LOCATION OF
RADIO RESEARCH LABORATORIES
& RADIO WAVE OBSERVATORIES
IN JAPAN

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MINISTRY OF POSTS AND TELECOMMUNICATIONS

Radio Research Laboratories

JAPAN

1960

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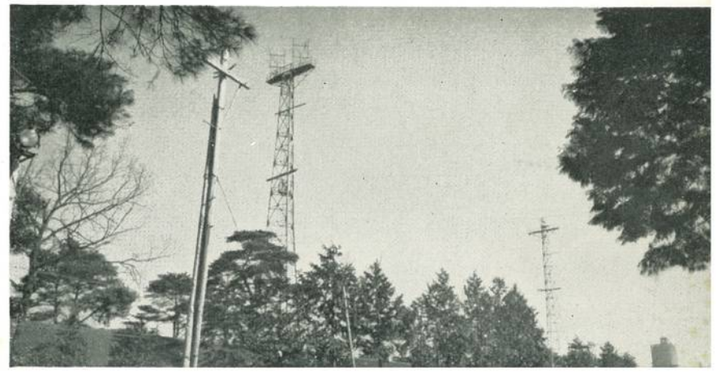
Outline of the Radio Research Laboratories

The Radio Research Laboratories came into existence on August 1, 1952, as a government research agency belonging to the Ministry of Posts and Telecommunications. It has a history of far longer years. It may be said that this Laboratories has its origin in the Research Committee of Radio Wave Propagation organized in 1922 within the National Scientific Research Council. Afterwards, through the Physical Institute for Radio Waves, Ministry of Education, the present Laboratories developed into an agency having for its object overall researches in radio matters.

This Laboratories has, within Tokyo Metropolis, the headquarters at Kokubunji (139°29′ E, 35°42′ N) and two detached offices at Koganei and Ogikubo. Throughout the country, there are five branch observatories—at Wakkanai (141°41′ E, 45°24′ N), Akita (140°08′ E, 39°44′ N), Hiraiso (140°38′ E, 36°22′ N), Inubo (140°51′ E, 35°42′ N) and Yamagawa (130°38′ E, 31°13′ N). Its structure is as shown in the attached table.

The Radio Research Laboratories is taking up various problems necessary for more effective and wider utilization of radio waves. In addition to the research work, this Laboratories is carrying on the following services related to not only radiocommunication but also general matters of scientific research or public utility:

Emission of standard frequencies and broadcasting of standard time signals;
Broadcasting of URSI grams;
Radio propagation forecasts and radio forewarnings;
Governmental type approval of radio apparatus and devices;
Performance test and calibration of radio apparatus and devices;
Data centre (C2) for the ionosphere on the IGY program.



Outline of the History of Ionospheric Observation in Japan

The first step of study for the ionospheric soundings in Japan was made in 1931 by the Navy Technical Institute at Meguro, Tokyo. The Institute achieved success in the measurement of height of the ionosphere in 1932, adopting the frequency modulation method of Appleton and Bernett. Furthermore, the Institute made the continuous observation of the virtual height of the ionosphere, so called h'–t observation, in use of the pulse method on 2Mc and 4Mc from 1932 to 1934. This is the beginning of the routine ionospheric soundings in Japan. Finally, the first observation the ionosphere in virtual height versus frequency, so called h'–f observation, was started in Japan in June, 1934.

On the other hand, the Hiraiso Branch of Electrotechnical Laboratory, Ministry of Communications, constructed the ionosonde of h'–t type in 1932, and began to make the h'–f observation in 1936.

In 1940, the Japanese Army began the routine ionospheric soundings of h'–f and other related observations at Tsitsihar, Manchuria. Thus, the ionospheric soundings accompanied by the study of ionosphere were continued by the Army, the Navy and the Electrotechnical Laboratory. But when the Physical Society for Radio Wave was established in the Ministry of Education in March, 1941, all the works of responsibility for the research work on the ionosphere was transferred to this Society, which was reorganized into the Physical Institute for Radio Waves in April, 1942. This Society started, first of all, the h'–f observation by an Automatic Recorder of the Berkner type at Hankow in China on the 21st of September, 1941, at the time of a solar eclipse. The Physical Institute for Radio Waves, after reorganization established the stations of the routine ionospheric soundings in the Far East Region in maximum numbers of 21. It was one of these stations, where the ionospheric soundings on routine basis is continued even until now at Kokubunji, in the present site of the Radio Research Laboratories which works as the successor of the Physical Institute for Radio Waves since the several reorganization after the end of the War. Though the station of this routine ionospheric soundings was temporarily moved to Kaminoge, Tokyo, during the World War II, the observation was resumed at Kokubunji after the end of war, keeping up the long traditions of the ionospheric observation in Tokyo area since 1932. After the war, three stations for the routine ionospheric soundings were established in every five degrees of latitude at Wakkanai, Akita and Yamagawa, adding to the Kokubunji station which act the part of key station in Japan.

Observations and Studies of the Ionosphere

Observations of the Ionosphere at Vertical Incidence

The observations of the ionosphere at vertical incidence are made at four observatories at Wakkanai, Akita, Kokubunji and Yamagawa in order to utilize the observational results for forecasting radio propagation conditions and for investigating physical characteristics of the ionosphere itself. The routine observation following after the IGY is being made every 15 minutes every day, and every 5 minutes during special observation periods. At each observatory, the panoramic recorders with the transmitter and receiver of non-tuning type are used regularly, and the automatic recorders of tuning type are installed as spares. The values scaled from the films of observation are published monthly in the "Ionospheric Data in Japan."

At Kokubunji, additionally, the minimum heights and critical frequencies of the E and F layers are continuously recorded by means of the modified panoramic recorder on Special Observation Days. These records can reveal precise variations in the ionosphere related to the solar effect, e. g. in cases of Dellinger effect, magnetic storms, etc. This process has succeeded in the observation of aurora in the districts of Tokyo.

Other Observations of the Ionosphere

Besides, observations are carried out on the ionospheric absorption at Kokubunji and on the ionospheric drifts at Yamagawa, the former following the method of the local transmitter of pulse waves and the latter the fading method of closely spaced receivers, as described in the IGY Manual. Furthermore, other specific observations are made tentatively for the purpose of studying the ionosphere.

Radio observations of artificial satellites are going on, too, by measuring the shift of Doppler frequency in reception of the wave radiated from the satellite. At the same time, the telemetering signals from the satellite have been recorded on magnetic tapes, when possible. It is thought that the outer atmosphere will become more evident by this means. Observations of electron and ion density of the ionosphere by rocket as well as its instrumentation, are taken in cooperation with the Institute of Industrial Science, University of Tokyo, by firing the sounding rocket in the Akita Rocket Range.

Physical Study of the Ionosphere

Theoretical research work on the ionosphere and outer atmosphere has been carried on very actively for many years. Fruitful results have been accomplished on the *F*2 layer with regard to the functional form for the rate of electron disappearance, diffusion effect of ion and electron on the distribution of electron density, diurnal variation in, and lunar effect on, the electron density, the height, and the like. These results will be checked by the analysis of IGY data accumulated in recent years. Furthermore, voluminous studies have been made of the world-wide or disturbed ionospheric state related to the solar and geophysical phenomena, as well as of the theoretical work on the outer atmosphere, using the observational results of charged particles, cosmic ray, geomagnetism, etc.

Studies in Ionospheric Propagation

Sweep Frequency Pulse TransmissionTest at Oblique Incidence

With a view to investigating the ionospheric propagation by the observational data in comparison with the ionospheric vertical-incidence soundings at the apex of the propagation path, the transmission tests by pulse wave on sweep frequency at oblique incidence were conducted over a distance of 1,000 km between Hiraiso and Yamagawa in 1955. Further tests have been carried on since 1957 between Wakkanai and Yamagawa over a distance of 1,840 km by using a method of the round trip, which is initiated by a pilot signal. The frequencies of this equipment range from 2 to 37 Mc/s.

Studies in the Propagational Characteristics of Long and Medium Waves

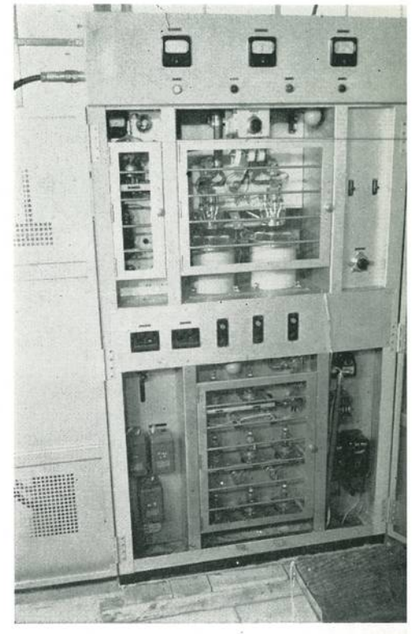
For the purpose of establishing the method of field strength calculation and of lightening the construction of lower ionosphere, field intensity measurements are made in the frequency range below medium-high frequencies by means of transmission of pulse waves or transmissions from broadcasting stations.

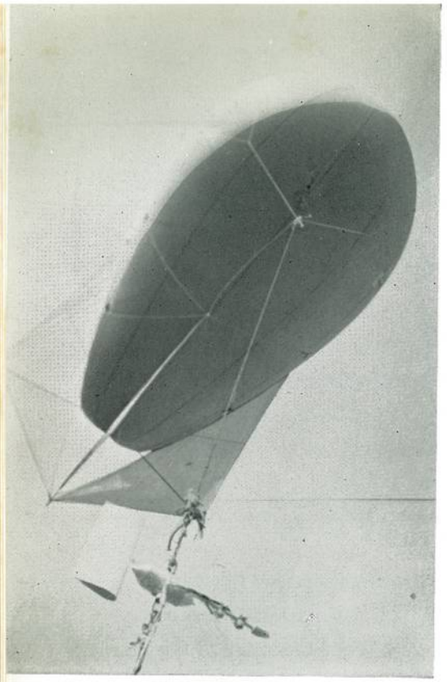
Analysis of Ionospheric-Scattering

The long-distance communication making use of radio scatter phenomenon due to irregularity in electron density in the ionosphere has been in practical use in some countries of late years. But there still remains much to be studied into the propagational mechanism, distance characteristic, regional characteristic, etc. Up to 1959, this Laboratories, in cooperation with the Central Radio Propagation Laboratory, U. S. A., was engaged in the investigation of ionospheric scattering and latitudinal distribution of the sporadic *E* layer, by receiving at several stations in Japan the 49.68 Mc/s signals transmitted from Okinawa. A new plan of experiment in and after 1960 is under way.

Measurements of Atmospheric Radio Noise in High Frequency Bands

The knowledge of geographical distribution of atmospheric radio noise in high frequency bands is essential for the designing of radio circuits. The C. C. I. R. has requested every country to cooperate in the preparation of charts showing the world-wide distribution of atmospheric radio noise. With a view to expressing statistically the characteristics of noises, the cumulative amplitude distribution and crossing rate distribution of atmospheric radio noise in high frequency bands are measured by means of the equipment designed originally by this Laboratories. Also, the Laboratories has participated in the 15-years' measurement program by the use of C. R. P. L.'s noise recorder in accordance with the resolution of the C. C. I. R. Observational results by both systems are under comparison.





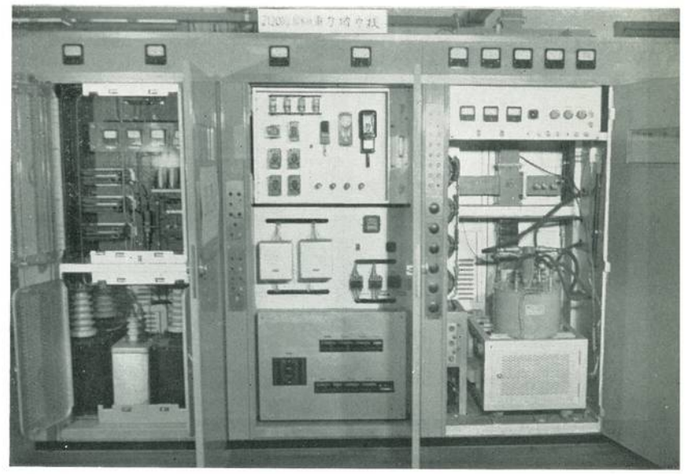
Research on Tropospheric Propagation

Studies of Relations between Meteorology and Radio Propagation

Since the meteorological condition vitally affects the propagation of very short waves, the knowledge of distribution and variation of atmospheric refractive indices is very important to the analysis of the propagation characteristics of frequencies above VHF. The observational data collected from meteorological stations all over Japan are being analyzed statistically, and the vertical or horizontal distributions of the refractive index along the propagation paths are measured by helicopter or kitoon to find out the relation between atmospheric conditions and radio propagation.

Development of Tropospheric Scatter Communication

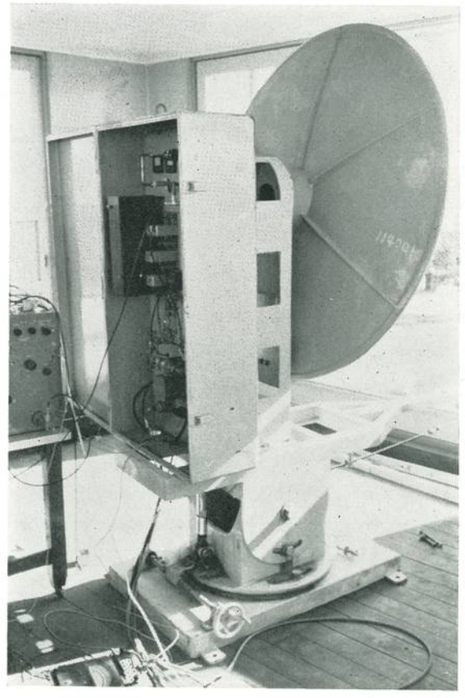
The long-range propagation of very short waves due to inhomogeneities in the troposphere has the feasibility of transmission of wideband signals such as in television. Many fundamental experiments were performed for several years, and recently a more improved test was made over a distance of 300 km with high-powered transmitters operating on the frequencies approximately 600 and 2,000 Mc/s, to provide the information necessary for designing communication systems.



Studies of Propagation over Irregular Terrain

In a mountainous country like Japan, the diffractive propagation over mountains is of great importance. The existence of a stable high field intensity was found at the back of a mountain and a success was made in telephone conversation over 400 km on 150 Mc/s with a 50 W transmitter. The recent experiments on UHF and SHF made clear the multipath propagation characteristics of the diffracted waves over mountain ridges.

Theoretical considerations have been given to the propagation over compound media of different electric constants and to diffraction over many mountains. The general formula for calculation of field intensity was obtained and propagation charts were prepared to serve practical use.

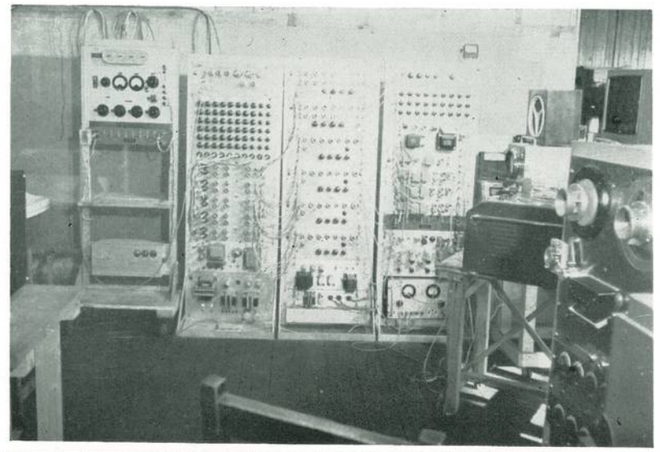


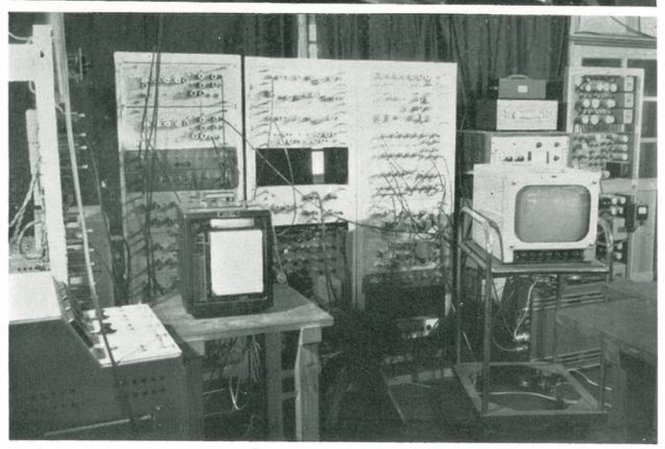
Studies of Millimetric Waves

As the demand of SHF band to be utilized for communication purposes is growing to saturation, the development of millimetric waves is a pressing subject for study in every country. At this Laboratories, researches are going on into the propagational problems in the millimetric wave communication and for the establishment of standards for circuit designing; the propagation experiments on the 35 Gc/s FM & PM radar systems are now in progress. Besides, the use of ferrite in the millimetric wave circuits and the method of measuring millimetric wave power are now under development.

Studies of Communication Systems

The study and development of communication systems to include as many channels as possible within a limited frequency band forms an increasingly important subject in future. Studies are in progress here mainly with regard to the compression of bandwidths required for voice and TV transmissions.

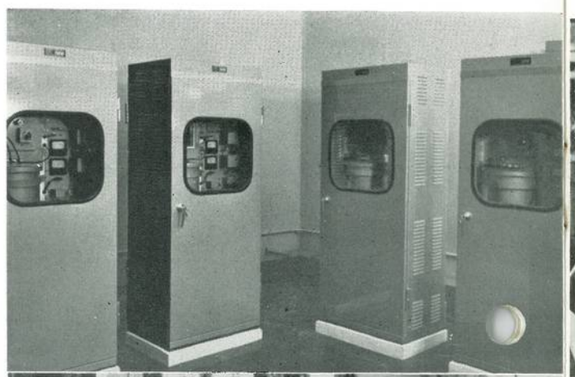


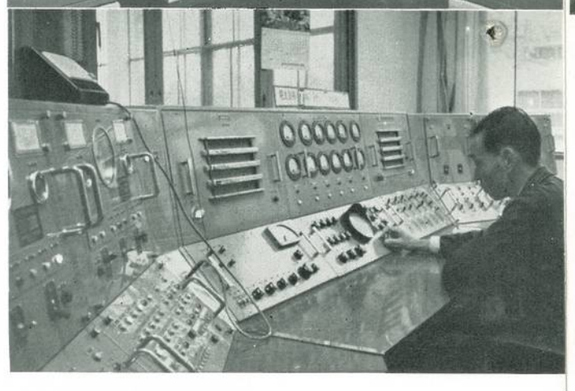


STANDARD FREQUENCIES

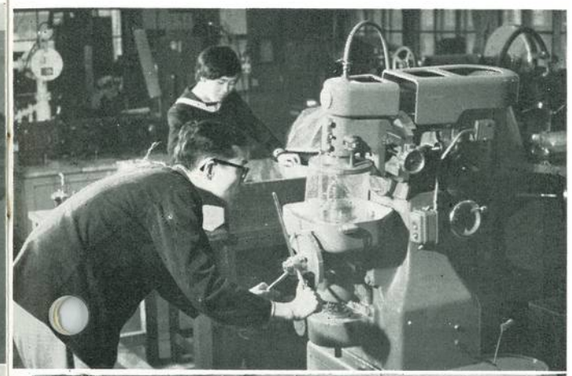
Emission of Standard Frequencies and Broadcasting of Time Signals

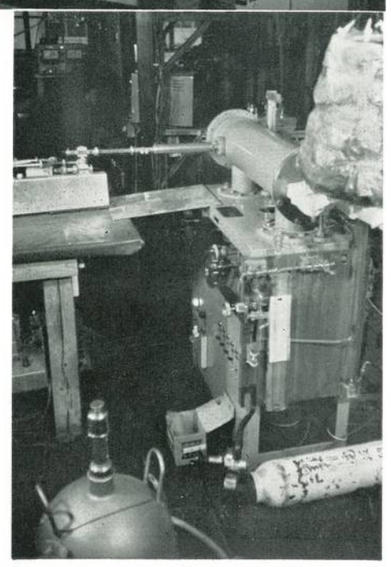
The standard frequencies JJY, in conjunction with the Tokyo Astronomical Observatory, are broadcast at Koganei as shown in the table below. The accuracy of frequency is about 5×10^{-9}, the stability less than 5×10^{-10}/day, and the accuracy of time signals 0.01 second. At the same time as the transmission of time signals are broadcast radio forewarnings. As recommended by the C.C.I.R., the transmission of the standard low frequency will be started on the emission of frequency 16.2 kc/s.





CALL SIGN	CARRIER FREQ. (Mc/s)	MODULATION FREQ. (kc/s)	EMISSION POWER (kW)	HOURS OF EMISSION (JST)
JJY	2.5	1	2	15.59–07.59
	5.0	1	2	00.00–24.00
	10.0	1	2	00.00–24.00
	15.0	1	2	00.00–24.00





Study of high Q Quartz Oscillator

GT-cut, quartz plates with high Q of 3×10^6 have come to be produced for practical use. And, the study of higher Q plates is also making progress.

Precision Thermostat

It is necessary to use a precision thermostat in order to ensure the accurate standard frequency transmission by means of a quartz oscillator. A thermostat holding the temperature within $\pm1.5/10000°$ per degree C variation in sorroundings has been brought to completion.

Frequency Comparator

The frequency comparator in use for the comparison of frequencies between the quartz oscillator and the resonator, is of a recorder type with a precision of 1×10^{-10}. However, from the necessity of having a comparative precision of about 10^{-12}, a plan is under way to increase the resolving power.

Atomic Frequency Comparator

As the result of several years' work, an atomic frequency comparator of ammonium maser was already completed. Long-range measurements were made continuously after August 1959, and it was found to have a frequency accuracy of 2×10^{-10}.

Radio Forecasts and Forewarnings

The prediction of radio propagation conditions is most important to the assignment of frequencies, as is the radio forewarning of ionospheric disturbance to the operation of radio circuits.

Radio Forecasts

On the basis of the ionospheric data collected from home and abroad, radio forecasts are being issued two months in advance on behalf of the radiocommunication services having radio circuits national or international. They are published in the form of monthly pamphlets for distribution among those agencies concerned.

In addition, as a guide for everyone who wishes to predict the condition of radiocommunication at an optional time and place, "the world-wide distribution charts of $F2$ critical frequencies and 4,000 km MUF" obtained publication. These charts are composed of 256 maps showing the distribution of f_oF2 and 4,000 km MUF with sunspot numbers 10 and 100, in 8 seasons of the year (every 1.5 months), and for every three hours in UT throughout day and night.

Radio Forewarnings

Radio forewarnings aim at cautioning the operators of radio circuits against the occurrence of Dellinger effects, geomagnetic storms, or ionospheric disturbances anticipated within 12 hours. This service is carried on at Hiraiso Radio Wave Observatory, where all the necessary data are scrutinized several times a day to find the possibility and degree of disturbances to occur and the result is broadcast on the standard frequencies JJY. Advices of ionospheric storms are given by ursigram to the regions concerned, particularly to the Western Pacific Region. Besides the warnings mentioned above, the disturbance forecasts for the period of one week and of one month are prepared and distributed to all quarters concerned.

In addition to these services, continuous studies are carried on for improvement of the hitting rate of radio forecasts and forewarnings. And in consequence of these studies, remarkable progress has been made.

Broadcasting of URSIGRAMS

This service was resumed at the Radio Research Laboratories on December 25, 1951, on the request of the IXth Plenary Assembly of the International Scientific Radio Union. Its object is to report promptly radio disturbances and to rapidly interchange between the radio organizations concerned the data concerning various phenomena of the sun, terrestrial magnetism, cosmic ray, ionosphere, etc. The Radio Research Laboratories has taken the role of the Western Pacific Regional Center since 1955.

All the information concerned is exchanged by radio to and from the three other Regional Centers and is broadcast further on as scheduled in tables I and II.

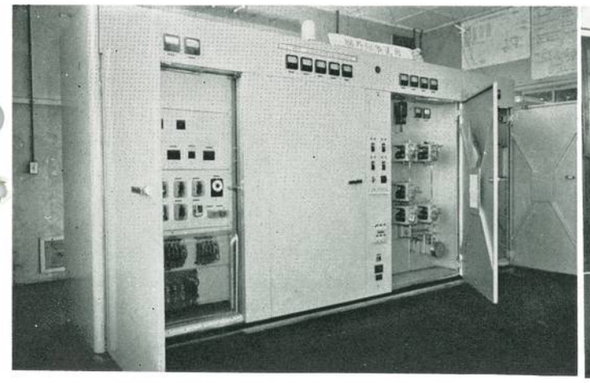


TABLE I BROADCAST OF WORLD-WIDE ALERT

(THIS ALERT IS ONE ORIGINATING IN THE WORLD WARNING CENTER IN U. S. A.)

CALL SIGN	TIME (UT)	FREQUENCY (kc/s)	DIRECTION	REMARKS
JJD	20.00	A1 12,000	N. W.	FOR EUROPE
	20.30	A1 12,000	S.	FOR AUSTRALIA
	21.00	A1 12.295	N. W.	FOR EUROPE
	21.30	A1 15.950	S.	FOR AUSTRALIA

TABLE II BROADCAST OF CURRENT DATA SUMMARIES

(DATA COLLECTED IN THE WESTERN PACIFIC REGION)

CALL SIGN	TIME (UT)	FREQUENCY (kc/s)	DIRECTION	REMARKS
JJD	04.30	A1 23,665	S.	FOR AUSTRALIA
	05.00	A1 18,785	N. W.	FOR EUROPE
	05.30	A1 18,180	S.	FOR AUSTRALIA
	08.00	A1 18,785	S.	FOR AUSTRALIA
	08.30	A1 18,180	N. W.	FOR EUROPE
	09.00	A1 12,295	S.	FOR AUSTRALIA
	10.00	A1 10,415	N. W.	FOR EUROPE
	12.00 15.00 17.00 19.00	8,000	OMNI- DIRECTIVE	

Service for and Research on Radio Apparatus and Devices

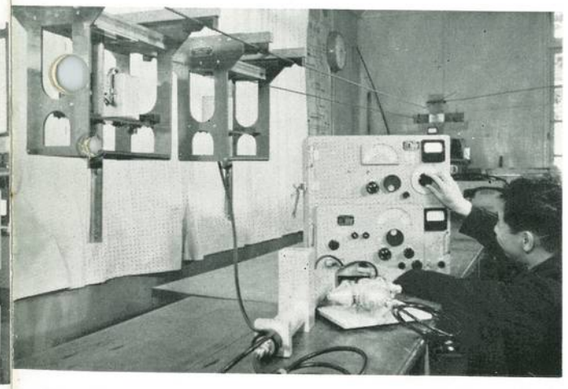
Governmental Type Approval, Calibration Service and Performance Test

This Laboratories carries on, as a government enterprise, the service of type approval of radio direction-finders and automatic alarm receivers for ship's use, radiocommunication apparatus for survival craft, radio transmitters and receivers for aircraft, radio frequency meters, and others.

In order that various radio measuring equipments used for radio regulatory purposes may keep the high accuracy required, this Laboratories has held the practical standards for high frequencies and endeavored to develop various devices for calibrating efficiently measuring meters up to these standards. Remarkable improvement has been made in the practical standards or calibration devices for radio frequency voltage, current, impedance, field strength, frequencies, power, etc.

Improvement of Radio Measuring Apparatus

Improvements in radio measuring apparatus for radio regulatory purposes and for radio research studies carried out at this Laboratories have largely contributed to the rise in level of radio measuring instruments used in Japan. At present, much effort is being given to the extention of frequency range of measuring apparatus and to the development of automatic method of measurement. Various automatic devices for measurement such as automatic reading machines of recorded curves have been brought to completion.



Publications and Periodicals

The publications and periodicals issued from the Radio Research Laboratories up to data are as follows:

Ionospheric Data in Japan	In English	Monthly
Propagation Forecasts	In Japanese	Monthly
Monthly Forecast and Actual Disturbance in Radiocommunication	In English	Monthly
Journal of the Radio Research Laboratories	In English	Bimontely
Review of the Radio Research Laboratories	In Japanese	Bimonthly
Atlas of Radio Wave Propagation Curves for Frequencies between 30 Mc/s and 10,000 Mc/s	In English	Jan. 1957
World Maps of $F2$ Critical Frequencies and Maximum Usable Frequencies for 4,000 km	In English	Aug. 1958

World Data Center C2 for the Ionosphere

In the IGY program, World Data Centers $C2$ in the fields of geomagnetism, ionosphere, cosmic rays and air glow were established in Japan. This Laboratories has been designated as the $C2$ Center for the ionosphere and is playing an active part in cooperation with the three other Centers of "A" (C. R. P. L. in U. S. A.), "B" (Nizmir in U. S. S. R.), and "C1" (R. R. S. in Britain).

From Australia, India, Japan, New Zealand and Pakistan are forwarded to this Center the observational data concerning vertical incidence, absorption, drift, atmospherics, whistlers, meteors, etc., observed at 40 stations. Copies of these reports are sent by this Center to the three other Centers. Also, the copies of observational data obtained at other Centers are being sent to this Center. Accordingly, the ionospheric observational data are gathering here from 464 stations all over the world.

Ionospheric Observations at Showa Base, Antarctica

In connection with the program of the International Geophysical Year (IGY) that began in July, 1957, the Radio Research Laboratories undertook the charge of observation of the ionosphere. The year before, in November, 1956, some members of the Laboratories set off for the antarctic by way of preliminary observations. The took observatoins at sea during the round voyage between Japan and Antarctica. Further, on voyages 3 and 4 they were also successful in obtaining data by observation on board.

On the other hand, since January, 1959, they have entered into the whole year's observations at the Showa Base of Japan and the ionospheric observations are in progress over two years with valuable data being amassed.

Structure of the Radio Research Laboratories

Director, Radio Research Laboratories	Vice-Directors	Planning Section	Kokubunji, Tokyo
		First Radio Wave Section (Ionospheric Propagation)	
		Second Radio Wave Section (Tropospheric Propagation)	
		Standard Frequency Section	Midori-cho Koganei, Tokyo
		Apparatus Section	Nakadori-cho Ogikubo, Tokyo
		Research Section of Radiophysics	Kokubunji, Tokyo
		Research Section of Ionosphere	
		Research Section of Tropospheric Propagation	
		Research Section of Millimetric Wave	
		Research Section of Communication System	
		Research Section of Crystal Oscillation	Midori-cho Koganei, Tokyo
		Research Section of Atomic Frequency Utilization	
		Research Section of Measuring Equipment	Kokubunji-Tokyo
	Chief, Administrative Division	General Affairs Section	Kokubunji-Tokyo
		Accounts Section	
		Wakkanai Radio Wave Observatory	Wakkanai-shi, Hokkaido
		Akita Radio Wave Observatory	Akita-shi
		Hiraiso Radio Wave Observatory	Nakaminato-shi, Ibaragi Prefecture
		Inubo Radio Wave Observatory	Choshi-shi, Chiba Prefecture
		Yamagawa Radio Wave Observatory	Yamagawa-machi Kagoshima Prefecture