. Experiments on signal transmission through a satellite communication system.
2. Measurement of the rainfall effect on radio propagation, especially in quasi-millimetric waves.
3. Measurement of characteristics of CS-borne mission equipments and ground terminals.
4. Evaluation of the interference between the space telecommunication systems and the terrestrial telecommunication systems.
5. Experiments on spacecraft operation and control.
6. Experiments on satellite telecommunication system operations.

CS Spacecraft Summary

1. Satellite Location	135°E on geostationary orbit
2. Life	3 years
3. Physical configuration	Cylindrical type Diameter 2.2 m Height (including antenna) 3.5 m
4. Weight	340 kg (at the beginning of life on geostationary orbit)
5. Electrical power source of solar panal	420 W (at the end of life)
6. Size of solar array panel	Diameter 2.2 m Height 2.2 m
7. Attitude stabilization	Spin-stabilized
8. Communications	
Antenna	Mechanical despun type antenna with shaped beam horn reflector
Transponder	6/4 GHz transponder 2 systems 30/20 GHz transponder 6 systems

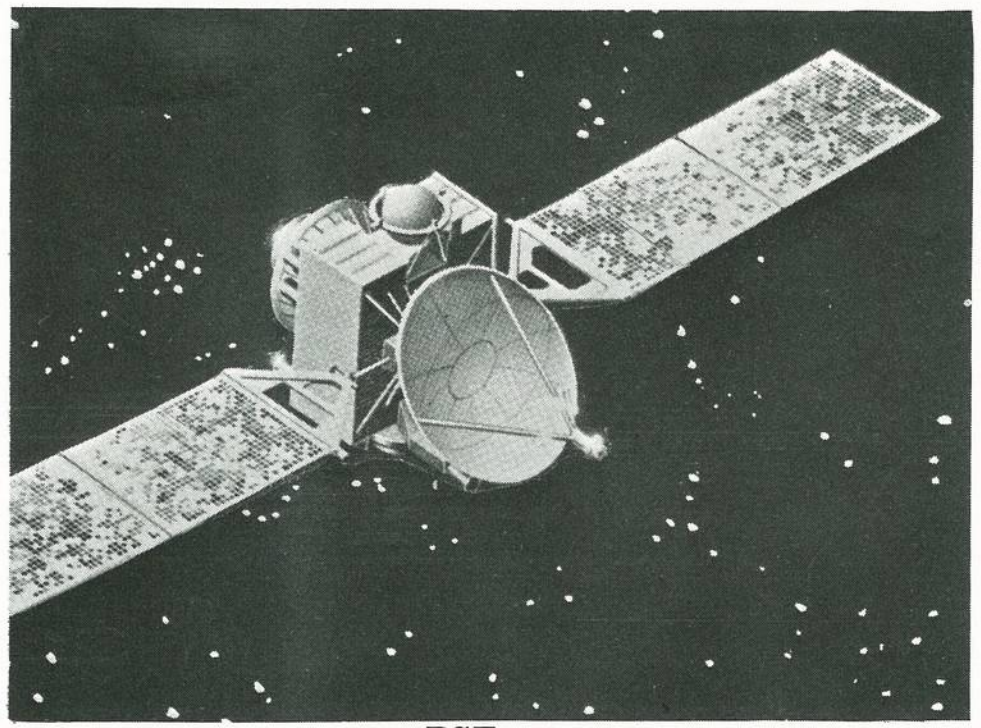


CS

PROJECT OF MEDIUM-SCALE BROADCASTING SATELLITE FOR EXPERIMENTAL PURPOSES (BSE)

The purposes of this satellite are to conduct technical experiments, such as video and audio signals transmission experiments which are necessary for the future operational satellite development in order to cope with the presumable increase in demand for new broadcasting media. The BSE is expected to be launched in February 1978.

The ground facilities of the BSE project are composed of Main Transmit & Receive Station, now under construction at the Kashima Branch, which will have the functions of TV signals transmission in 14 GHz band and satellite operation and control, Transportable Transmit & Receive Stations, Receive-only Stations and Simple Receiving Equipments. These facilities will be installed throughout Japan, and various satellite broadcasting experiments will be made for about three years after the launching.



BSE

BSE Spacecraft Summary

1. Satellite location	110°E on geostationary orbit
2. Life	3 years
3. Physical configuration	Rectangular solid (box type) with deployable solar array panel Width 1.3 m Height 3.1 m Length 9.0 m (including deployed solar array panel)
4. Weight	350 kg (at the beginning of life on geostationary orbit)
5. Electrical power source of solar panel	780 W (at the end of life)
6. Size of solar array panel	1.5 m×3 m (two sheets)
7. Attitude stabilization	Zero-momentum 3-axis stabilization using three momentum wheels
8. Communications	
Capacity	2-color TV channels broadcasting
Output power	100 watts/channel

EXPERIMENTAL COMMUNICATIONS SATELLITE (ECS)

The ECS is expected to be launched into the geostationary orbit in February 1979, in order to utilize millimeter radio waves for satellite communications in the near future. It is expected that the experiments using "ECS" mentioned below will provide data needed for establishing new space communications in millimeter wave range.

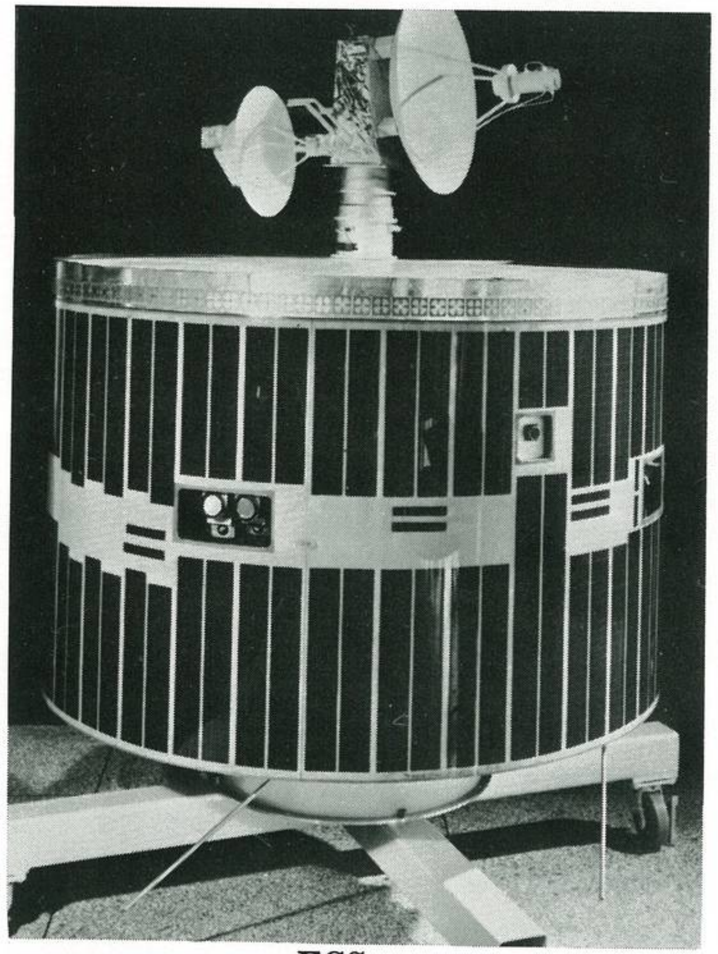
The outline of the ECS experimental system is given below.

ECS Experiments (Tentative)

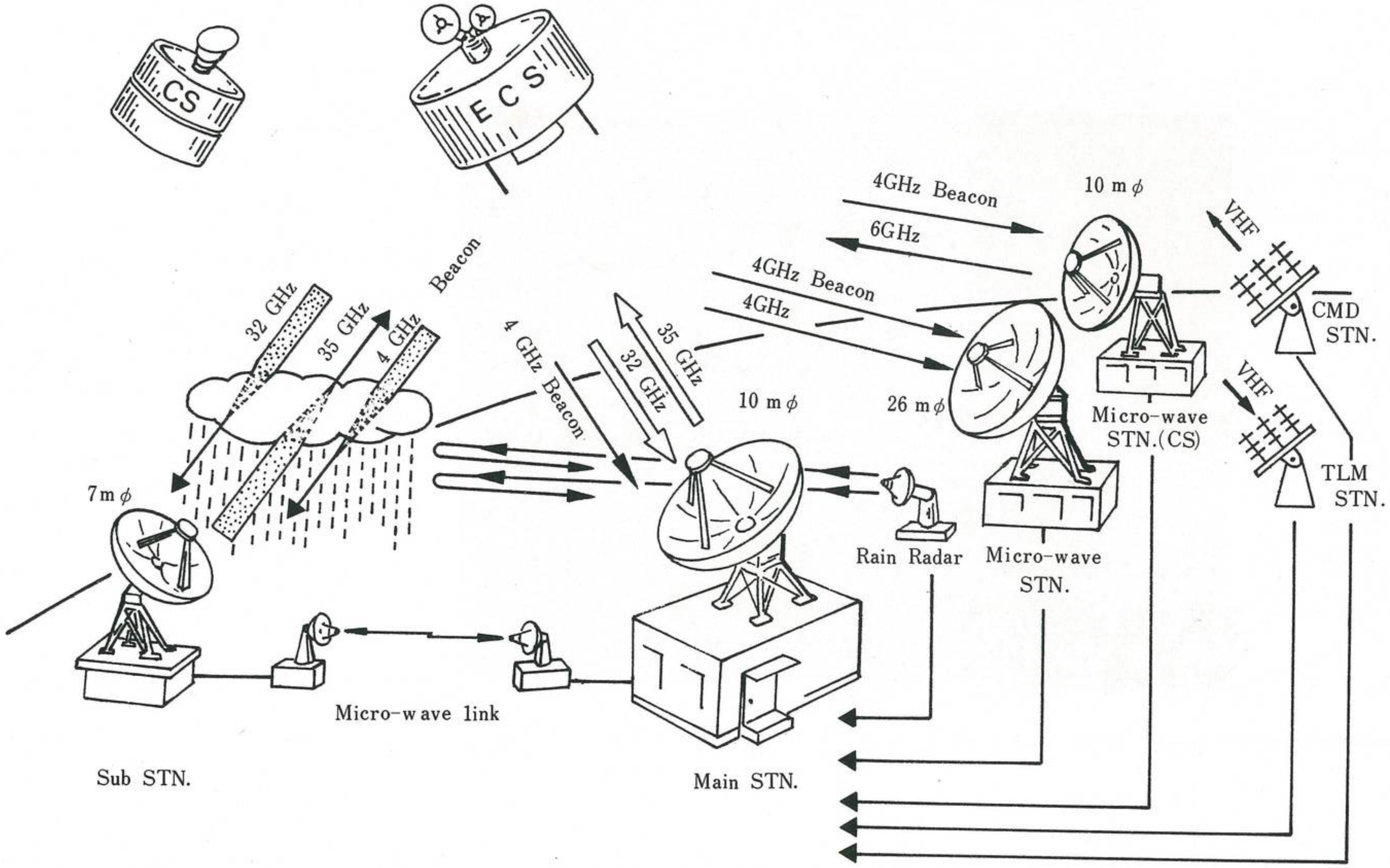
1. Effects of precipitation on millimeter wave propagation.
2. Space diversity experiments.
3. Evaluation of satellite communications system in millimeter wave range.
4. Cooperative experiments with "CS"—effective utilization of the geostationary orbit.
5. Characteristics of millimeter wave earth stations.
6. Characteristics and reliability of transponders and other on-board equipments.
7. Operation and control techniques for satellite and communications system

Outline of the spacecraft "ECS"

1. Orbit	Geosynchronous, 145°E
2. Mission duration	1 year
3. Physical configuration	Cylindrical with despun antenna
4. Dimension	Diameter 1.4 m Height 0.8 m
5. Weight	130 kg (initial weight in orbit)
6. Solar array power	100 W (1 year from launch)
7. Dimension of solar array	Diameter 1.4 m Height 0.8 m
8. Stabilization	Spin-stabilized
9. Transponder	C-band (6/4 GHz) 1 channel K-band (35/32 GHz) 1 channel Cross-strap is available by command
10. Antenna	Mechanical despun type



ECS

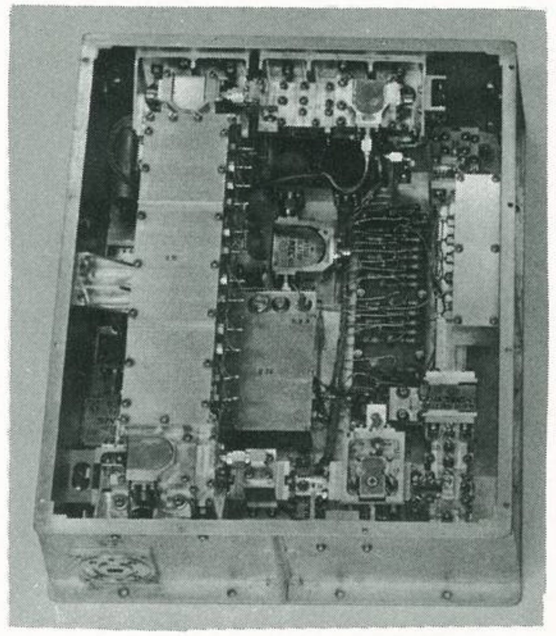


RESEARCH AND DEVELOPMENT OF SATELLITE-BORNE MILLIMETER WAVE TRANSPONDER

The transponder for Experimental Communications Satellite (ECS) consists of two channels, of which the receiving frequencies are 34.83 GHz and 6.305 GHz, transmitting frequencies are 31.6 GHz and 4.08 GHz and intermediate frequency (IF) is 4.08 GHz. These two channels are capable of being cross-strapped at the IF section.

A travelling wave tube whose saturation output is about 2 W is used for the millimeter wave transmitter.

Researches for developing compact solid state oscillators and amplifiers with high efficiency, high stability, and high output power using Gunn and IMPATT diodes are being carried out in parallel for the future millimeter wave communications.

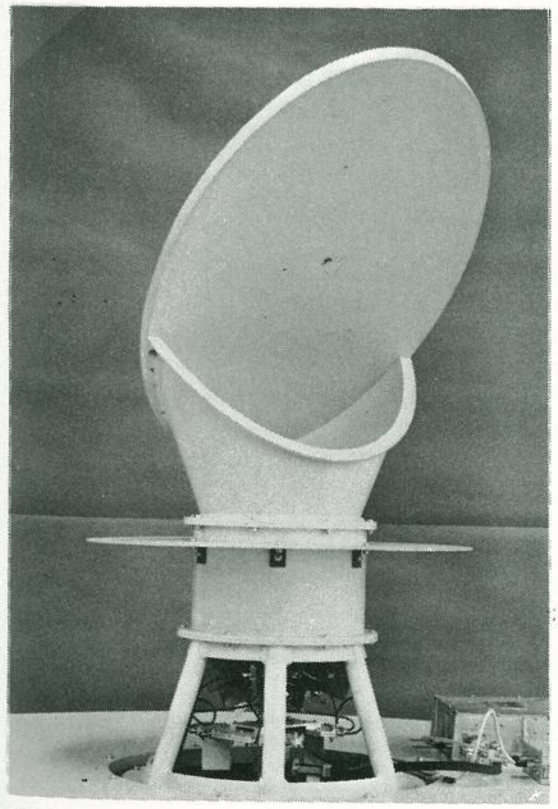


Receiving part of a millimeter wave transponder

RESEARCH AND DEVELOPMENT OF SATELLITE-BORNE ANTENNA

Researches in satellite-borne antenna intended for the future use as well as the development of a mechanical despun antenna for Experimental Communications Satellite (ECS) have been carried out.

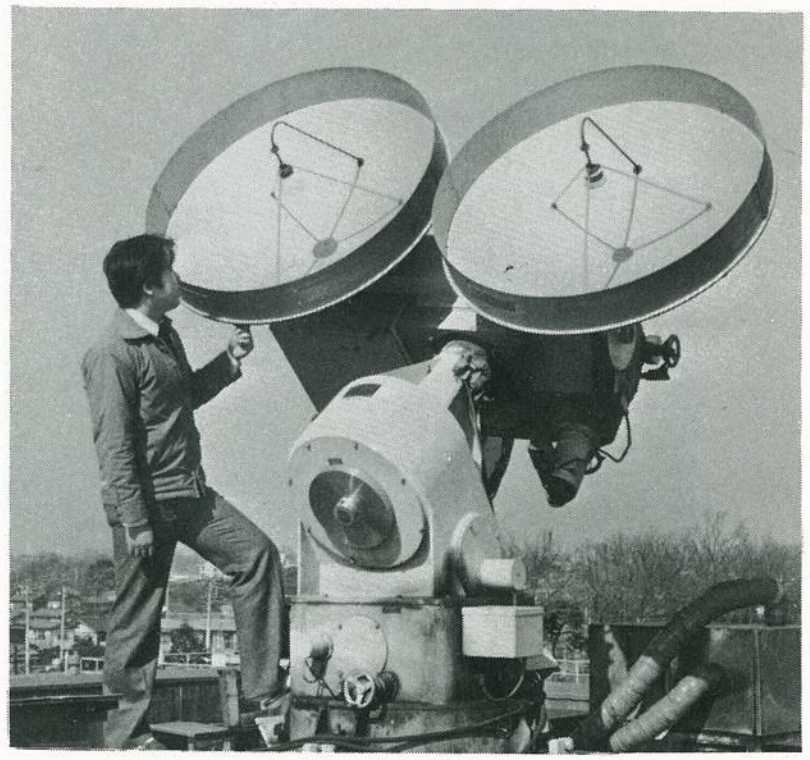
A breadboard model of horn reflector type despun antenna was tentatively constructed. The antenna was designed for multifrequency use for communications in microwave band and millimeter wave band, and a modified reflector was adopted to obtain a flat beam.



Satellite-borne horn reflector type antenna

STUDY OF MILLIMETER WAVE PROPAGATION ALONG THE EARTH-SPACE PATHS

In order to design the future millimeter wave space communications, it is very important to know the propagation characteristics through various kinds of rain falls along the earth-space path. For the reason above, the 35 GHz sun-tracking radiometer system has been operated since November 1970, when 2.6 km and 15 km diversity experiments were carried out. In these experiments diversity effects with a distance of 15 km were found to be more remarkable than those with a distance of 2.6 km. The 5 GHz radar system was put into operation for the comparison between the attenuation deduced from the radar backscattering and that measured by the 35 GHz sun-tracker along the sun-earth path.



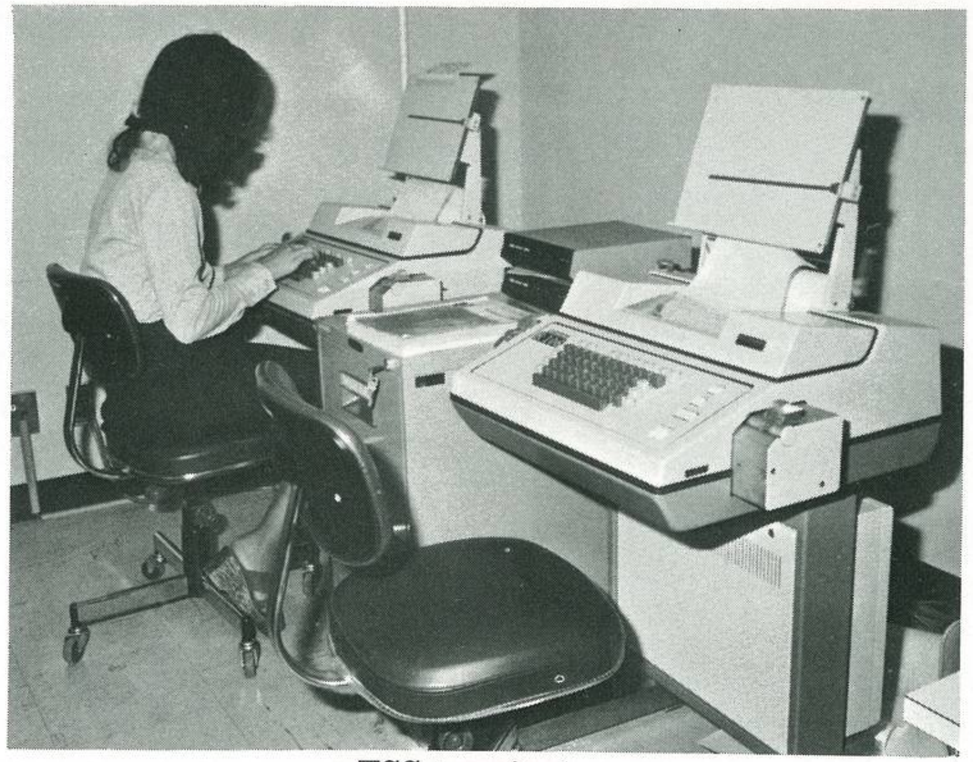
Sun-tracker

COMPUTER SYSTEM AND ITS OPERATION

To cope with the increasing demand for calculation at the Radio Research Laboratories, the TOSBAC 5600/160 was installed in 1975 as the main computer. The new system is controlled by the operating system GCOS III and has the multi-dimensional capability. That is to say, it can perform not only the central batch processing but also remote operations by TSS (time-sharing system) terminals and RJE (remote job entry) devices, which are installed at such places as the Kokubunji Headquarters, Kashima Branch, Hiraiso Branch, and four Radio Wave Observatories of Wakkanai, Akita, Inubo, and Yamagawa. Furthermore, the system is connected with the minicomputers installed at the Radio Research Laboratories such as NEAC 3200/50 and PDP 11/45 through the CCC (computer communication controller), making up the so-called computer complex. This computer system is mostly used for scientific and engineering calculations and data processing in various fields of research made at the Radio Research Laboratories, and for administrative and business purposes as well.


Remote batch


Main computer system


TSS terminal

RESEARCH IN EFFICIENT IMAGE PROCESSING

Researches are in progress with regard to the efficient image coding for reducing transmission bandwidth, the improvement in quality of deteriorated images, and the automatic processing of observational photographic data, mainly by using the technique of computer simulation. To facilitate these research activities, hardware and software systems are also developed, such as the program system for image processing, the storing and displaying monitor system of pictorial data, and so forth.

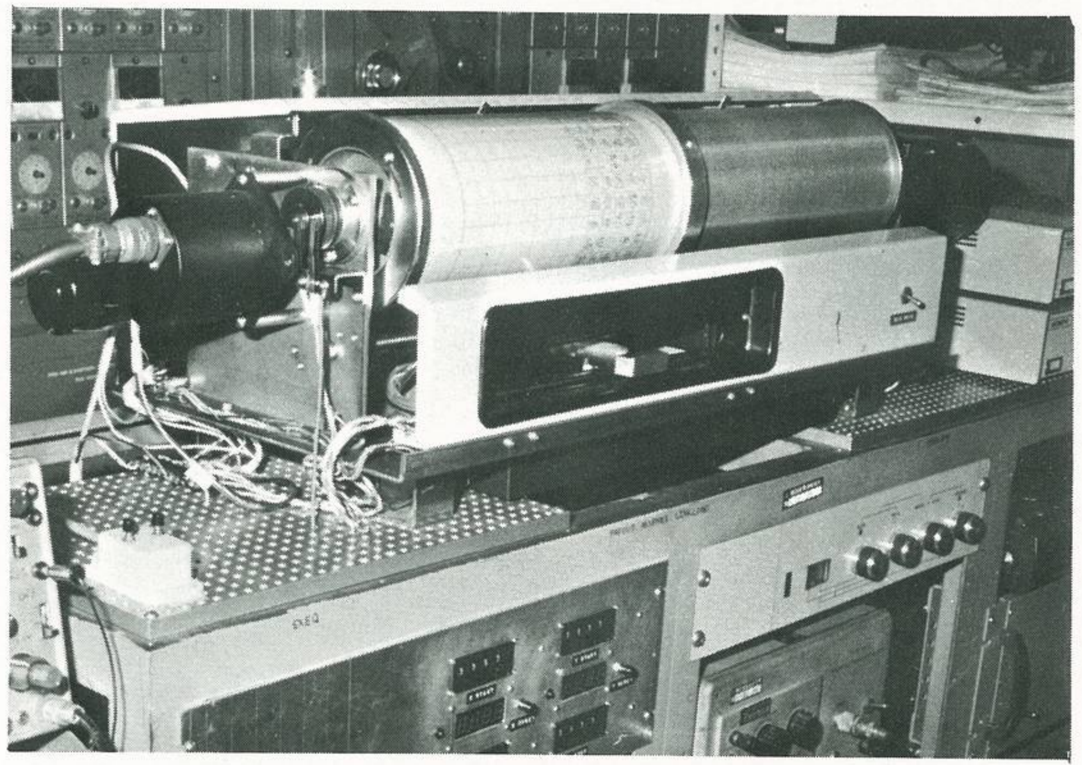
The photograph shows an image which is selected from the stored ones on a magnetic disk and displayed on a graphic computer terminal in pseudo half-tone representation, and a window image which is arbitrarily chosen by handling a position controlling knob and is displayed on a conventional TV monitor via the image memory of refreshing type.

Image display monitor system

RESEARCH IN WRITTEN INFORMATION PROCESSING

For the purpose of performing efficient transmission and automatic processing of written Japanese information, the development of an automatic recognition system of handwritten Chinese characters by stroke extraction method is under way. The system is based on the fact that the characters are drawn as a sequence of a few types of fundamental stroke segment. Another distinguishing feature of the system consists in its stroke extraction procedure through Analysis-by-Synthesis method. Each character is decomposed into stroke segments by the procedure and the character identification is carried out with their positional distribution.

In addition to the above, the development of software system for computer processing of the Japanese language is in progress.

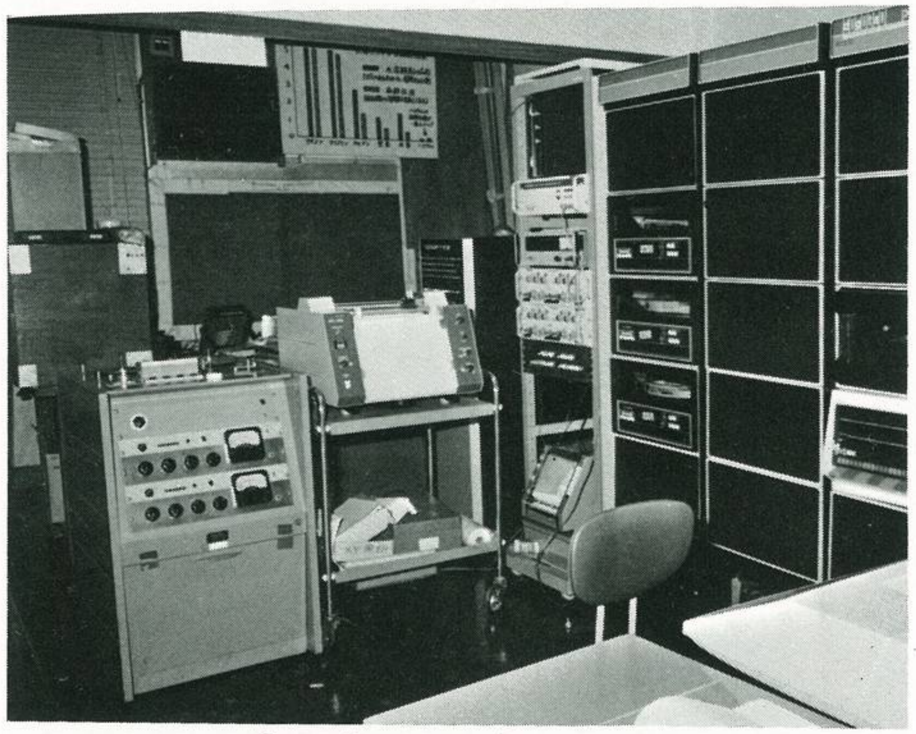


High resolution character reading machine

RESEARCHES IN SPEECH COMMUNICATION

In a radio communication circuit, the quality of transmitted speech signal sometimes deteriorates because of fading, noise, and interference with adjacent channels. On the other hand, the effective utilization of radio wave is an urgent problem in mobile and satellite communications. In order to solve such problems, it is to be desired that the signal to noise ratio of received speech signal be improved and that a low bit rate transmission system less than 10 kbits/s be established.

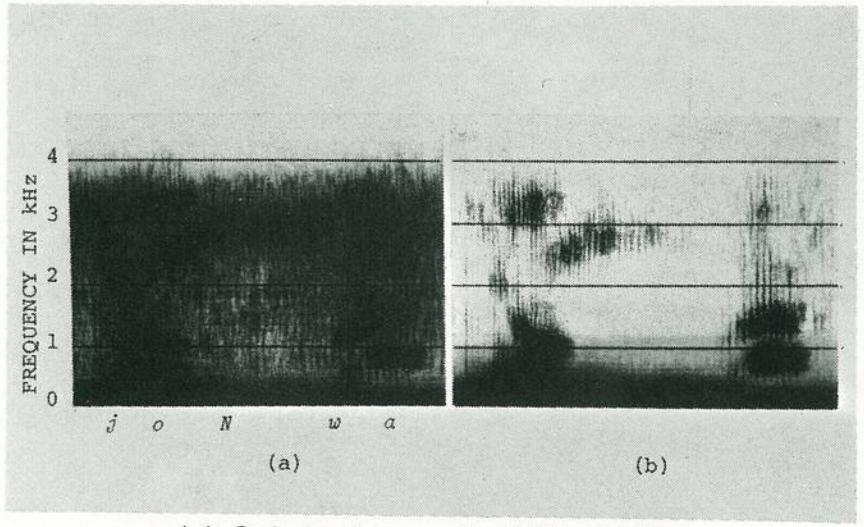
A new speech processing system SPAC (SPlicing of AutoCorrelation function) was proposed in 1975. SPAC is capable of compressing or expanding the speech spectrum, of prolonging or shortening the duration of utterance, and of reducing the noise level superposed on the speech signal. SPAC will be applied to many fields as shown in Table. Studies of the improvement in speech quality and the low bit rate transmission system are being conducted with emphasis by the use of SPAC.



Speech processing system

Expected applications of SPAC

Function	Application	
Frequency Spectrum Expansion	Stenography (with low speed reproduction of recorded tape)	Narrow band transmission Transform between male and female voices Special effect
Compression	Communication aid for hard of hearing Unscrambler of helium speech	
Time Scale Prolongation	Stenography	Synchronization of sound in movies Adjustment of utterance to the specified window of audio response system (or to the program length of broadcasting) Education
Shortening	Reading service for blind Audio Response system Information retrieval by speech Quick review of recorded tape	
Reduction of Noise Level	Communication in noisy environment Improvement in speech quality	Expansion of service area in radio communication
Distortion	Improvement in speech quality	Development of new speech transmission system Ex. Clipped speech+SPAC DM+SPAC
Quantizing Level	Low bit rate transmission	



(a) Original speech, S/N=0 dB
(b) Processed speech by SPAC

EFFICIENT FREQUENCY UTILIZATION IN THE LAND MO[illegible]LE RADIO SYSTEM

The radio-frequency spectrum in the land mobile telephone service has become so congested in recent years that it is necessary to exploit more usable channels.

The following three practical methods of reducing the channel separation have been studied:

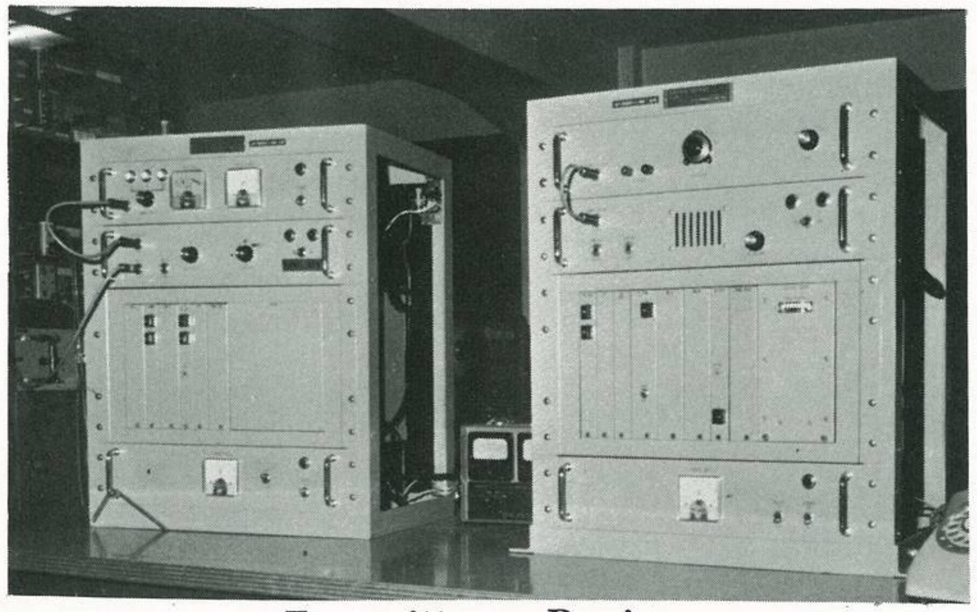
APPLICATION OF LINCOMPEX SYSTEM

As an extension of the existing maritime Lincompex system in MF and HF bands, a specified 150 MHz band land mobile Lincompex system (with a bandwidth of 3 kHz) has been developed in order to overcome deep and rapid fading occurring in this band.

Field tests by a running vehicle were carried out in the metropolitan area. Speech quality of this Lincompex system is hardly affected by fading when compared with the SSB system without Lincompex, and the protection against city noise is almost the same as that of the existing FM system.

These satisfactory results indicate that there is a possibility of this extremely narrow band system with 3 kHz being used in the land mobile telephone service in the future.

Further study of multiple-signal characteristics of the Lincompex system is expected to be made.



Transmitter Receiver
Lincompex equipment for land mobile radiocommunication in the 150 MHz band

[illegible]NTERFERENCE PREDICTION BY MODELLING

A statistical treatment is used in the interference prediction method. The statistical models, such as propagation, external noise, and operation models, are made up of the distribution functions of each model, which are characterized by their mean values, and standard deviations.

Both a receiver characteristics model and a statistical model of communication traffic have been developed on the basis of measured values of the actual FM system, rather than on the basis of theoretical analysis.

POSSIBILITY OF FM CHANNEL SPLITTING

One of the most practical methods needed to potential users is to determine the minimum bandwidth necessary for various modulating parameters in the FM system.

As a partial answer to this, a narrower band FM system is tested in the optimum relations among individual parameters affected by speech processing, taking into consideration both the usual FM system and the land mobile Lincompex system.

Results of propagation tests

grade	overall rating	average field strength in dB (μV/m)		
		Lincompex (3 kHz)	FM (16 kHz)	SSB (3kHz)
5	excellent	41	47	*
4	good	25	30	37
3	fair	18	22	24
2	poor	18	16	19
1	unusable	**	**	**

* Not found
** Not measured

An equipment with usual band transmitter and narrower band receiver (left),
an equipment with narrower band receiver and usual band transmitter (right)

FM equipments with bandwidths changeable from usual to narrower ones, such equipments being used as a simplex operation in the 150 MHz band

RESEARCHES ON UNDERSEA COMMUNICATION AND OBSERVATION TECHNIQUES

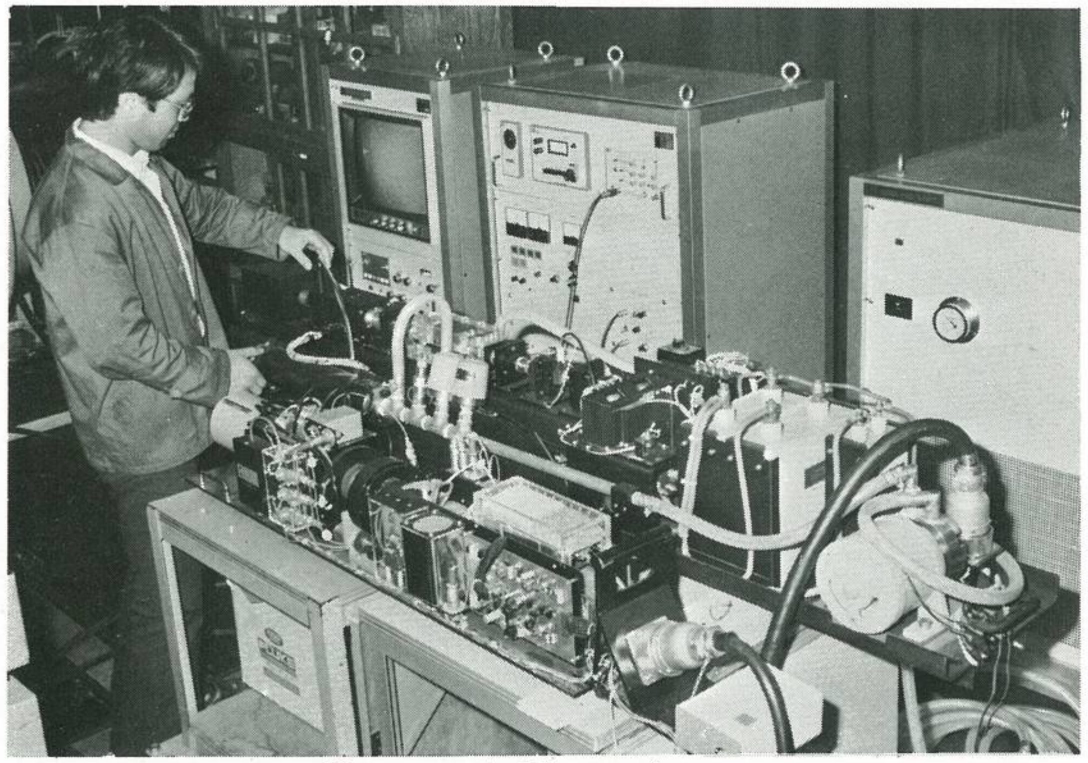
The wide-band transmission of information is very difficult in the seawater because of severe attenuation of radio waves. There is, however, a propagation window in the visible ray band. Accordingly, the laser beam seems to play an important role in the undersea communications or observations.

The attenuation and the scattering characteristics of laser beam have been investigated as a function of the propagation distance and the turbidity. The results of these basic researches were applied to the development of the range-gated laser viewer and of the large-capacity undersea communication system.

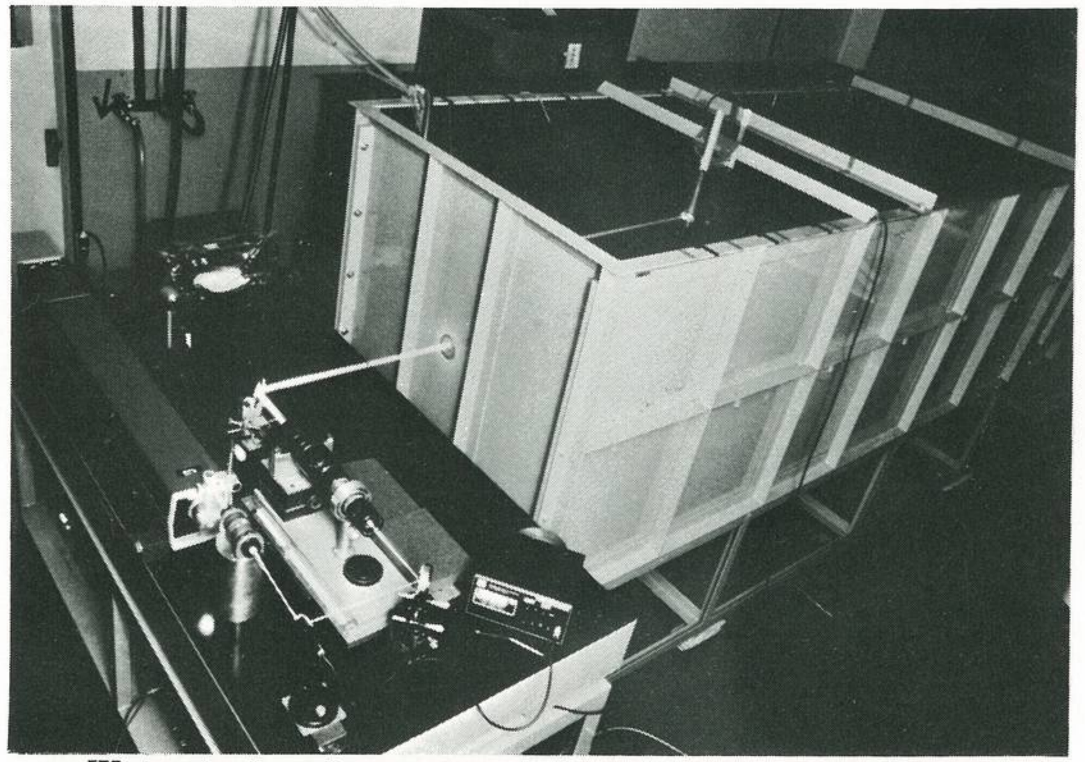
The range-gated laser viewer illuminates the target by sharp laser pulse and can reject the backscattered components, and will be a new powerful undersea observation equipment.

The large-capacity undersea communication system, which has an acoustic collimator, is expected to be used for TV signal or high-speed data transmission in the seawater.

Theoretical and experimental researches in multi-spectrum scope are also in progress for the development of a very sensitive detector of contaminative materials in the seawater.



Range-gated laser viewer



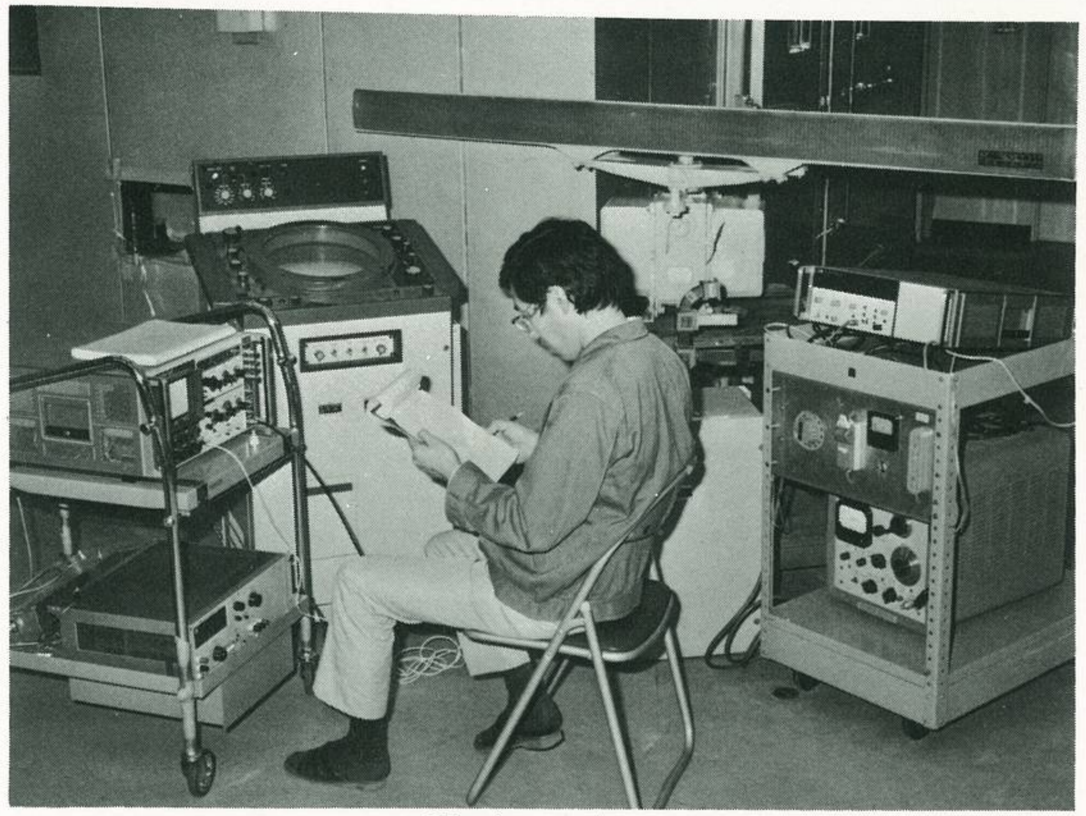
Water tank and experimental equipment for the laser propagation simulation

TYPE APPROVAL TEST, PERFORMANCE TEST AND CALIBRATION

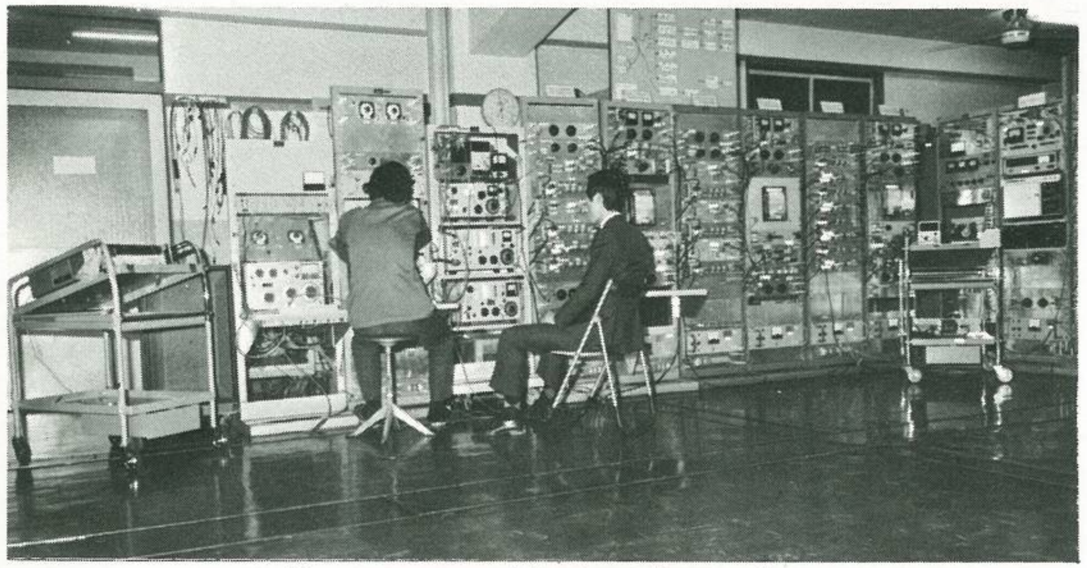
The following radio equipments intended to be installed at radio stations are legally bound to be authorized by the type approval under the Radio Research Laboratories: Radio direction finders, marine radars, radio apparatus for survival craft, automatic alarm signal receivers, aircraft transmitters, and receivers, which are used for the safety of navigation.

In order to keep the legal standard level in radio technique, on the other hand, it is recommended that such equipments as frequency meters, radio sondes, radio equipments for mobile service and radio transceivers in citizen bands pass the tests of type approval.

The Radio Research Laboratories conducts the performance test of radio equipments and the calibration of measuring equipments in response to the requests from the public.



Marine radar



Type approval test equipment

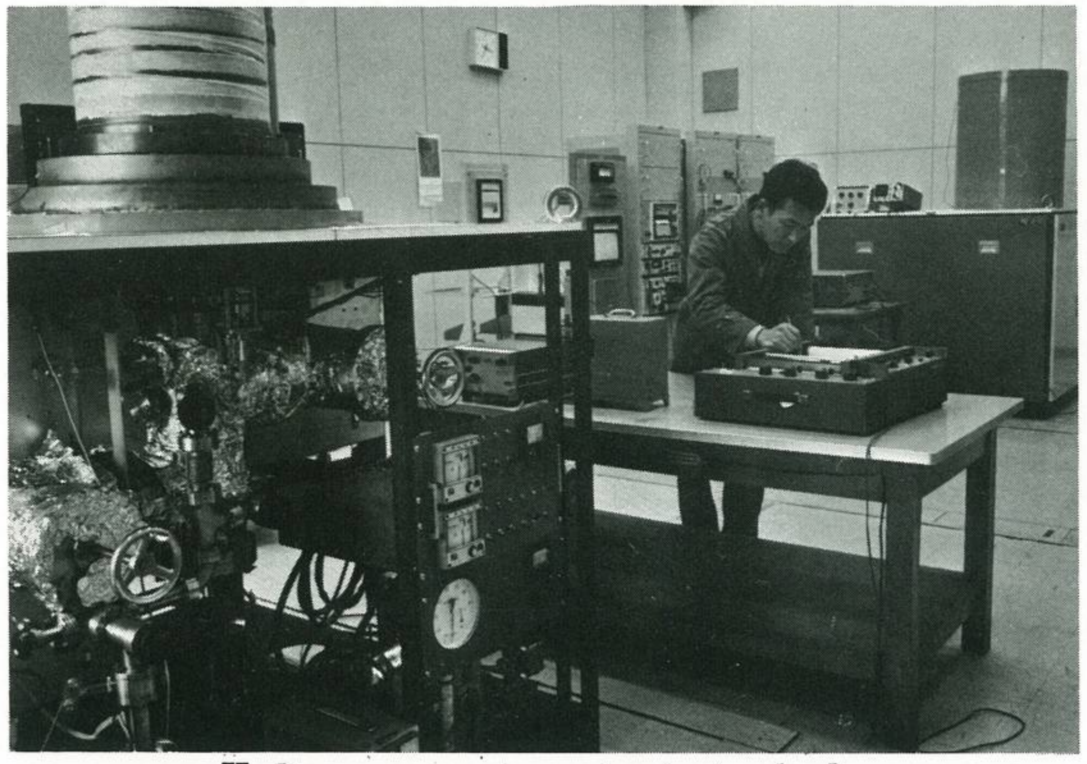
Calibration test for standard signal generator

RESEARCHES IN ATOMIC FREQUENCY STANDARDS

Time and frequency are defined on the basis of a constant and stable atomic proper oscillation. We have developed Hydrogen maser type, atomic standard since 1965, and succeeded the next year in its oscillation for the third time in the world. Further study of the storage bulb effect on the absolute frequency value, and an international direct comparison of H-maser frequency between the Radio Research Laboratories and the NRC of Canada, using the RRL-made specific bulb, resulted in coincidence of 2×10^{-13}.

The present short-term frequency stability of the H-maser standards is 6×10^{-15} for averaging time of 100 seconds, and the frequency accuracy is 3×10^{-12}. The other H-masers improved on the basis of the results of preceding study are now under construction and adjustment. As a primary standard or a highly stable clock, such H-masers are expected to have much higher stability.

Besides, the trial production of a cesium working standard with high accuracy is now under way for the improvement in precision of the Japanese Standard Time.

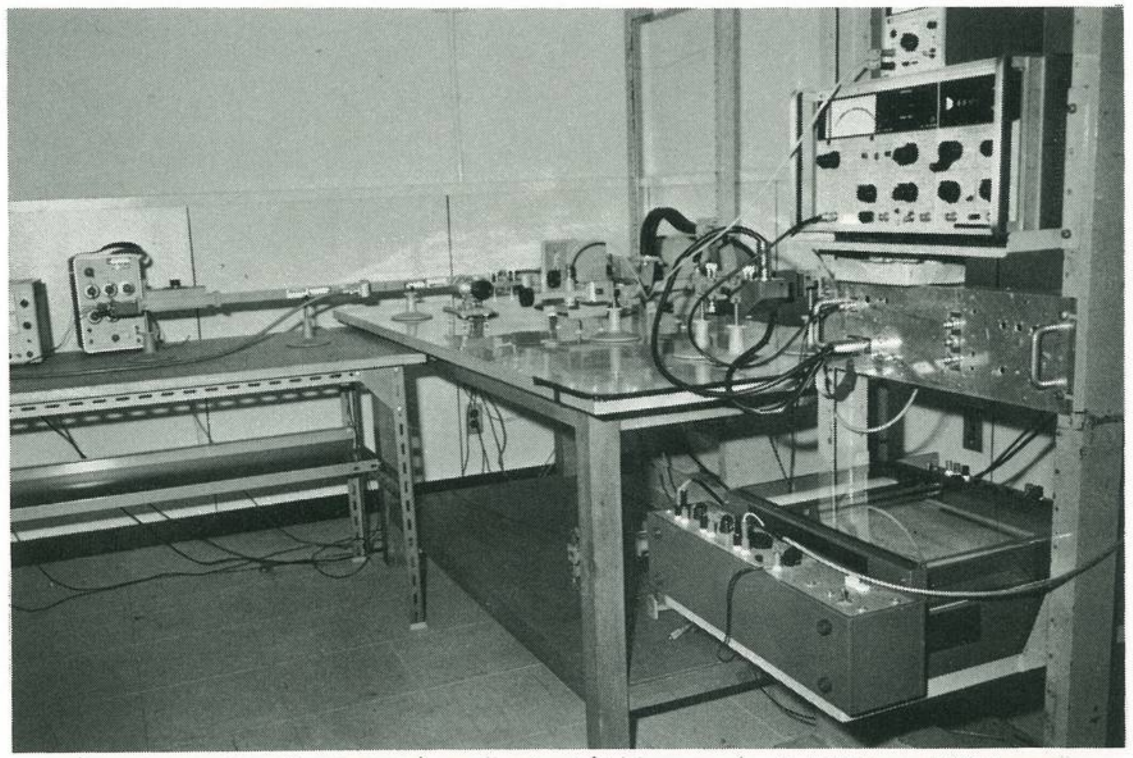


Hydrogen maser type atomic standard

PRECISION MEASUREMENT OF FREQUENCY

For appropriate application of standard frequency generators to the various fields of science, researches in frequency stability of the generators are now being carried out, particularly in the microwave region. The picture shows a measuring set-up of X-band precision sources which includes a cavity resonator as a passive reference.

Moreover, the study of a superconducting cavity oscillator has lately started for the purpose of obtaining an extremely stable active reference.



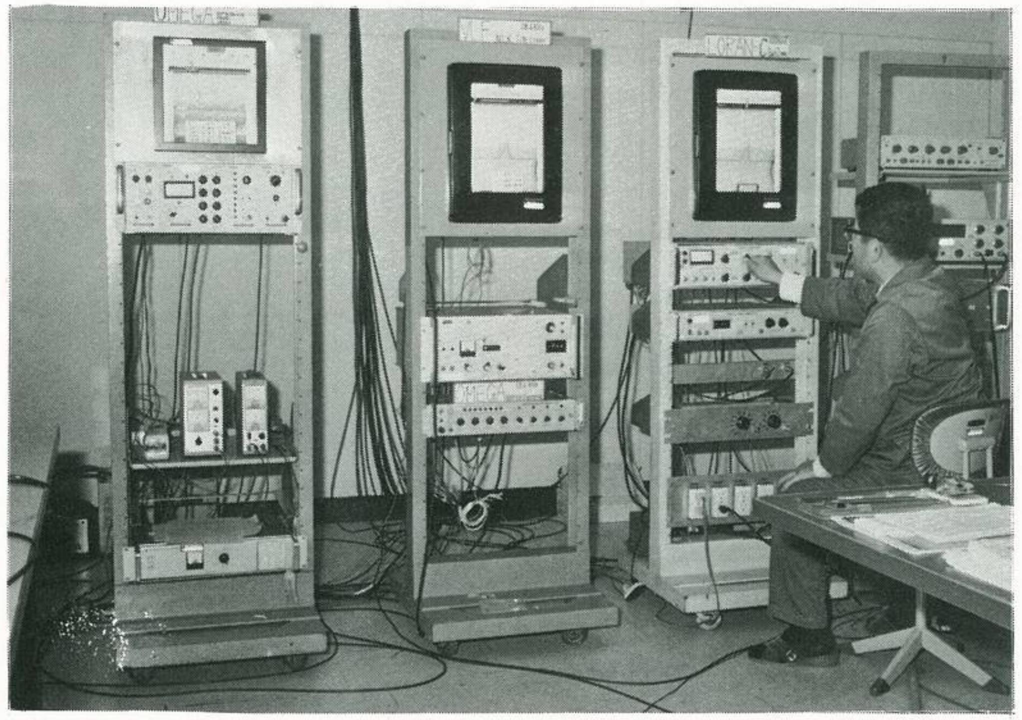
A set-up for the measurment of frequency stability of X-band precision sources

INTERNATIONAL COMPARISONS OF TIME VIA LORAN-C, VLF, AND SATELLITES

The international comparison of atomic time scales has been made mainly via Loran-C and VLF, and occasionally through direct comparison of the RRL's atomic clocks with those transported from the U.S. Naval Observatory. The measurement of the Loran-C signal from Iwojima has been made regularly since 1969. The phase comparison, using a leading part of received pulse of 100 kHz (Loran-C Iwojima) which consists of only ground wave, makes it possible to keep the accuracy of about 0.1 μs. As to the VLF, receptions of signals both from Omega Stations of North Dakota, Hawaii and Japan 13.6 kHz and from Station NLK (Jim Creek, Washington) at 18.6 kHz are being made. An accuracy of a few microseconds can be obtained in the time comparison through the VLF technique.

A two-way time comparison experiment in SHF-band between Kashima (RRL) and Rosman (NASA) earth stations was carried out via the geostationary satellite ATS-1 in 1975. In this experiment, the time difference was measured with the SSRA communication system, where a pseudo random noise code was used. The result of the experiment has shown that the SSRA system can give an accuracy of several nanoseconds in an intercontinental time comparison, and that the discontinuity of clock synchronization due to the earth's rotation is clearly observed.

Besides, further study of the international comparison of the time via low-altitude orbiting satellite (navigation satellite) is now being carried out.

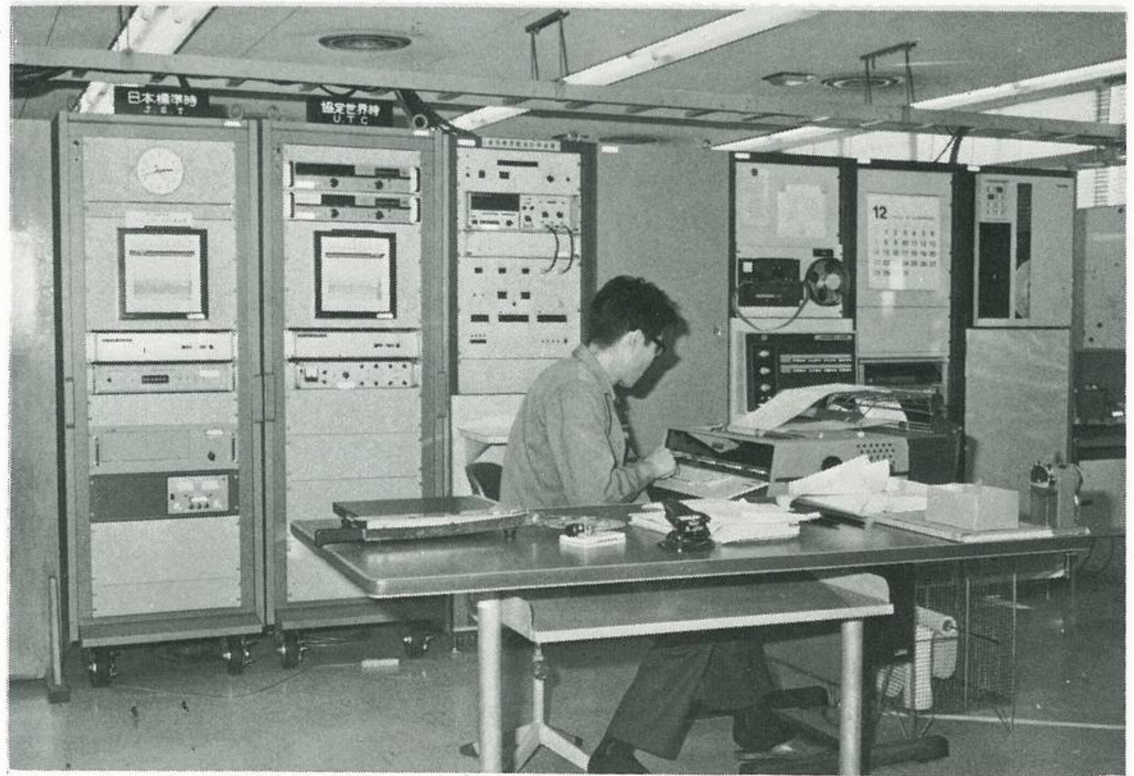


Timing receivers for Loran-C and VLF transmissions

JAPANESE STANDARD TIME

The Radio Research Laboratories has been responsible for keeping the Japanese Standard Time (JST), which is the Coordinated Universal Time (UTC) scale based on the atomic clock according to the international agreement.

In practice, two systems, one which consists of the primary standard of the hydrogen masers, and the other which consists of the cesium working standards combined by the automatic data processing system, are used to establish a uniform time scale. The JST thus determined has been compared by the various methods with the International Atomic Time (TAI) and with the standard time scale in the U.S.A.



Automatic data processing system for time standard determination

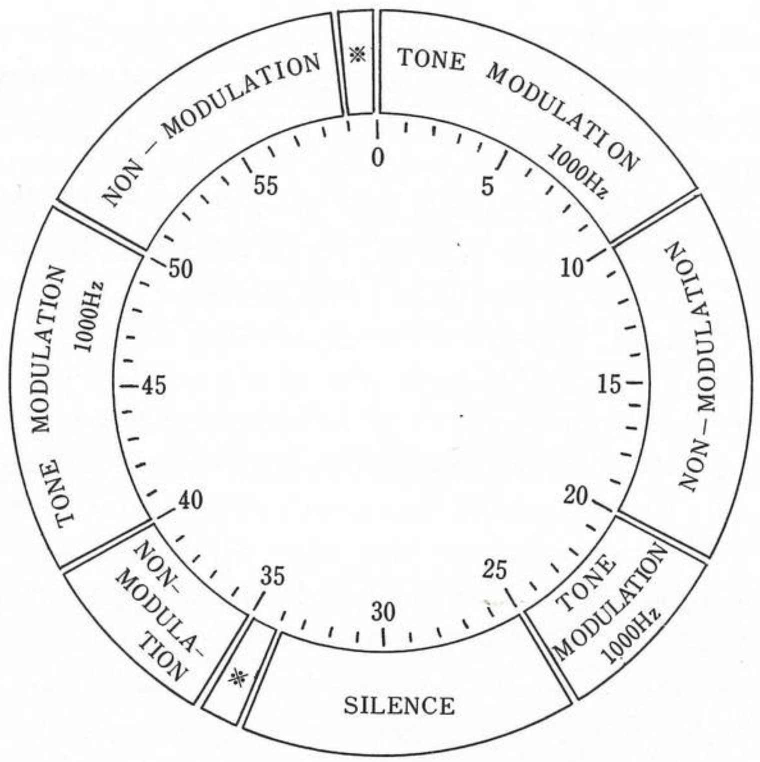
STANDARD FREQUENCY AND TIME BROADCAST SERVICE

The standard frequencies and time signals are broadcast for users in many fields from JJY and JG2AS stations at HF and LF, respectively.

The transmitted frequencies are maintained within $\pm 1 \times 10^{-11}$ in accuracy with respect to the value determined by the international definition of the second.

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

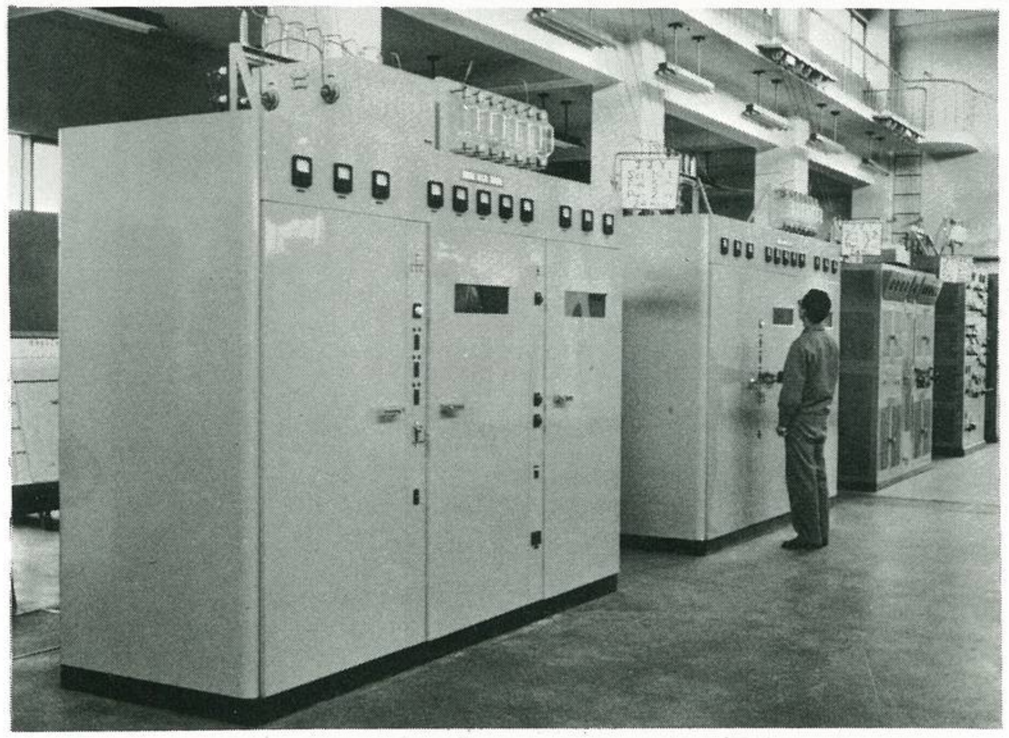
JG2AS has been used especially for high precision frequency calibration because of more stable propagation characteristics compared with those of HF wave.



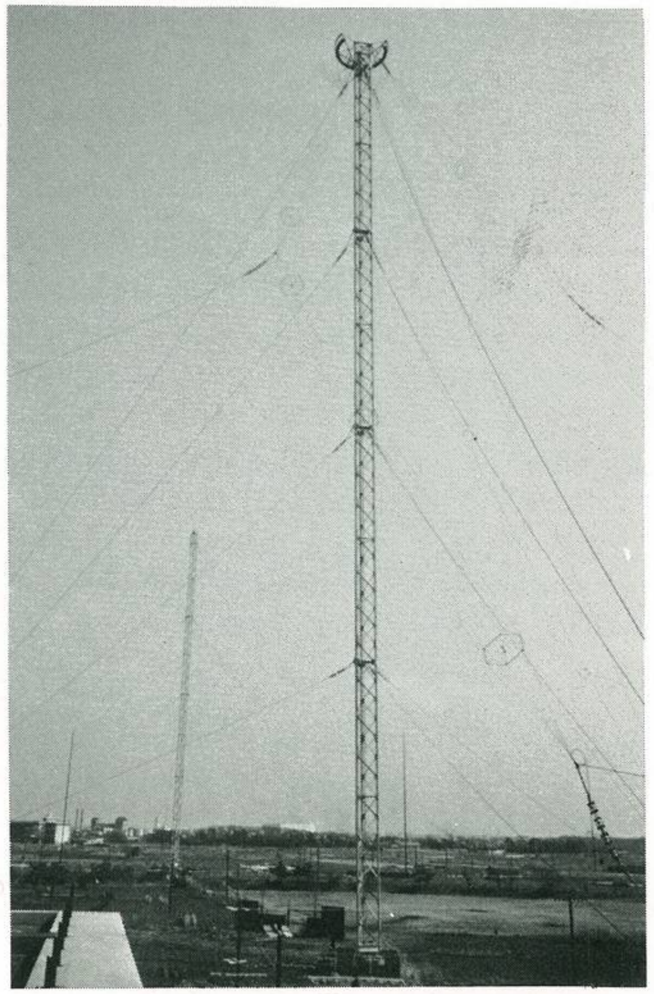
Hourly broadcasting schedule
※ Station announcement

Stations for standard-frequency and time-singnal

	SERVICE STATION	EXPERIMENTAL STATION
CALL SIGN	JJY	JG2AS (JJF-2)
FREQUENCIES	2.5 MHz, 5 MHz, 8 MHz 10 MHz, 15 MHz	40.0 kHz
ANTENNA RADIATION POWER	2 kW (2.5, 5, 10, 15 MHz) 1.5 kW (8 MHz)	1 kW
OPERATION HOURS	24 hrs	08:30~17:00 (JST) EVERYDAY EXCEPT SUNDAYS
PULSES OF SECOND	CONTINUOUS	CONTINUOUS IN ABSENCE OF TELEGRAPH MESSAGE (JJF-2)
ACCURACY	$\pm 1 \times 10^{-11}$	$\pm 1 \times 10^{-11}$
LOCATION	KOGANEI, TOKYO	KEMIGAWA, CHIBA PREFECTURE



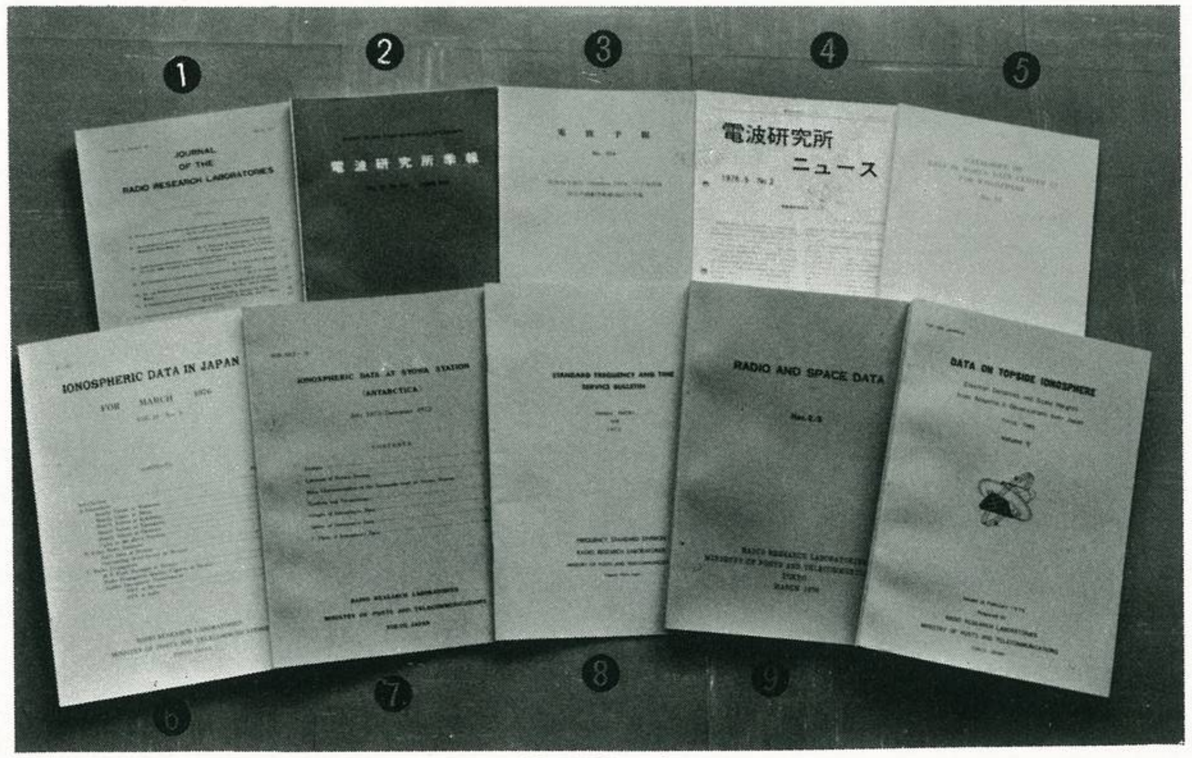
JJY transmitter room (Koganei Station)



LF 40 kHz transmitting antenna (Kemigawa Station)

PUBLICATIONS

1.	Journal of the Radio Research Laboratories	Thrice a year
2.	Review of the Radio Research Laboratories	Quarterly
3.	Monthly Radio Propagation Forecast (Japanese version)	Monthly
4.	RRL News (Japanese version)	Monthly
5.	Catalogue of Data in WDC-C2 Center for Ionosphere	Annual
6.	Ionospheric Data in Japan	Monthly
7.	Ionospheric Data at Syowa Station (Antarctica)	Semi-Annual
8.	Standard Frequency and Time Service Bulletin	Monthly
9.	Radio and Space Data	Annual
10.	Data on Topside Ionosphere	Semi-Annual



Publications

RESEARCH PROJECTS AND SERVICES

Planning and Support Division

Project No.	Item
51101	Planning and Coordination of Research Projects
51102	Information Activities
51103	Publication of Journals, Data and Bulletins
51201	Patent Service and Related Investigation
51202	Library
51203	World Data Center C2 for Ionosphere
51204	International URSIGRAM Center
51205	Workshop

Technical Consulting Division

52101	International Affairs of Radio Communication
52201	Radio Frequency Utilization
52301	Radio Technique Application
52403	Radio Communication System

Information Processing Division

53020	Software Technology
53120	Computer Programming Technique
53201	Processing of ISS Data
53220	Radio Science Study with Satellite Data
53320	Pattern Processing
53401	Computer Usage
53420	Data Processing System

Radio Wave Division

54001	Coordination of Ionospheric Observation
54123	Ionospheric Propagation
54130	Analysis of ISS Radio Noise Data
54201	HF Radio Propagation Prediction
54202	Routine Ionospheric Sounding at Kokubunji
54203	Coordination of Ionospheric Sounding Data
54210	Routine Ionospheric Observations in Antarctica
54220	Exploitation of Ionospheric Observation Technique
54302	Space and Atmospheric Physics
54321	Extra-terrestrial VLF Radio Wave Study
54420	Radio Propagation in Non-ionized Atmosphere
54422	Millimeter Wave Propagation Study

Artificial Satellite Research Division

55123	Satellite Communication System
55131	Satellite-borne Communication Device
55142	Antenna for Satellite Communication
55170	Experiments on CS and BSE Projects
55180	Experiments on ETS-II/ECS Projects
55211	Upper Atmosphere Study using ISS Data
55212	Space Chamber and Ionospheric Plasma
55240	Improvement in ISS-borne Topside Sounder
55323	Orbit and Attitude of Satellite
55330	Application of Satellite

Communication System and Apparatus Division

56124	Efficiency Promotion of Radio Communication
56220	Fundamental Research in Speech Information Transmission
56221	High-efficiency Transmission of Speech Signal and Noise Reduction
56320	Effective Utilization of Frequency for Land-mobile Radio System
56420	Measurement Technology on TV Ghost
56526	High-accuracy Attitude Determination of Spacecraft using Laser
56527	Development of Laser Methods for Environmental Research
56620	Data Transmission in the Seawater using Laser
56621	Maritime Radio Communication and Associated Technology
56701	Calibration Service of Radio Equipment
56702	Type Approval for Radio Equipment
56725	Testing Method

Frequency Standard Division

57120	Hydrogen Atomic Standard
57122	Development of New Atomic Standard System
57123	Application of Atomic Standard
57220	Determination of Atomic Time Scale
57221	Time Synchronization Via Satellite
57222	Precision Measurement of Frequency and Time
57301	Dissemination of Standard Frequencies and Time Signal
57302	Electric Power Control for Frequency and Time Standard System
57320	Establishment of Working Standard
57322	Utilization Study of Standard Frequency and Time-signal Emission

Special Research Section for Space Physics

61120	Irregularities in the Ionosphere

Special Research Section for Atmospheric Radio Science
62121 Acoustic Sounding of Lower Troposphere
62122 Development of Acoustic Sounder System for Air Pollution Monitoring

Special Research Section for Radio Physics
63120 Theoretical Research in Electromagnetic Wave
63121 Theoretical Research in Propagation of Electromagnetic Wave

Special Research Section for Electromagnetic Compatibility
64120 Radio Noise Effects on Communicaion Quality Degradation

Kashima Branch
67001 CS and BSE Main Fixed Earth Station
67120 Satellite Communication System Study using CS and BSE
67121 Millimeter Wave Satellite Communication Study using ETS-II/ECS
67220 Development and Application of VLBI System
67301 Telemetry and Telecommand of ISS
67320 Telemetry and Telecommand of CS and BSE

Hiraiso Branch
68101 Radio Disturbance Warning Services
68102 HF Radio Propagation Study
68122 Lower Ionosphere and LF and MF Radio Propagations
68201 Observation and Study of Solar Radio Emissions
68202 Observation of HF Galactic Radio Emissions

Wakkanai Radio Wave Observatory
69101 Routine Ionospheric Observation and Data Reduction
69120 Special Observations at Wakkanai
—Geomagnetic Effects on Ionospheric Propagation—

Akita Radio Wave Observatory
69201 Routine Ionospheric Observation and Data Reduction
69220 Special Observations at Akita
—Study of Lower Atmospheric Structure and Movement using Meteor Radar—

Inubo Radio Wave Observatory
69301 Routine Observation of VLF Radio Waves
69320 Special Observations at Inubo
—VLF Wave Propagation with Emphasis on Solar-terrestrial Relationship—

Yamagawa Radio Wave Observatory
69401 Routine Ionospheric Observation and Data Reduction
69420 Special Observations at Yamagawa
—Trans-equatorial Radio Propagation—

Okinawa Radio Wave Observatory
69501 Routine Ionospheric Observation and Data Reduction
69520 Special Observations at Okinawa
—Low-latitude Ionospheric Phenomena—

Joint Researches
J–121 Policy Planning Committee toward CCIR
J–125 Research and Operation Center for ISS
J–126 Project and Promotion Center for CS and BSE
J–127 Project and Promotion Center for Radio Observations in Antarctica
J–128 Project and Promotion Center for ETS-II/ECS

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