ATMOSPHERIC NOISE MEASUREMENTS

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Data Summary Nº 1 — Station ARN-2 — Nº 10

by
L. G. MEIRA Fº
and
F. DE MENDONÇA

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REPORT Nº LAFE-13
May, 1964

The measurements reported herein were performed in cooperation with the Radio Noise Section, Troposphere and Space Telecommunications Division of N B S — Boulder Laboratories.

Comissão Nacional de Atividades Espaciais
São José dos Campos
São Paulo — Brasil

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A B S T R A C T

Under the designation of Project "OBRA", one of the 16 atmospheric noise receiving stations of the world-wide net work supervised by the NBS, has been in operation at this Laboratory since August 1963.

This report is intended to account for the work done under this project up to December 1963, including the transference of the whole station from its early site, repairing the equipment and collecting data.

Also, the initial sections of the report outline the general problem of radio noise measurements and describe the techniques and equipment used.

Data are presented as they were obtained, without any attempt to reach conclusions. This will possibly be done later.

I. INTRODUCTION

Under a very general viewpoint, noise could be regarded as any fluctuation of a DC value in space or time, or better, human independent variations. In communication systems by radio, controlled variations of some magnitudes (voltages, fields, etc.) are used to transmit information. It is obvious that aleatory variations, overlapping those controlled, will tend to mask them; in other words, noise destroys information.

In systems operating below about 30 Mc/s one of the chief factors determining the lower limit for the power required, besides absorption, is the noise introduced at the propagation medium itself, atmospheric noise in this case. It should be noted that if such a system were considered as consisting of three parts: transmitter, medium and receiver, the second element is the only one upon which man cannot exert any influence. Hence, transmitter and receiver must be designed as to minimize unwanted characteristics introduced by the propagation medium. It follows from the above considerations that we need a detailed knowledge of atmospheric noise among the first parameters in designing a communication system at low frequencies.

An important aspect of the problem is the fact that the noise influence upon communication systems is largely dependant upon the process used. Watt et al. (1958) studied the behavior of several systems operating under thermal and atmospheric noise interference. Three processes were considered:

CW (Morse Code)
FSK (Frequency Shift Keying)
Human Voice (AM)

Among the results, we selected the best and worst conditions found, respectively:

CW, for 10% errors admitted, and 12 words per minute speed it is enough to have a signal 11.5 db below noise (rms values, for a 1 Kc/s bandwidth).

FM multiplex, 36 voice channels, for 10% errors it is necessary a signal 49 db above noise.

In both cases, transmission was under atmospheric noise, the former with steady carrier and the second subjected to tropospheric fading.

II. ATMOSPHERIC RADIO NOISE MEASUREMENTS

One could, at a first glance, conclude from what was said above that the most readly usable noise data would be those giving the percentage of errors expected from given systems and conditions or, inversely, the signal level necessary to keep errors below a certain percentage.

In fact, measurements have been made this way. However, it would be impracticable to carry them out in a large scale (continuous measurements for several places and several systems). Besides, the large number of factors envolved would make comparison between different observer's data impossible.

Hence, noise parameters were looked for which had a more precise mathematical meaning and would therefore make comparisons easier. Thus a relation would be established between the parameters and the resulting interference for any desired system, as in the paper by Watt mentioned above.

Many approaches were attempted, holding different compromises between the precise meaning of parameters, their relationship to the interference, and the easiness of their measurement.

It is commonly accepted that interference on all common kinds of communication systems is determined by the noise amplitude characteristic; its determination has therefore deserved special interest from the investigators.

Many used methods make an integration of the noise envelope, with averaging periods of several minutes. Some of them are:

- average value of the noise envelope (1st moment).
- rms values of the noise envelope (2nd moment).
- ratio between 1st and 2nd moments; has as advantage an easier calibration.

Examples of other kinds of measurements are:

- "crossing rate" measurements; the number of times a given (variable) level is crossed in the upward direction is counted. Good results attained at VLF.
- "quasi-peak" detection; a capacitor is charged with a small time constant and discharges through a large one. The values of the time constants are chosen to follow some characteristics of the human ear.However, the results are of difficult interpretation.
- as a complement to "crossing rate" measurements it is useful to measure the time interval between peaks above a reference, or any other time function that will yield information about the pulse spacing distribution.

A good characterization of noise can be obtained through the amplitude probability distribution (APD) function of the voltage envelope.

This function can be determined directly by measuring the percentage of time a given level is exceeded and varying this level. Crichlow et. al. (1960) presented an indirect method in which the APD function is determined through three of its statistical moments. Section 4 of this report presents a brief description of the method.

III. ATMOSPHERIC NOISE VARIATIONS

Atmospheric radio noise variations are random in nature and must be treated statistically. However, some regularities are observed for long term variations, and among them we have:

- diurnal variations; in a general way noise levels are higher at night time, as the best propagation conditions are found at these hours. Noise levels are usually higher in the afternoon than at morning, as thunderstorms are more frequent after midday.
- yearly variations; thunderstorm centers shift from equator to tropics from summer to winter; although absorption is greater on summer, there is an increase in noise levels during this season.
- by intrinsic conditions to the physical processes of atmospheric noise generation by thunderstorms and wave propagation, noise levels decrease with frequency. At frequencies of about 10 Mc/s, however, cosmic or man-

-made noise can become the predominant one, depending on local meteorological conditions.

- a factor affecting largely the received noise level, as well as its characteristics, is the receiver bandwidth. When it is reduced, noise level is lowered and its amplitude probability distribution is altered, tending to that of thermal noise by flattening and overlapping of the peaks.

IV. DETERMINATION OF ATMOSPHERIC RADIO NOISE AMPLITUDE PROBABILITY DISTRIBUTION BY MEANS OF THREE PARAMETERS

Noise amplitude distribution function is usually represented on a graph where the ordinade corresponds to the signal level (relative to rms value) and the abcisse to the percentage of time during which the corresponding ordinade is exceeded.

Rayleigh paper is used; its scales are built so that thermal noise, obeying a Rayleigh distribution, will plot as a straight line of slope - 1/2.

When atmospheric noise is plotted this way, a curve similar to that of fig. 1 is obtained. Three regions can be distinguished in it:

1. low amplitude, high probability region; distribution is practically Rayleigh, as it is composed of many overlapping pulses like thermal noise.
2. approximately an arc of circunference.
3. high amplitude, low probability signals (separate pulses). Distribution plots almost linearly.

A curve of this kind can be perfectly characterized through 4 parameters. As for atmospheric noise an experimental relationship can be derived between two of them (Crichlow, et al. 1959), one need to measure only 3 of them to characterize perfectly the curve.

The parameters adopted by the National Bureau of Standards to be measured by the ARN-2 stations are the three which follow:

V_{rms} = root mean square value of noise envelope.

L_d = ratio between the rms value and the logarithmic average of noise voltage.

V_d = ratio between the rms value and the average of noise voltage.

Let e be equal to $1/\sqrt{2}$ times the instantaneous envelope voltage and p(e) the probability of e being exceeded. Then

$$V_{rms} = \sqrt{\int_0^1 e^2 \, dp}$$

$$V_{ave} = \int_0^1 e \, dp$$

$$V_{log} = \text{antilog} \int_0^1 \log e \, dp$$

$$V_d = 20 \log V_{rms}/V_{ave}$$

$$L_d = 20 \log V_{rms}/V_{log}$$

as defined by Crichlow et al. (1959).

Together, these three parameters give us the rms value of noise and the amplitude probability distribution APD of the difference between the instantaneous and the rms value.

APD curves for values of L_d and V_d commonly found in atmospheric noise were presented in a NBS Monograph (1960). The validity of such curves has been checked by comparison with others obtained directly.

V. THE ATMOSPHERIC RADIO NOISE STATION ARN-2

The National Bureau of Standards developed the equipment for continuous measurement of radio noise during IGY. It was called ARN-2 station and 16 of them were installed in a world-wide net.

The station operates on 8 channels of fixed frequency, two of which are recorded each time during 15 minutes. At the end of this period the two next channels are connected so that one sample for each frequency is obtained at the end of every hour. Fig. 2 shows the block diagram for a single channel. Automatic switching units were omitted for the sake of clarity.

The sampling interval is 15 minutes and the value thus obtained is taken as representative of the noise level through the whole hour. The log and linear deviation recorders operate on a single frequency. They are connected to four of the channels during one week and to the remaining four during the next one, so that all the eight channels are scanned.

In synthesis, the system is a receiver of unusual stability and selectivity, bandwidth of about 200 cps. The parabolic amplifier after the IF section allows the detected signal to be proportional to the square of the envelope voltage, the rms value being hence obtained by integration. The signal at the integrator output is kept at a constant level by means of a feedback loop in which the deviations of the integrated signal from reference will cause the attenuator at the IF input to move in such a way that the deviations are compensated. A chart strip recorder working as a servo of the attenuator registers the rms value of the noise envelope.

Part of the IF signal is picked up at the second IF amplifier output and after amplified and detected, is fed into linear and logarithmic amplifiers preceded by integrators. By means of suitable calibration with respect to the integrator reference level, the recorders at the output of the above amplifiers record directly L_d and V_d in db below V_{rms}.

Special programming units are included which provide more reliability on the results. For the power recorders, a programmer of the attenuator, after a frequency change in which the attenuator is reset to zero, allows it to move upwards, thus approaching the noise level from below. After three minutes, time enough for this value to be reached, the programmer moves the attenuator an aditional 6 or 8 db and doesn't permit any further movement in this direction. At this time the integrated output is below reference and the attenuator will move downwards, approaching noise level from above. This kind of operation avoids partially false results decurrent from sudden interferences, as noise is considered to be the lowest signal existing.

Each recorded frequency is identified by means of two auxiliary pens at the edge of the chart.

For the log and linear deviation recorders, a timer prevents them to operate unless 4 minutes have elapsed since the last attenuator step. As this interval is greater than the time necessary for the integrator to move the attenuator one step (2 db) if the signal is 1 db from reference, it becomes practically assured that the recorded deviation is in fact with respect to the rms value within a precision better than 1 db.

An alignement oscilator together with a small transmitting antenna and a temperature-limited diode operating as noise generator allow the rms (power) measurements to be referenced to an absolute level.

Summaryzing what was said above, the results of ARN-2 measurements are presented using the symbols:

F_a = effective noise figure: external noise avaliable from an equivalent short, lossless vertical, antenna in db above kTB; this can be converted to

E_n = equivalent vertically polarized ground wave rms noise field strength in db above 1 μV/m for a 1 Kc/s bandwidth.

$E_n = F_a + 20 \log_{10} f(Mc/s) - 65.5$

T taken as 288 ^{o}K.

L_d = db value of the ratio between the rms value and the logarithmic average of the noise envelope.

V_d = db value of the ratio between the rms value and the average of the noise envelope.

Some of the stations have also equipment for directional measurements, consisting of a National NC-183-D receiver and a horizontal Yagi in a rotary assembly.

VI. THE ARN-2 STATION Nº 10

It was seen at the preceding sections how the need for atmospheric radio noise measurements appeared, some of the adopted techniques and how a world network was stablished in 1957 supervised by the NBS.

São José dos Campos, Brazil, was chosen for installation of one of these stations: the ARN-2 Nº 10, its operation being carried out by the ITA.

However, several problems related to personnel, maintenance difficulties, roof insulation leakages, and others, prevented the station from operating within the schedule; data acquisition suffered many interruptions.

Data were last recorded intermittently only until April 1962, for the initial phase on operations.

An agreement was made by the beginning of 1963 between ITA's Electronic Enginnering Division and CNAE, the second being in charge of the operation from 1963 on. It was decided that better assistence could be given to the equipment if it were re-installed within CNAE's laboratories.

This was done starting March 1963. It follows a brief outline of the tasks performed.

Building - a larger one was built as to make equipment maintenance easier. Special attention was given to the roof insulation to avoid the frequent leakage occurring at the older installations. See figures 9, and 10.

Antenna - the antenna system was completely dismounted and its parts submitted to cleaning and preservation processes. The ground plane posts were changed from wood to steel. At the ground plane center a copper screen was used instead of metal sheet.

Racks - all the units were removed from the racks and individually checked; the racks themselves and the front panels were re-painted. Many of the defective units (which were held over in São José dos Campos by previous operators) were used as a supply of components. The station was put into operation and developed many defects which were removed. Finally we started continuous operation on July 1963 and it has been working properly since then. As a result, the set ARN-2 has been re-integrate on the world wide system, and the data so far obtained has been of good quality. Figure 11 shows noise receiving station.

VII. RADIO NOISE DATA FROM ARN-2 STATION Nº 10, FOR THE PERIOD AUG. 63 - DEC. 63

Place: São José dos Campos - Brazil - 23.3°S - 45.8°W.
Local time: (GMT - 3 h).
Receiver: ARN-2 (NBS) with a vertical, omnidirectional antenna, with a horizontal plane of 30 meters radius.

Data is found in tables 1 to 5. The symbols used mean:

F_{am} = median value of daily F_a during a month for a given hour.

D_u and D_l = upper and lower deciles of the monthly distribution for a given hour.

L_{dm} = median value of daily L_d during the month.

V_{dm} = the same for V_d.

An asterisk above any median value indicates it was evaluate from less than 15 observations for F_{am} or less than 7 for L_{dm} or V_{dm}.

Although special care is taken to avoid interference in the measurements, it is possible that some times the received signal is contamined with other than atmospheric noise. In this case the value of L_d will decrease and this fact is used to mark probably contaminated data. In a study from several uncontaminated noise samples (NBS Technical Notes series 18) it was evaluated the most probable and the minimum value of L_d corresponding to each V_d that will result on an APD curve of the form expected in atmospheric noise. It is also suggested that whenever the value of L_d found is below the minimum for that V_d, the most probable value of L_d should be used instead of the one actually measured. This suggestion was followed throughout the data presented in this report. A small circle above the L_d value indicates a quantity which is not the actually measured value.

Figs. 3 to 7 present the power data in graphical form.

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MONTH-HOUR VALUES OF RADIO NOISE

Station S. José, Brasil Lat. 23.3°S Long. 45.8°W Month Aug. 1963

Frequency (Mc)

Hour (LST)	.051 Fam	Du	Dℓ	Vdm*	Ldm*	.113 Fam	Du	Dℓ	Vdm*	Ldm*	.246 Fam	Du	Dℓ	Vdm	Ldm	.545 Fam	Du	Dℓ	Vdm*	Ldm*
00	121	13	13	7.0	12.5	115	10	12	3.5	7.5	102	12	12	4.0	9.5	88	6	12	5.0	9.5
01	120	14	10	7.0	12.5	113	14	10	5.5	10.0	100	14	10	5.5	10.0	87	7	13	5.5	10.0
02	122	14	10	8.5	15.0	115	12	12	4.5	9.0	102	12	12	4.0	8.0	88	6	14	4.0	8.0
03	124	12	15	8.0	13.0	115	13	13	5.0	8.5	102	12	16	4.0	8.5	87	9	16	3.5	7.5
04	126	10	14	8.5	15.0	117	10	15	5.5	10.0	99	15	14	4.0	9.0	88	7	16	4.0	7.5
05	124	12	12	8.0	13.0	112	16	14	5.0	9.0	96	15	13	5.5	11.5	90	4	14	2.0	4.0
06	122	10	14	9.0	16.0	109	9	19	5.0	9.0	82	13	13			77	12	6		
07	113	13	12	7.0	12.0	99	10	16	4.0	7.5	82	10	13	4.5	8.0	86	10	6	2.5	5.0
08	111	12	11	1.0	2.5	101	9	16	1.5	3.0	82	10	11	4.5	8.5	87	12	8		
09	116	6	16	2.5	5.0	103	10	18			84	10	8	5.0	9.0	90	9	7	3.0	6.0
10	110	12	11	3.0	6.0	101	9	15	3.5	6.5	82	7	10	7.0	12.5	91	10	8	4.0	7.5
11	109	13	13	1.0	2.5	97	13	15	4.5	8.5	83	7	10	4.5	8.5	89	9	8		
12	116	8	20	5.0	9.0	99	10	10	5.0	9.0	79	9	5	4.0	7.5	90	6	8	3.0	6.0
13	115	9	18			99	9	9			79	10	7			88	9	5	2.0	4.0
14	116	7	12	1.0	3.0	101	7	7	2.0	4.0	82	6	8	7.0	12.5	90	9	8	3.0	6.0
15	116	7	17	5.5	10.0	101	11	9	6.5	11.5	79	8	5	4.0	7.5	88	8	6	1.5	3.0
16	112	9	12			98	16	11	6.5	11.5	79	12	6	6.0	11.0	88	8	8	1.0	2.5
17	116	10	12			99	16	6	5.5	10.0	79	15	5	12.5	22.0	88*			1.0	3.0
18	119	10	14			107	11	12	5.5	10.0	89	12	11	6.5	11.5	86	8	20		
19	118	12	14	6.0	11.0	107	10	12	6.5	11.5	92	12	8	4.0	9.0	84	10	10		
20	118	12	10	6.0	11.0	107	12	8	4.0	7.5	98	9	11	4.0	9.0	88	6	11	2.0	5.0
21	117	14	8	5.5	10.0	109	9	7			98	10	8	6.0	11.0	90	6	14	3.0	6.0
22	124	9	16	4.5	8.5	114	9	13	6.5	11.5	100	10	10	5.0	9.5	90	6	12	2.0	4.0
23	124	10	14	5.5	10.0	115	10	14	5.0	9.0	100	12	14	7.0	12.5	90	6	10		

Hour (LST)	2.5 Fam	Du	Dℓ	Vdm*	Ldm*	5.0 Fam	Du	Dℓ	Vdm*	Ldm*	10.0 Fam	Du	Dℓ	Vdm*	Ldm*	20.0 Fam	Du	Dℓ	Vdm*	Ldm*
00	63	6	14	4.0	8.0	61	12	12	5.0	8.5	45	7	10	1.0	4.0	28	9	5	6.5	11.5
01	65	6	16	4.5	8.5	57	6	10	3.5	6.5	45	5	13	1.5	4.0	25	12	2	0.5	2.5
02	65	6	16	4.5	8.5	56	7	13	4.0	7.5	45	8	15	3.0	6.0	25	12	2	1.0	2.5
03	65	4	14	5.5	10.0	55	7	12	5.0	9.0	45	8	10	2.0	5.0	24	13	3	1.0	2.5
04	65	4	12	3.0	7.5	55	8	14	5.0	9.0	41	7	15	3.5	7.0	23	12	2	1.0	2.5
05	63	7	10	3.0	8.0	55	8	16	3.0	6.5	39	6	10			23	12	2	1.0	3.0
06	63	10	8	3.5	7.0	59	10	14	4.5	8.5	42	5	14	5.0	9.0	23	13	2		
07	47	10	13			57	12	10	5.5	10.0	41	9	7	5.5	10.5	25	10	2		
08	41	9	8	4.5	8.5	51	11	8	7.5	13.5	39	14	8	4.5	9.5	28*			2.5	5.0
09	41	9	12	3.5	6.5	47	11	8	4.0	8.0	45	4	20	7.0	12.5	21	12	4	6.5	11.5
10	35	9	10	6.5	12.0	43	11	8	2.0	4.0	41	6	12			27	12	6	6.5	11.5
11	34	8	6			39	10	7	3.5	6.5	43	7	11	7.5	12.5	27	16	4	7.0	12.5
12	33	8	8	6.0	11.0	39	8	6	3.5	6.5	43	4	8	7.0	12.0	29	16	6	9.0	16.0
13	33	11	7	5.5	10.0	39	12	9	2.5	6.0	43	4	12			33	8	9		
14	37	15	11	5.5	10.0	41	8	8			44	4	9	5.0	9.0	35	11	10	4.0	7.5
15	39	4	11	3.5	6.5	43	11	7	6.5	11.5	43*			7.0	11.5	33	10	8	3.5	7.0
16	41	7	14	3.5	7.5	49	6	8	6.0	11.0	47	5	10	6.0	10.0	31	9	5	4.0	7.5
17	47	8	7	3.5	6.5	53	12	2	5.0	9.0	47	20	6	5.5	10.0	21*			2.0	4.0
18	57*			5.0	11.0	57	14	5	4.5	8.5	49	20	6	3.0	7.0	29	11	4	2.0	4.0
19	60	7	6	3.5	7.5	56	9	6	4.5	8.0	47	8	6	4.0	8.0	27	14	2	1.0	3.0
20	61	7	16	5.0	8.5	60	10	9	5.0	9.0	45	4	5	5.5	10.0	35	7	10	3.0	6.0
21	61	8	12	3.5	8.0	59	8	8	4.5	8.5	45	4	6	8.0	14.5	35	7	11	5.5	9.0
22	63	8	10	3.5	8.0	62	11	11	2.5	7.0	47	6	8	8.0	11.0	37	9	7	5.5	9.0
23	63	8	11	5.5	10.0	61	10	8	4.0	7.5	44	8	5	5.0	9.0	35	8	11	3.5	6.5

TABLE 1

F_{am} = median value of effective antenna noise in db above ktb
D_u = ratio of upper decile to median in db
D_ℓ = ratio of median to lower decile in db
V_{dm} = median deviation of average voltage in db below mean power
L_{dm} = median deviation of average logarithm in db below mean power

USCOMM-NBS-DC

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MONTH-HOUR VALUES OF RADIO NOISE

Station S. José, Brasil Lat. 23.3ºS Long. 45.8ºW Month Sept. 1963

Frequency (Mc)

Hour (LST)	.051					.113					.246					.545				
	F_{am}	D_u	D_ℓ	V_{dm}	L_{dm}	F_{am}	D_u	D_ℓ	V_{dm}	L_{dm}	F_{am}	D_u	D_ℓ	V_{dm}	L_{dm}	F_{am}	D_u	D_ℓ	V_{dm}	L_{dm}
00	129	7	13			120	6	14			106	10	15			90	8	14		
01	127	8	8			122	7	9			109	7	23			92	5	23		
02	127	9	13			122	6	17			107	9	16			89	9	14		
03	128	10	9			122	6	15			109	8	26			93	6	32		
04	128	8	8			124	3	12			106	10	15			90	8	13		
05	122	15	7			123	7	13			106	7	29			90	6	26		
06	120	12	10			106	14	14			83	20	10			81	10	12		
07	120	11	14			106	12	7			84	16	9			82	8	16		
08	118	11	13			104	12	7			83	18	16			84	7	12		
09	114	16	14			104*					83*					87	4	14		
10	115*					101	15	11			82	7	9			90	4	8		
11	113*					102*					80*					82	10	9		
12	113	14	11			100	14	10			79	14	8			87	7	13		
13	115	8	27			103*					80	16	15			83*				
14	116	10	24			102	14	10			86	8	21			89	5	21		
15	113	12	31			102*					84*					90*				
16	118*					104	8	12			79	15	2			91	4	11		
17	116	16	9			110	14	16			88*					88	6	13		
18	118	15	14			112	14	18			91	19	14			87	9	16		
19	122	15	12			116	13	9			99	12	13			89	9	21		
20	123	16	10			116	16	10			99	17	14			83	16	6		
21	126	12	14			118	8	4			107	9	32			95*				
22	129	9	16			118	9	10			105	11	13			90	9	8		
23	126	10	2			122	9	10			107	10	23			92	8	8		

Hour (LST)	2.5					5.0					10.0					20.0				
	F_{am}	D_u	D_ℓ	V_{dm}	L_{dm}	F_{am}	D_u	D_ℓ	V_{dm}	L_{dm}	F_{am}	D_u	D_ℓ	V_{dm}	L_{dm}	F_{am}	D_u	D_ℓ	V_{dm}	L_{dm}
00	69	6	7			66	6	13			52	20	13			27	28	4		
01	69	6	13			58	10	15			49	21	11			28	12	7		
02	71	4	6			60	8	13			49	17	11			25	15	3		
03	69	6	19			54	14	7			46	17	12			24	18	3		
04	71	4	10			60	4	11			43	22	12			24	20	3		
05	67	6	15			55	13	12			44	18	11			24	11	3		
06	61	11	8			64	3	22			47	7	11			25	5	3		
07	53	10	13			55	4	18			46	9	15			26	16	5		
08	45*					46	10	19			48	3	16			26	16	9		
09	41	10	12			44	6	19			46	3	18			24	8	3		
10	34*					43*					44*					27*				
11	33	24	7			37	8	13			39	7	9			26	21	5		
12	32	22	7			39*					40	9	9			28*				
13	33	18	5			36	8	9			39	10	9			28	18	4		
14	37*					43*					43*					31*				
15	35*					43	8	20			43	7	9			30	18	4		
16	35*					50*					45*					33*				
17	43*					60	12	23			48	12	7			32	21	6		
18	60	11	8			60	11	18			54	12	11			32	20	8		
19	65	12	13			55	19	13			54	10	8			36	23	6		
20	67	12	9			63*					55	12	7			37	16	9		
21	69	8	17			59	13	10			52	10	14			34*				
22	70*					65	7	18			55	10	14			35	18	9		
23	70	8	16			65	7	16			50	10	7			32	16	8		

F_{am} = median value of effective antenna noise in db above ktb
D_u = ratio of upper decile to median in db
D_ℓ = ratio of median to lower decile in db
V_{dm} = median deviation of average voltage in db below mean power
L_{dm} = median deviation of average logarithm in db below mean power

TABLE 2

MONTH-HOUR VALUES OF RADIO NOISE

Station São José, Brasil Lat. 23.3°S Long. 45.8°W Month October 19 63

Frequency (Mc)

Hour (LST)	.051 F_{am}	.051 D_u	.051 D_l	.051 V_{dm}	.051 L_{dm}	.113 F_{am}	.113 D_u	.113 D_l	.113 V_{dm}	.113 L_{dm}	.246 F_{am}	.246 D_u	.246 D_l	.246 V_{dm}	.246 L_{dm}	.545 F_{am}	.545 D_u	.545 D_l	.545 V_{dm}	.545 L_{dm}
00	136	8	5			126	9	9			110	9	11			97	5	7		
01	137	7	9			127	8	11			109	8	5			94	10	7		
02	136	9	10			127	8	11			108	11	6			96	8	10		
03	138	7	12			126	10	11			109	10	8			98	6	12		
04	138	7	12			126	10	13			109	9	13			98	4	15		
05	136	6	13			118	10	19			92	17	19			85	10	16		
06	130	9	16			111	14	22			86	7	11			83	9	10		
07	130	8	17			114	11	16			91	15	16			84	9	11		
08	124	13	11			110	11	13			89	11	15			77*				
09	122*					110*					88*					82	16	10		
10	124	11	15			110	13	15			89	26	14			86	10	13		
11	128	12	15			110	10	12			91	9	18			88	9	9		
12	126	13	11			108	31	17			93	10	15			88	14	8		
13	132	8	13			113	14	10			95	19	17			89	14	12		
14	130	14	12			118	17	9			98	20	22			89	14	17		
15	134	18	10			118	23	10			103	26	15			93	20	14		
16	133	13	5			120	24	11			103	17	17			90	18	14		
17	138	13	11			124	13	15			100	23	15			89	20	8		
18	136	15	10			120	31	9			103	22	8			93	20	6		
19	135	16	10			122	17	7			107	15	10			98	10	10		
20	138	14	8			126	7	9			109	8	8			98	7	14		
21	136	10	7			126	7	11			109	9	10			98	6	11		
22	138	7	7			128	8	14			113	8	9			98	8	9		
23	136	8	4			126	10	11			111	7	5			99	6	9		

Hour (LST)	2.5 F_{am}	2.5 D_u	2.5 D_l	2.5 V_{dm}	2.5 L_{dm}	5.0 F_{am}	5.0 D_u	5.0 D_l	5.0 V_{dm}	5.0 L_{dm}	10.0 F_{am}	10.0 D_u	10.0 D_l	10.0 V_{dm}	10.0 L_{dm}	20.0 F_{am}	20.0 D_u	20.0 D_l	20.0 V_{dm}	20.0 L_{dm}
00	65	12	14			72	10	7			46	13	11			29	8	3		
01	65	15	17			66	11	12			43	7	12			29	6	7		
02	64	13	11			66	10	14			45	12	14			29	12	7		
03	67	10	14			68	10	11			45	16	15			27	8	6		
04	65	10	13			68	9	13			43	12	14			28	4	7		
05	65	10	13			70	9	17			41	14	12			27	8	5		
06	55	10	19			66	8	18			41	14	14			27	8	5		
07	47	9	15			58	7	11			47	7	15			27	6	6		
08	34	21	9			52	10	5			37	12	17			29*				
09	29*					42*					31*					29*				
10	27*					45*					34	14	15			26*				
11	33	18	8			37	17	8			35	10	15			27*				
12	33	26	6			42	12	9			39	8	16			29*				
13	37	25	12			41	20	8			34	10	8			33*				
14	49	20	18			48	14	9			37	11	7			35*				
15	53	19	25			52	17	9			39	18	7			37*				
16	61	14	19			62	13	14			42	17	7			37	10	8		
17	57	24	14			69	9	10			43	18	5			40*				
18	65	19	11			73	6	7			48	16	7			41	16	12		
19	71	15	13			73	9	7			50	11	9			45	19	16		
20	71	14	13			73	9	5			50	9	7			43*				
21	71	8	10			72	8	11			45	16	7			36	9	6		
22	69	9	14			69	30	5			46	13	9			33	5	6		
23	65	11	15			70	10	8			43	17	7			31	10	9		

TABLE 3

F_{am} = median value of effective antenna noise in db above ktb
D_u = ratio of upper decile to median in db
D_l = ratio of median to lower decile in db
V_{dm} = median deviation of average voltage in db below mean power
L_{dm} = median deviation of average logarithm in db below mean power

RN-13

MONTH-HOUR VALUES OF RADIO NOISE

Station São José, Brasil Lat. 23.3°S Long. 45.8°W Month November 19 63

Frequency (Mc)

Hour (LST)	.051 Fam	Du	Dℓ	Vdm	Ldm	.113 Fam	Du	Dℓ	Vdm	Ldm	.246 Fam	Du	Dℓ	Vdm	Ldm	.545 Fam	Du	Dℓ	Vdm	Ldm
00	139	7	6			119	11	11			99	13	11			92	12	9		
01	140	5	9			119	11	17			100	9	14			94	13	18		
02	138	6	12			117	11	24			101	9	13			93	9	17		
03	138	5	10			119	10	18			98	10	13			93	11	20		
04	138	5	12			117	9	22			95	13	11			86	14	13		
05	132	5	11			103	8	20			85*					80	10	13		
06	130	7	13			103	14	11			81	8	14			83	10	6		
07	128	8	16			105*					81*					84	11	8		
08	124	10	16			101	15	15			79	8	14			82	8	6		
09	124	14	17			98*					75*					88	10	4		
10	126	9	15			98	15	12			75	12	12			86	7	9		
11	128	10	17			97	21	10			78	29	13			94	22	16		
12	131	18	14			105	20	16			81	35	14			88	20	24		
13	136	17	10			115	20	24			102	13	27			96	13	27		
14	138	15	9			116	21	16			99	18	20			94	16	20		
15	140	18	14			119	16	20			102	14	22			92	19	8		
16	143	9	26			124	6	19			102	17	17			96	16	20		
17	141	11	10			118	11	11			96	21	13			91	17	12		
18	142	7	12			119	12	13			99	20	15			94	19	15		
19	140	11	12			119	16	15			103	24	13			98	16	27		
20	142	8	12			125	5	37			99	10	11			92	12	19		
21	140	8	8			120	12	8			105	7	13			96	8	16		
22	140	7	7			119	12	7			101	10	9			94	10	18		
23	139	9	7			118	15	15			101	11	9			94	10	12		

Hour (LST)	2.5 Fam	Du	Dℓ	Vdm	Ldm	5.0 Fam	Du	Dℓ	Vdm	Ldm	10.0 Fam	Du	Dℓ	Vdm	Ldm	20.0 Fam	Du	Dℓ	Vdm	Ldm
00	74	8	7			63	16	8			37	14	13			28	4	4		
01	73	13	7			55	20	7			38	10	13			28	11	5		
02	74	9	11			55	17	10			38	10	14			26	9	4		
03	72	14	9			55	18	9			38	16	12			24	6	2		
04	68	14	6			55	18	10			35	14	11			24	7	1		
05	68	11	13			57	18	13			35	14	14			27	5	4		
06	60	10	16			51	17	12			31	18	9			28	5	3		
07	50	10	12			49	13	14			27	14	9			27	3	2		
08	40	20	5			35	13	6			27	14	8			25	4	2		
09	38	12	6			35	10	9			28	8	9			25	2	3		
10	38	10	6			29	18	6			29	10	9			26	7	3		
11	40	10	6			31	4	7			27	11	6			26	6	3		
12	44	33	10			33	21	6			28	25	6			28	14	5		
13	46	42	12			51	6	24			30	20	12			31	13	5		
14	66	20	30			49	18	21			33	21	15			35	10	6		
15	67	23	29			49	16	12			38	20	20			35	9	6		
16	70	18	20			54	18	13			39	15	15			36	11	9		
17	68	16	8			56	13	7			43	14	19			36	14	9		
18	72	14	12			59	14	6			44	12	24			38	15	12		
19	76	12	8			60	17	7			43	10	20			39	22	13		
20	77	9	7			61	20	4			43	9	21			39	10	15		
21	76	8	6			59	17	4			41	10	21			38	4	10		
22	74	8	4			58	15	7			39	11	19			29	7	6		
23	73	8	6			59	22	4			39	10	16			27	5	5		

F_{am} = median value of effective antenna noise in db above ktb
D_u = ratio of upper decile to median in db
D_ℓ = ratio of median to lower decile in db
V_{dm} = median deviation of average voltage in db below mean power
L_{dm} = median deviation of average logarithm in db below mean power

TABLE 4

USCOMM-NBS-BL

RN-13

MONTH-HOUR VALUES OF RADIO NOISE

Station São José, Brasil Lat. 23.3ºS Long. 45.8ºW Month December 19 63

Frequency (Mc)

Hour (LST)	.051 Fam	Du	Dℓ	Vdm	Ldm	.113 Fam	Du	Dℓ	Vdm	Ldm	.246 Fam	Du	Dℓ	Vdm	Ldm	.545 Fam	Du	Dℓ	Vdm	Ldm
00	134	7	8			110	14	8			103	14	10			87	17	7		
01	133	9	9			108	15	8			102	14	11			88	15	9		
02	132	9	10			106	14	7			101	13	11			87	16	10		
03	132	8	20			106	14	10			101	12	12			84	15	6		
04	132	8	26			110	14	16			97	12	8			81	14	6		
05	127	9	29			93	13	5.			81	13	8			75	8	5		
06	121	13	5			93	10	11			85	16	16			85	7	11		
07	116	15	7			92	12	8			79	18	6			83	8	10		
08	119	11	8			92	10	5			81	8	8			85	8	8		
09	120	9	15			94	10	10			79	8	2			85	4	12		
10	119	9	13			94	7	12			83	8	8			85	5	8		
11	122	9	16			94	14	5			83	15	9			87	6	14		
12	128	13	12			100	22	10			91	31	12			87	23	14		
13	131	24	17			105	30	19			103	26	22			91	28	12		
14	133	10	16			112	27	23			106	23	23			87	24	6		
15	136	17	17			113	20	22			109	22	28			89	25	8		
16	144	11	22			113	23	22			108	23	27			91	27	13		
17	136	16	20			118	14	26			111	14	34			89	22	10		
18	135	12	18			118	12	26			112	9	25			91	13	13		
19	136	10	14			114	11	17			106	12	15			89	14	6		
20	135	8	4			114	10	12			103	14	12			91	13	8		
21	136	7	14			114	11	10			105	14	10			91	12	8		
22	135	8	12			111	14	7			105	13	10			91	12	8		
23	134	8	6			114	10	12			105	14	12			89	17	6		

Hour (LST)	2.5 Fam	Du	Dℓ	Vdm	Ldm	5.0 Fam	Du	Dℓ	Vdm	Ldm	10.0 Fam	Du	Dℓ	Vdm	Ldm	20.0 Fam	Du	Dℓ	Vdm	Ldm
00	71	10	8			55	10	18			43	9	17			24	22	2		
01	71	6	9			57	6	20			41	12	6			24	23	2		
02	71	8	10			55	7	16			39	10	7			24	15	2		
03	71	7	10			53	8	15			39	8	9			24	16	2		
04	69	8	10			53	10	16			39	11	8			24	8	2		
05	65	8	14			50	17	13			37	8	4			24	21	2		
06	55	10	8			46	19	9			35	11	6			24	18	2		
07	47	11	9			42	14	6			32	9	5			24	4	2		
08	39	13	14			43	13	8			32	9	7			24	4	2		
09	39	8	4			39	8	5			31	8	8			24	4	2		
10	38	7	5			38	7	7			27	10	6			24	2	2		
11	39	4	6			37	4	6			29	10	4			24	6	4		
12	41	25	6			37	20	5			35	14	10			24	13	2		
13	53	21	16			43	18	8			39	22	11			28	15	6		
14	59	28	22			45	20	14			41	13	12			29	17	5		
15	59	24	22			51	16	16			46	13	14			32	17	8		
16	59	28	23			53	15	17			45	12	11			34	14	8		
17	61	20	17			59	5	19			39	7	8			32	18	4		
18	66	13	10			60	10	16			47	12	6			34	19	9		
19	73	9	11			63	9	16			47	14	6			28	27	4		
20	74	7	14			63	11	16			47	13	7			28	28	6		
21	72	9	11			61	8	20			45	12	4			28	21	6		
22	73	6	12			61	10	20			45	10	4			26	28	4		
23	73	6	12			61	11	24			44	10	3			24	26	2		

F_{am} = median value of effective antenna noise in db above ktb
D_u = ratio of upper decile to median in db
D_ℓ = ratio of median to lower decile in db
V_{dm} = median deviation of average voltage in db below mean power
L_{dm} = median deviation of average logarithm in db below mean power

TABLE 5

USCOMM-NBS-BL

RN-13

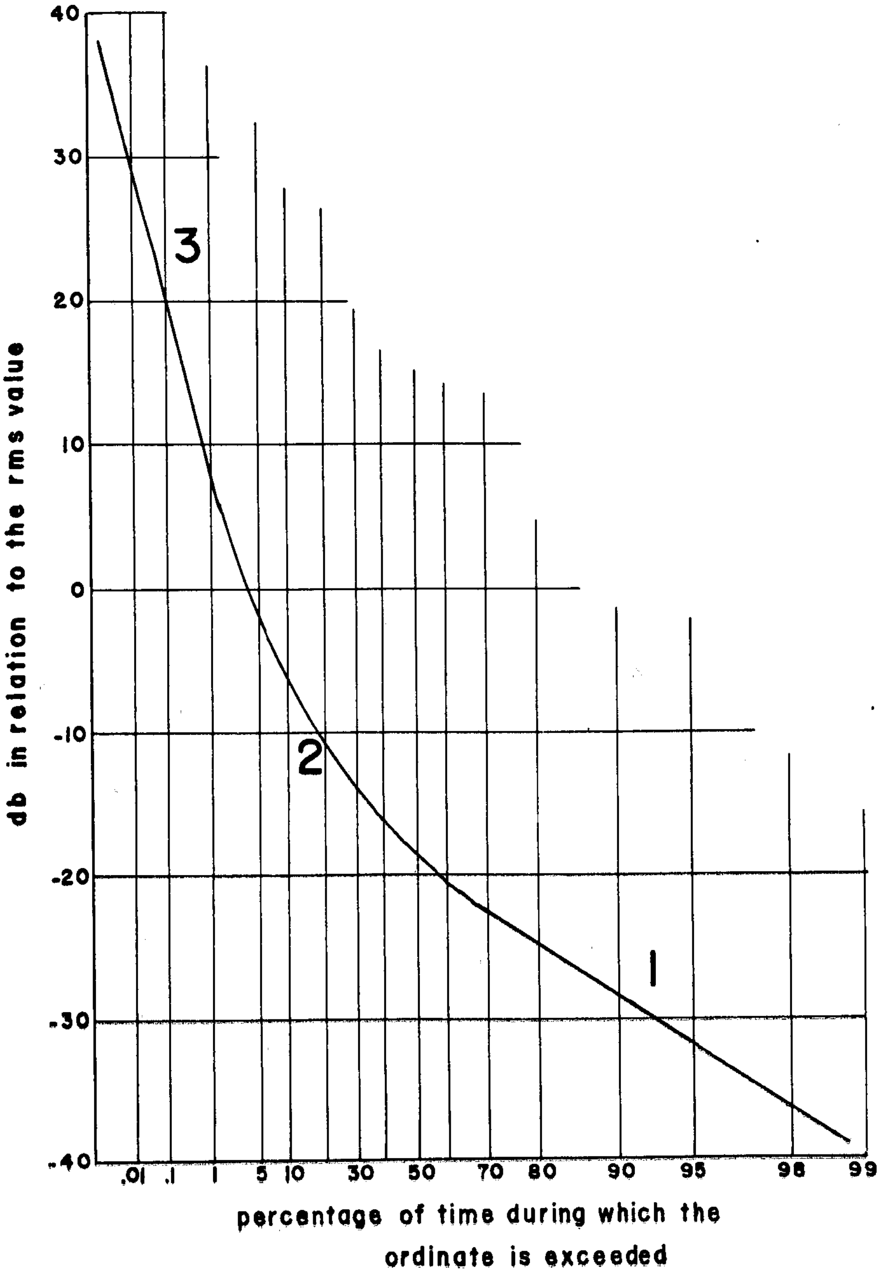


Fig. 1- Amplitude Probability Distribution Curve for Atmospheric Noise

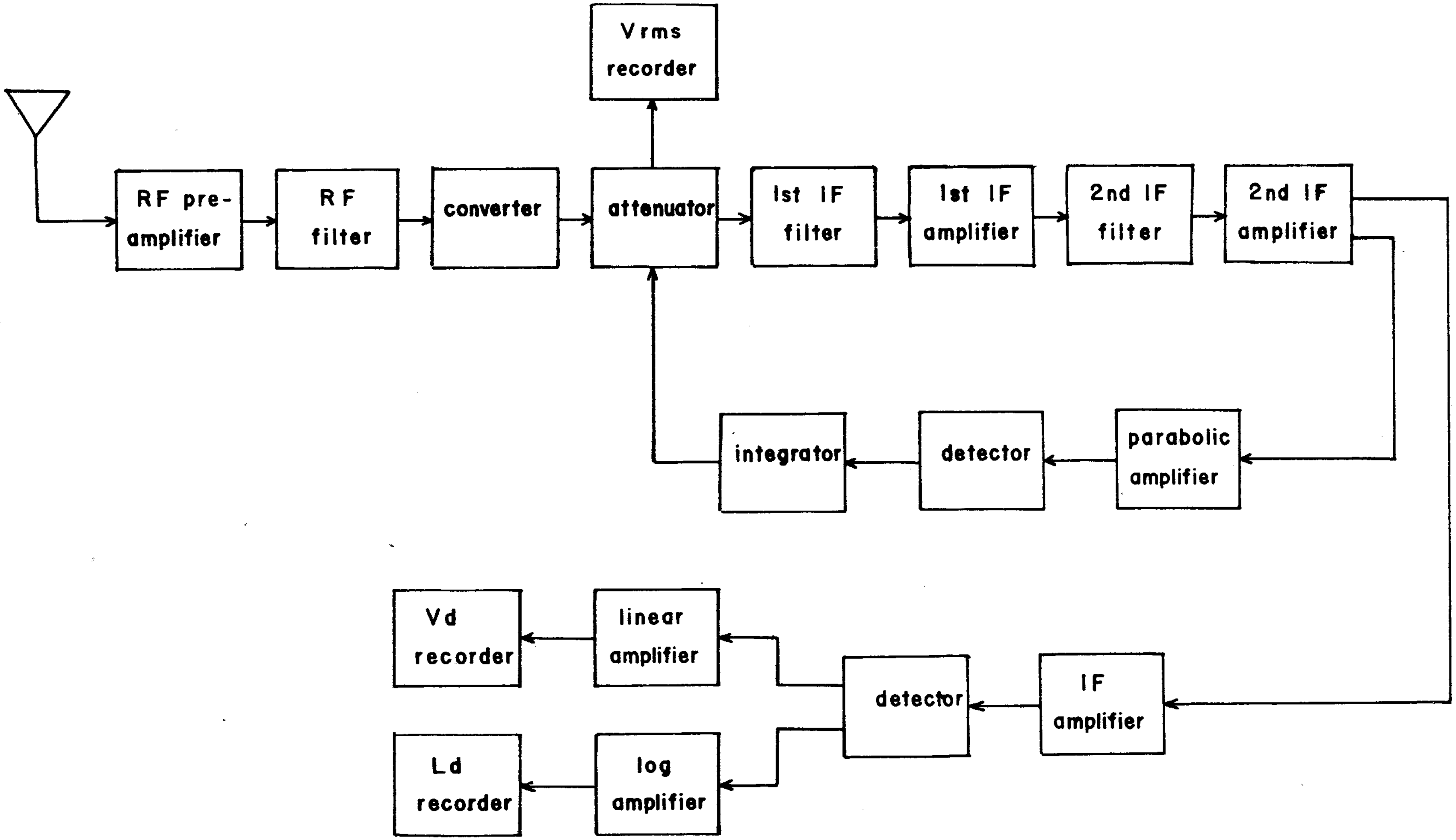


Fig. 2- ARN-2 block diagram for one channel

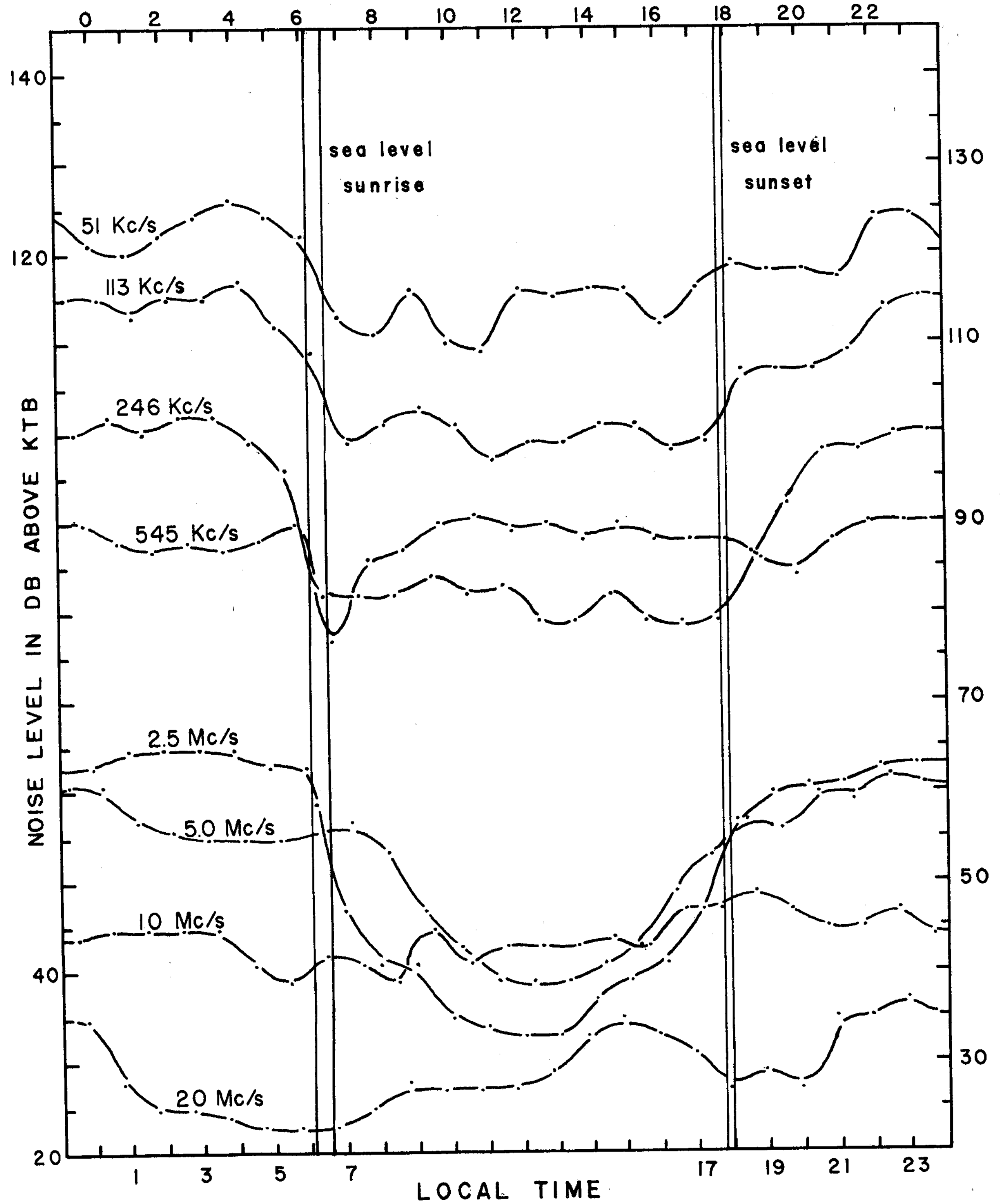


Fig. 3- Monthly Median Values for August 1963

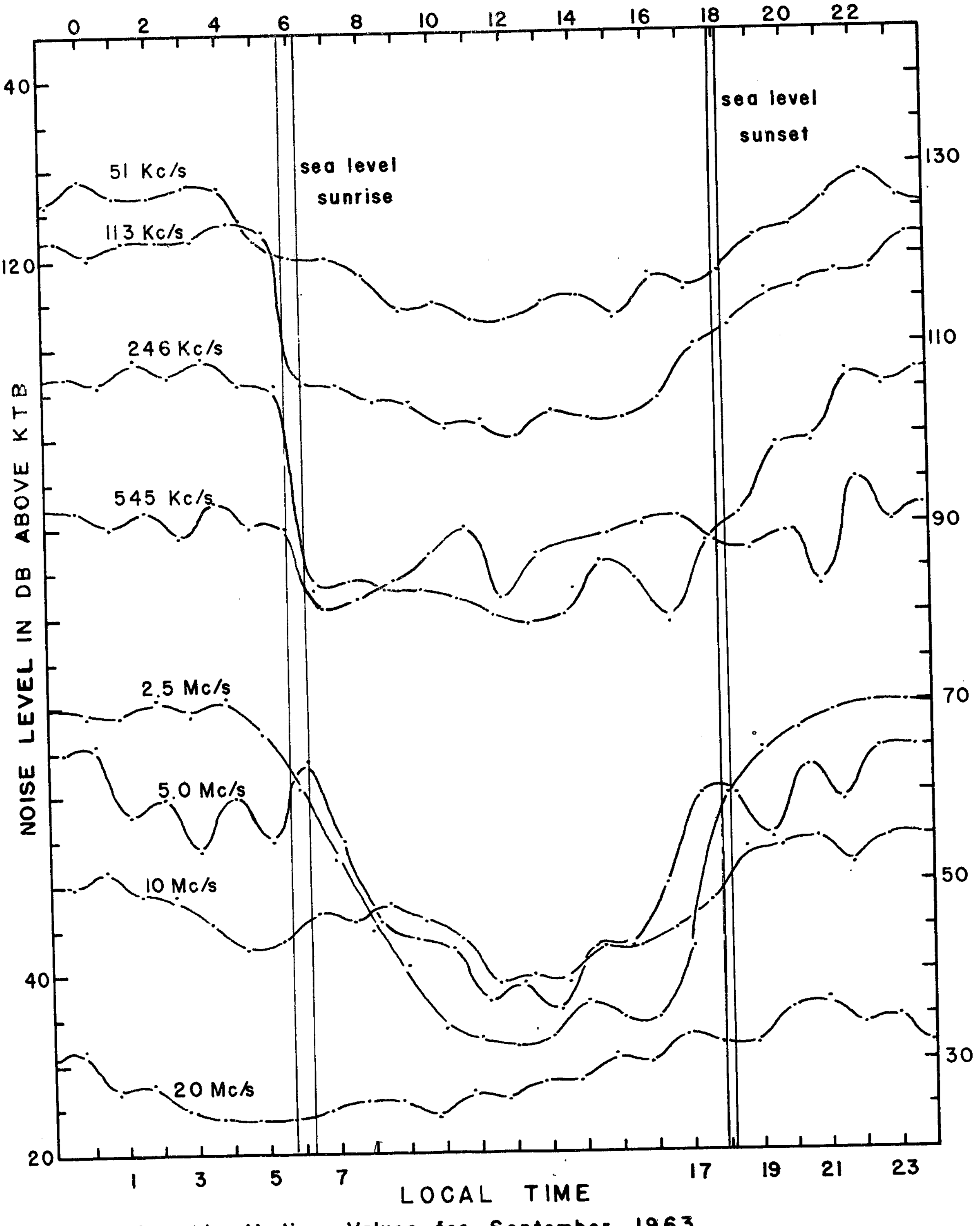


Fig. 4- Monthly Median Values for September 1963

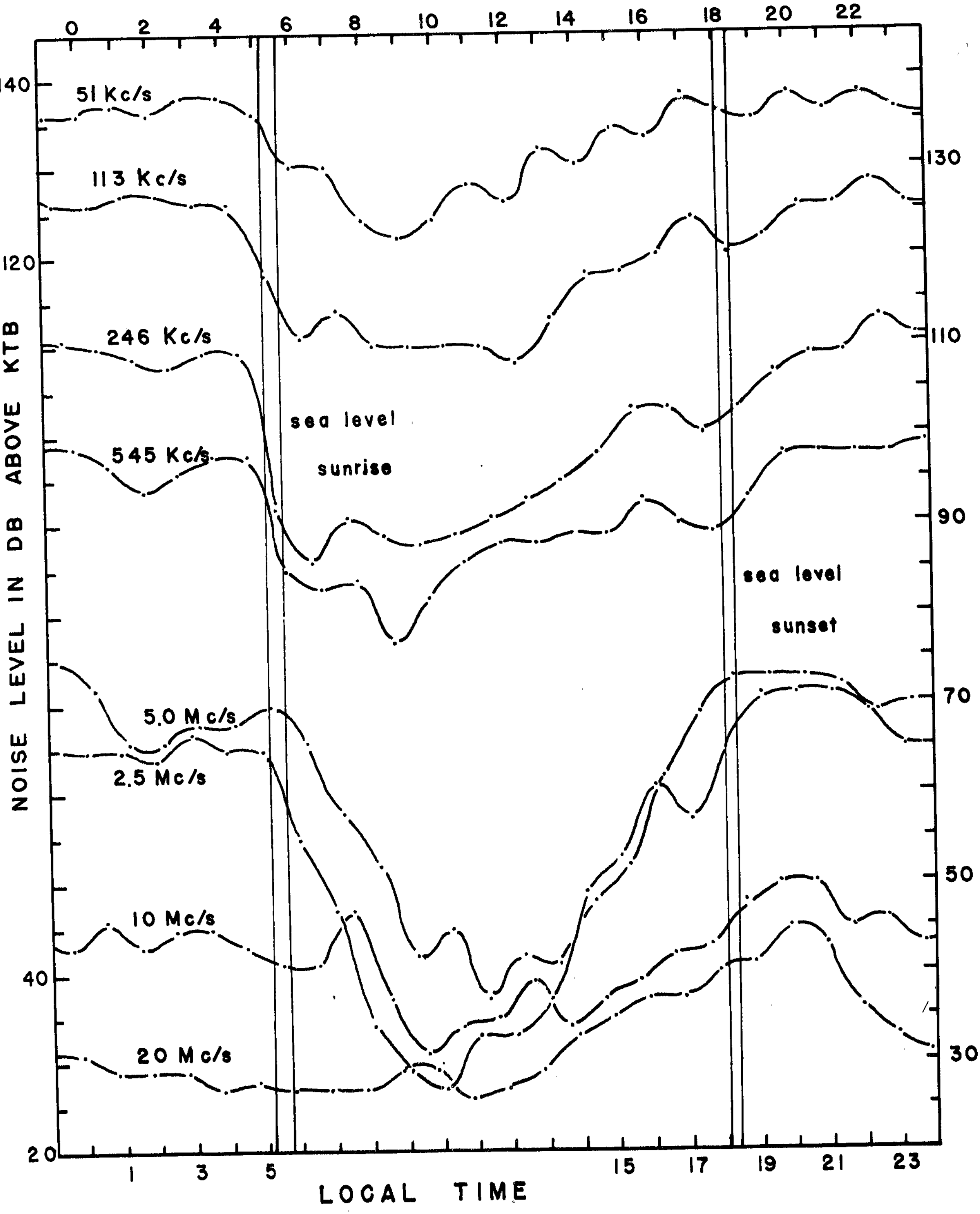


Fig. 5 - Monthly Median Values for October 1963

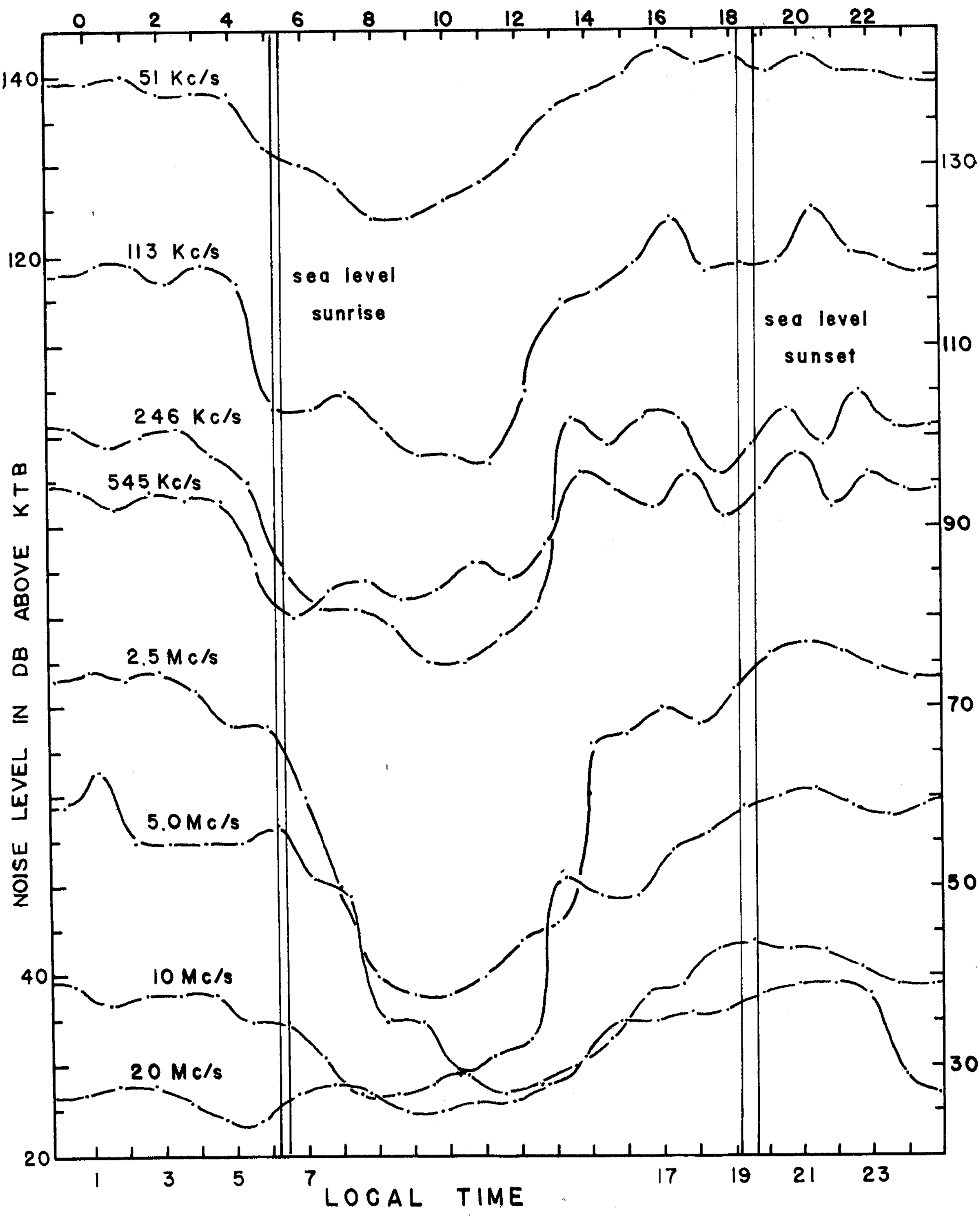


Fig. 6 - Monthly Median Values for November 1963

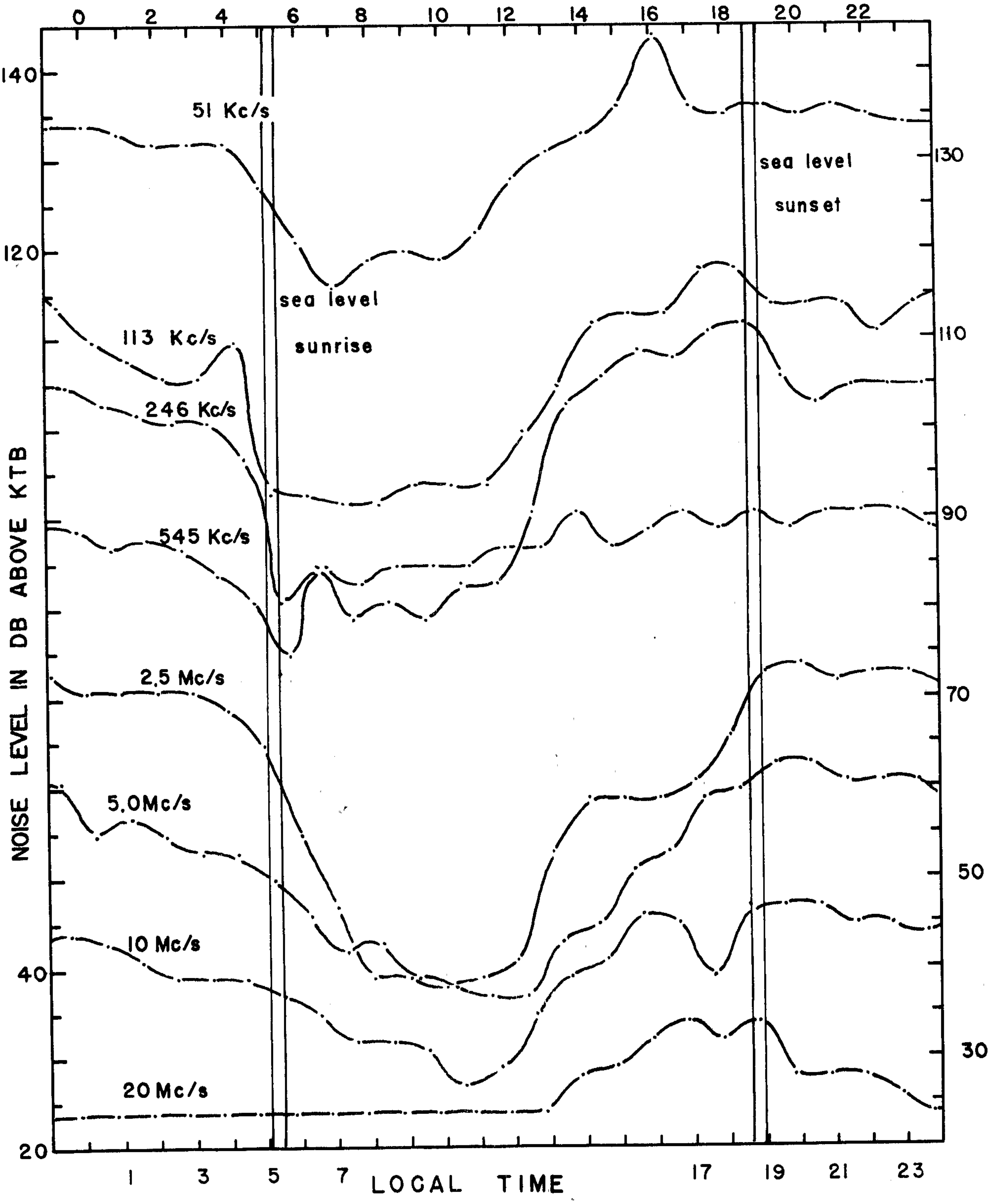
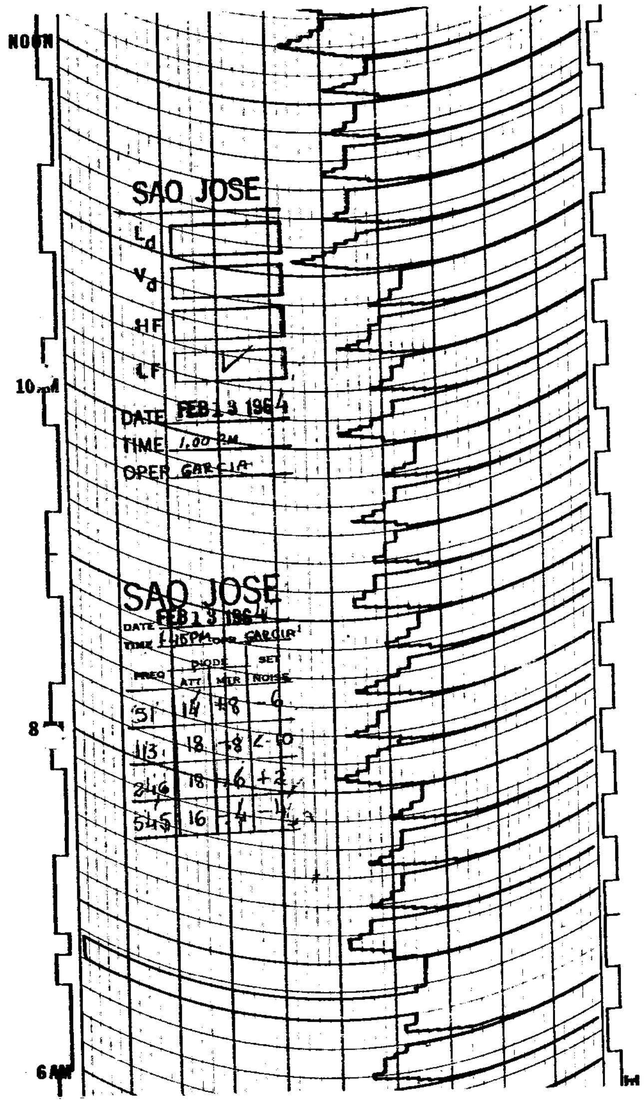


Fig. 7 - Monthly Median Values for December 1963



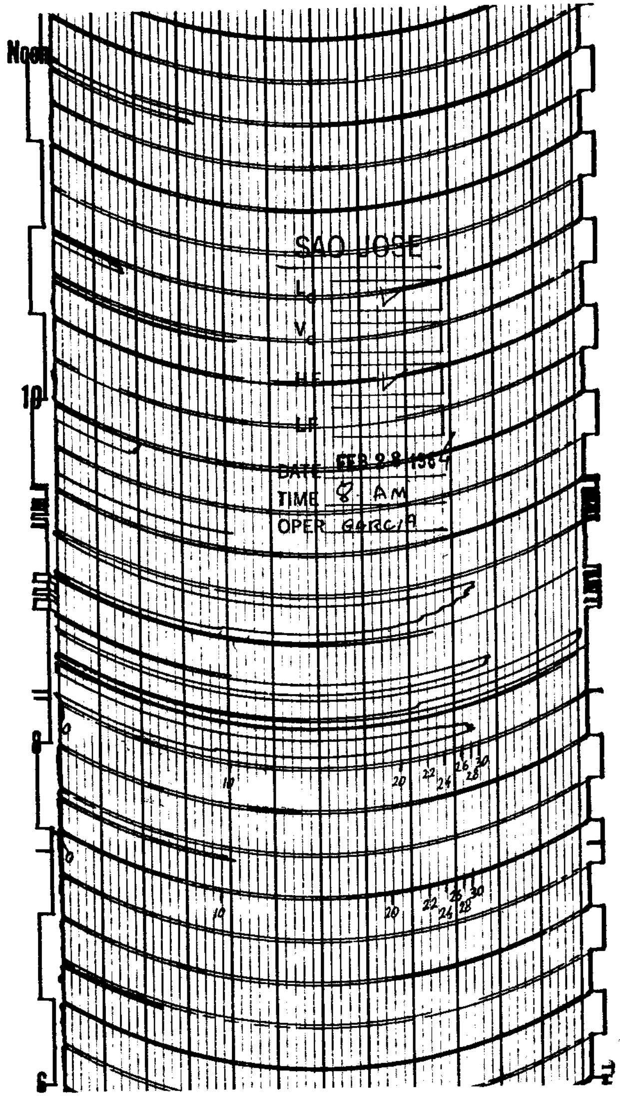


Fig. 8 - Recorder Charts

a) Log deviation

b) power

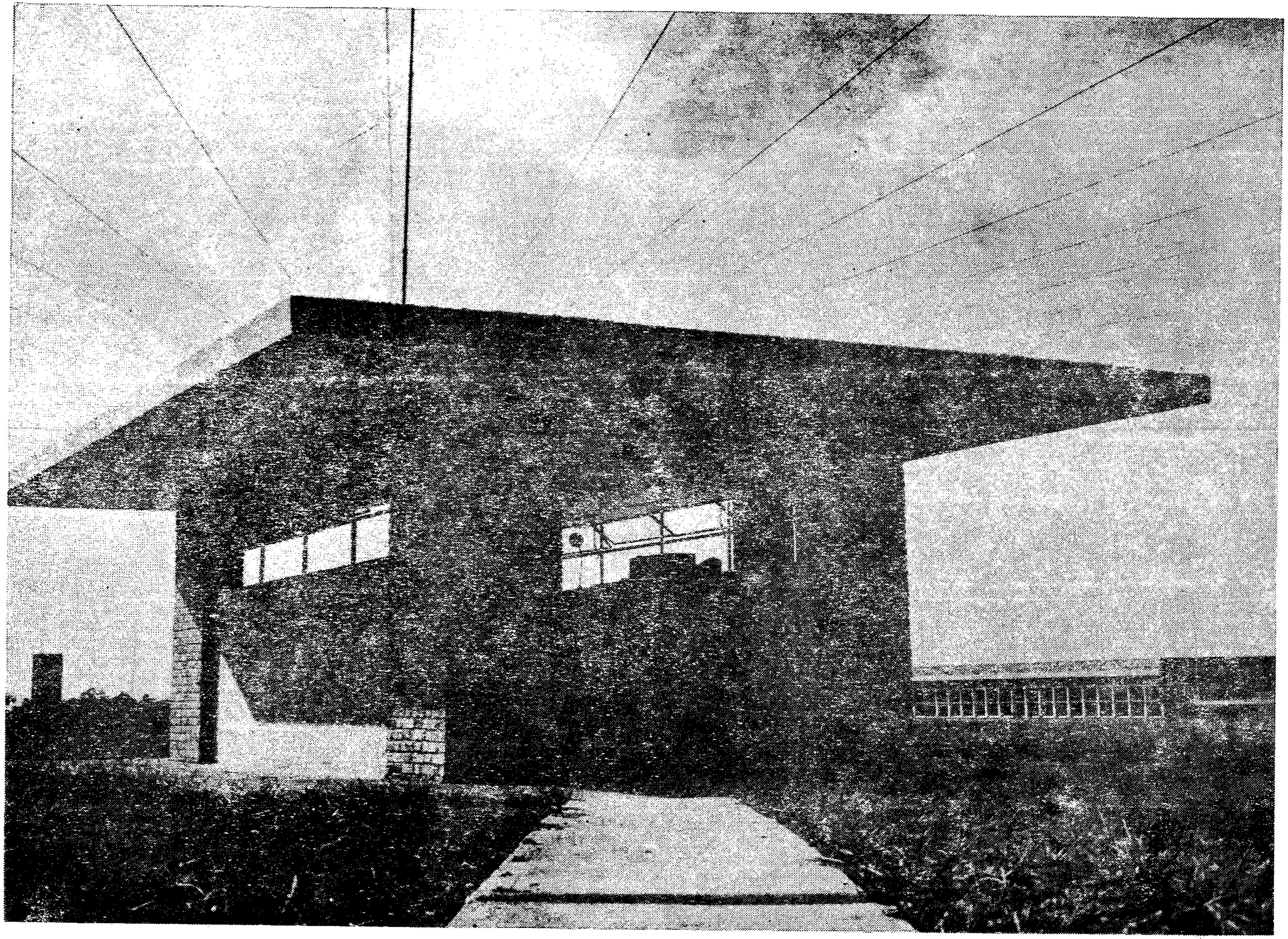


FIGURA 9 - BUILDING OF ARN-2 STATION Nº 10 IN SÃO JOSÉ DOS CAMPOS

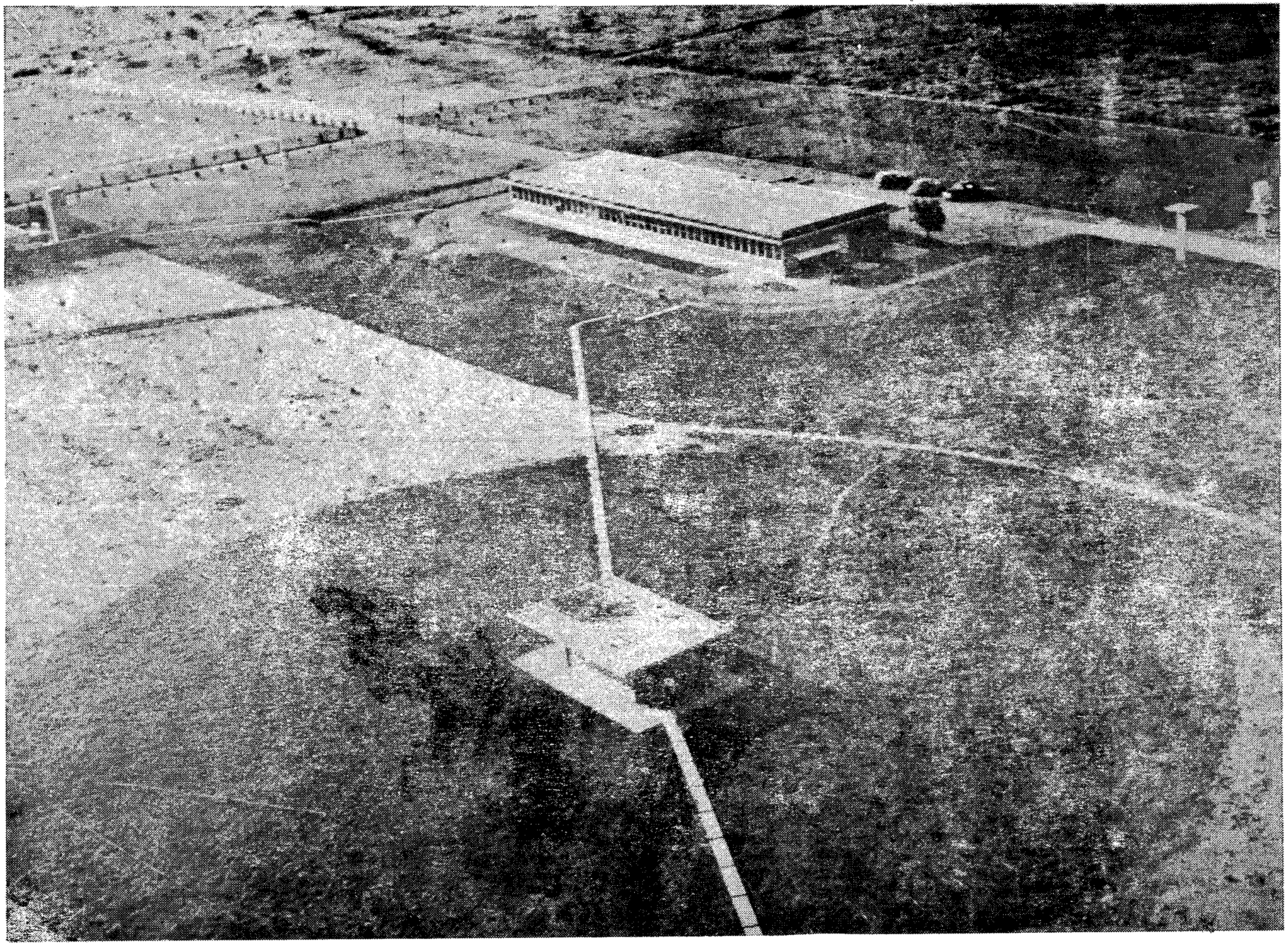


FIGURA 10 - ARN BUILDING IN THE FOREGROUND AND MAIN LABORATORY IN THE BACKGROUND

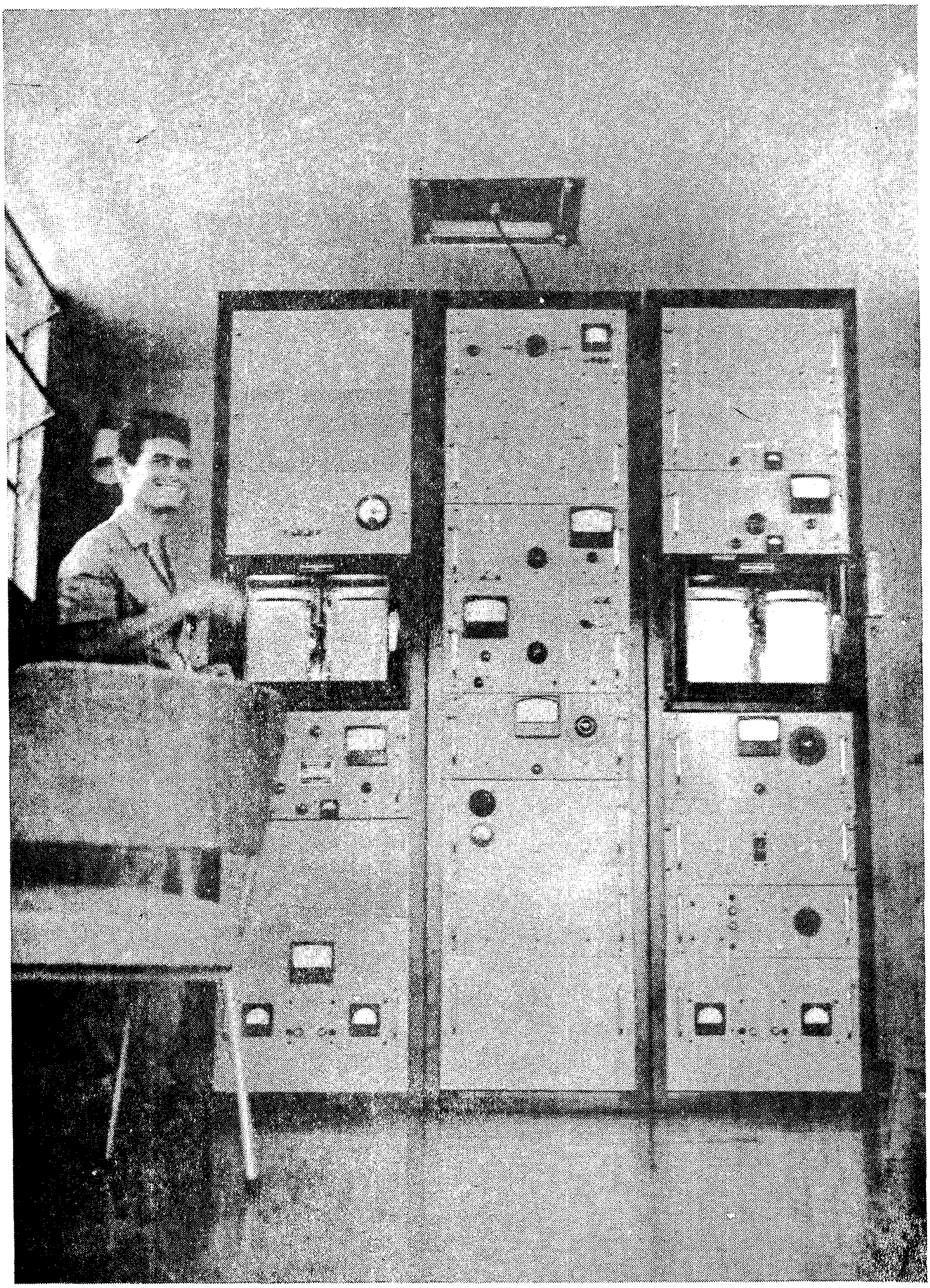


FIGURA 11 - ATMOSPHERIC RADIO NOISE RECEIVING EQUIPMENT