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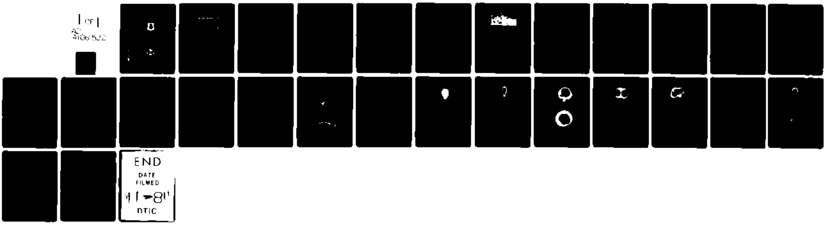

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FOREIGN TECHNOLOGY DIVISION

ANTENNA

(Selected Articles)

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TABLE OF CONTENTS

U. S. BOARD ON GEOGRAPHIC NAMES TRANSLITERATION SYSTEM

Block	Italic	Transliteration	Block	Italic	Transliteration
А а	*А а*	A, a	Р р	*Р р*	R, r
Б б	*Б б*	B, b	С с	*С с*	S, s
В в	*В в*	V, v	Т т	*Т т*	T, t
Г г	*Г г*	G, g	У у	*У у*	U, u
Д д	*Д д*	D, d	Ф ф	*Ф ф*	F, f
Е е	*Е е*	Ye, ye; E, e*	Х х	*Х х*	Kh, kh
Ж ж	*Ж ж*	Zh, zh	Ц ц	*Ц ц*	Ts, ts
З з	*З з*	Z, z	Ч ч	*Ч ч*	Ch, ch
И и	*И и*	I, i	Ш ш	*Ш ш*	Sh, sh
Й й	*Й й*	Y, y	Щ щ	*Щ щ*	Shch, shch
К к	*К к*	K, k	Ъ ъ	*Ъ ъ*	"
Л л	*Л л*	L, l	Ы ы	*Ы ы*	Y, y
М м	*М м*	M, m	Ь ь	*Ь ь*	'
Н н	*Н н*	N, n	Э э	*Э э*	E, e
О о	*О о*	O, o	Ю ю	*Ю ю*	Yu, yu
П п	*П п*	P, p	Я я	*Я я*	Ya, ya

*ye initially, after vowels, and after ъ, ь; e elsewhere.
When written as ё in Russian, transliterate as yё or ё.

RUSSIAN AND ENGLISH TRIGONOMETRIC FUNCTIONS

Russian	English	Russian	English	Russian	English
sin	sin	sh	sinh	arc sh	$\sinh^{-1}$
cos	cos	ch	cosh	arc ch	$\cosh^{-1}$
tg	tan	th	tanh	arc th	$\tanh^{-1}$
ctg	cot	cth	coth	arc cth	$\coth^{-1}$
sec	sec	sch	sech	arc sch	sech^{-1}
cosec	csc	csch	csch	arc csch	csch^{-1}

Russian	English
rot	curl
lg	log

RADIO ASTRONOMICAL ANTENNAS OF
METER WAVELENGTH

V. V. Vitkevich, Yu. P. Ilyasov, S. M. Kutuzov, M. M. Tyaptin

ABSTRACT

A description of radioastronomical antennas operating simultaneously on waves of 3.5 m and 7 m is given. The effective area of one antenna is about 1000 m^2.

Introduction

In order to make interferometers with large bases in radio-astronomy, simple, but fairly effective extension antennas are required. The laboratory of radio-astronomy of the P. N. Lebedev Institute of Physics of the USSR Academy of Sciences has developed, and created in a short time two single-type extension antennas operating simultaneously on two multiple waves in the meter range. One of the antennas has been installed in the region of Kalinin, the other in the region of Pereslavl' -Zalesskiy. Currently these antennas jointly with the antenna of the East-West line of the cross-shaped DKR-1000 radio telescope of the Institute of Physics of the Academy of Sciences are used to observe the solar wind by radio-astronomical method. At all three points, with distances between them on the order of 200 km, simultaneous measurements are made of the flickering of radio sources on heterogeneities of the interplanetary plasma. The direction and velocity of the solar wind are determined from the relative temporal shift in the observed flickerings. Observations at all three points were synchronized with accuracy to 0.1 s by radio station signals from the time service. The observation technique and the equipment are described in more detail in [1], while the first results obtained are presented in [2].

Below is an examination of the main parameters of the extension antennas.

Fundamentals of Antenna Design

Each extension antenna is a parabolic cylinder with reflector dimensions on the generatrix 280 m and on the tightening chord 20 m, with focal distance of 6 m. Figure 1 presents a photograph of the antenna installed in the region of Pereslavl' -Zalesskiy. The antenna reflector consists of 130 wires attached to nine supports. The latter are installed in a line on the rotation axis at a distance of 35 m from one another. The parabolic supports which are trihedral in cross section, are made of thin-walled steel pipes and are installed on rotating devices.

A feature of the antenna is the asymmetrical arrangement of the rotation axis in relation to the apex of the parabola of each support.

Figure 1.

The selected position of the axis made it possible to arrange the antenna low above the earth and to maintain the possibility of turning it to zenith distances on the order of 70°. By reducing the height of the support columns and the supports of the guy devices, the weight of the metal structures was considerably diminished. The normally employed massive reinforced concrete foundations were replaced by pile-driven. The low position of the antenna above the earth made it possible to significantly facilitate its assembly. Bins filled with sand were made on the short ends of the supports for balancing. The rotating devices of the supports consist of a system of geared, worm and chain gears with manual drive. The assemblies of the rotating devices are installed on platforms set on piles.

The antenna uses rotating dipole towers whose hinge axis is installed on the upper boom of the supports near their rotation axes. This guarantees the possibility of inclining the dipole towers during installation and adjustment of the irradiator on the earth.

The extension antenna uses a simple method of attaching the reflector wires on the intermediate supports with the help of special cut holes and rubber bushings. The latter dampen vibrations of the wires from the wind loads. This prevents their breaking and during assembly allows rapid attachment of the wire without using fasteners.

In order to compensate for load from stretching of the wires of the reflector and the load-bearing cables, the extreme parabolic supports are strengthened and held by special anchor adjustable tightening devices which permit unhampered turning of the antenna.

This antenna design reduced the length of the high-frequency cables in the feeder system.

Dipole-Feeder System

The irradiator of the extension antenna is divided into eight parts according to the number of spans. Each span 35 m long has 10 dipoles. The dipole is wave for $\lambda_1 = 3.5$ m and half-wave for $\lambda_2 = 7$ m. A wire counterreflector 1.65 m wide is installed above the dipoles at a distance of 1.05 m. Behind the counterreflector there is two-wire collecting feeder. The dipoles are connected to the feeder by segments of two-wire cable KATV. Inphase excitation of all the dipoles simultaneously on both waves is guaranteed by means of the corresponding selection of these cable segments as shown in figure 2. In addition,

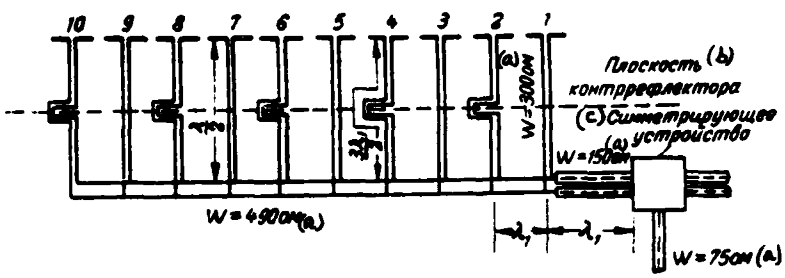

Figure 2.
a--Ohm; b--plane of counterreflector; c--symmetrical device.

this plan makes it possible to match the sections of the irradiator made of 20 dipoles fairly simply on both waves (this will be shown below).

At wave $\lambda_1 = 3.5$ m, the high input reistances of the dipoles are converted without any transformation to the input of the two-wire feeder, and further to the input of the section. At wave $\lambda_2 = 7$ m, relatively low input resistances of the dipoles are transformed through the four-wave transformer W=300 Ohm, and are futher converted through a whole number of half-waves to the input of the section.

The input resistance of 20 dipoles united into one section with the help of a wide-band symmetrical device [4] was computed and measured in the frequency band 82-88 MHz and 41-46 MHz. The results of the calculation and the experiment are presented in figure 3.. As

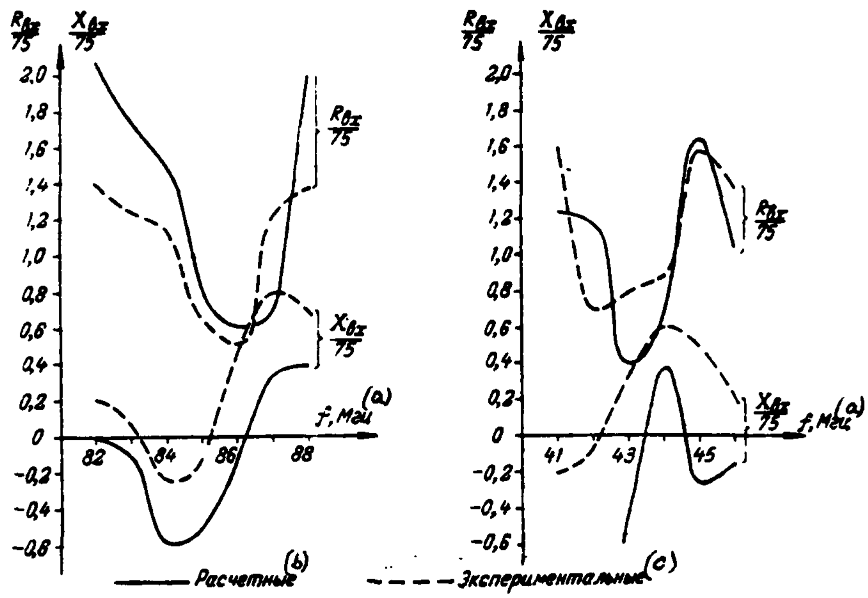

Figure 3.
a--MHz; b--calculated; c--experimental.

is apparent from figure 3, the coincidence is fairly good. The symmetrical device is designed to operate on a coaxial cable with wave resistance of W=75 Ohm. The measured reflection coefficient after matching at the inlet to the symmetrical device was not greater than 0.15 on both waves.

Thus, the dipole-feeder system described above makes it possible to obtain inphase excitation of the section of the irraditor simultaneously on both waves and to match it fairly simply.

The four irradiator sections are further united on a binary plan with the help of wide-band hybrid rings [3]. For this purpose, an RKM-5/18 cable 50 m long is laid on the dipole towers from each section. An RKM-5/18 cable 80 m long is laid on the ground from the point of unification ofthe two sections (half of the antenna).

For simultaneous observations of the flickerings in all three points, it is required that the beam pattern of the antennas be inclined in relation to the inphase position. The angle of inclination depends on the inclination of the observed source. The inclination of the beam pattern of the antenna is done by including additional cable segments into the appropriate branches of the feeder system.

For the extension antenna near Kalinin, it is necessary to incline the beam pattern on the average about 2.5° to the east, and for the antenna near Pereslavl'-Zalesskiy, about 1° to the west. As measurements have shown, when additional phasing cables are included, congruence of the antennas is practically unchanged.

<u>Adjustment of the Antenna</u>

As indicated above, the effective area of the extension antennas must be large in order to confidently record the flickerings of the weak discrete sources.

The conducted estimates yielded values of effective area equal to 1160 m^2 at wave 3.5 m and 1770 m^2 at wave 7 m. Table 1 presents the values adopted in the calculations for the efficiency of individual elements in the dipole-feeder system for λ_1=3.5 m and λ_2=7 m, and table 2 presents the factors which determine the total coefficient of surface use.

The calculated width of the beam pattern for half power at wave 3.5 m equals 41' x 10°, and for wave 7 m, 82' x 20° respectively in the E and H planes.

At wave λ_1=3.5 m, the measurements of antenna efficiency for emission of the background yielded a value of 0.5±0.05. Each antenna was divided into two halves for operation with a correlation receiver.

Measurement of the width of the beam pattern in the E-plane ($2\Theta_{0.5}$) and the effective area ($A_{эфф}$) were made at wave λ_1=3.5 m for the radio source Cassiopeia-A for each half of the antenna. Table 3 presents the results of these measurements.

The measurement results show that the antenna parameters with a small spread approach the calculated.

TABLE 1.

Element of dipole-feeder system	Efficiency at waves	
	[illegible]	[illegible]
Dipole	0.98	0.98
Two-wire cable	0.92	0.97
Two-wire feeder	0.94	0.97
Symmetrical device	0.94	0.96
Losses for congruence of section with 75-Ohm channel	0.975	0.975
Cable RKM-5/18 (50 Ohm), hybrid ring	0.77	0.86
Cable RKM-5/18 (80 Ohm), hybrid ring	0.69	0.83
Total calculated efficiency	0.40	0.62

TABLE 2.

Factors influencing coefficient of surface use	Partial values of coefficient of surface use on waves	
	$\lambda_1 = 3.5$ m	$\lambda_2 = 7$ m
Leakage through reflector	0.95	0.97
Nonuniform amplitude distribution on dipoles	0.98	0.98
Nonuniform phase distribution	0.95	0.95
Shading of counterreflector	0.91	0.91
Nonuniform amplitude distribution on exposure	0.92	0.90
Overflow over the edges of the reflector	0.71	0.69
Overall coefficient of surface use	0.52	0.51

TABLE 3.

Parameters	Antenna sections	Values of parameters in regions	
		Kalinin	Pereslavl'-Zalesskiy
$A_{эфф}$, m^2	1, 2	656	650
	3, 4	512	593
$2\Theta_{0.5}$	1, 2	1°10'	1°06'
	3, 4	1°16'	1°10'

At wave 7 m, the measured effective surface of the entire antenna is 1810 m^2 while the width of the beam pattern in the E-plane for half power is 68'. When the beam pattern is recorded, sometimes strong fluctuations are observed which are induced by the ionosphere.

Since 1966, regular observations of flickerings of weak radio sources on heterogeneities of interplanetary plasma have been made on these antennas. The effective surface of each antenna on the order of

1000 m^2 at λ_1=3.5 m makes it possible to confidently record these flickerings.

The dipole-feeder system makes it possible to operate simultaneously on two waves with good sensitivity.

The antennas are reliable to operate, their design is simple and makes it possible to rapidly assemble them, as well as disassemble them if it is necessary to install the antenna in a new place.

In conclusion, the authors are grateful to V. A. Yegorov for help in conducting the experiments with the antenna irradiator.

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METHODS OF AUTOMATIC MEASUREMENT
OF ANTENNA PARAMETERS

V. A. Torgovanov

ABSTRACT

Introduced is the concept of generalized complex radiation patterns of antennas - series of patterns measured at different frequencies and polarizations. An automatic method of the recording of generalized patterns is proposed.

Introduction

In recent years, phased antenna arrays have been greatly developed, including with nonmechanical beam oscillation in space. These are complicated multiple-element antenna systems. In the majority of cases, the elements of the antenna arrays are relatively small weak-directional antennas.

The development of a complex antenna system-array must be based on comprehensive and complete study of its elements, the emitters.

The antenna parameters used until now, and namely the beam pattern measured at one frequency, the polarization characteristics measured in one direction (at one point of the pattern), and others are insufficient for complete characterization of the emitters. Essentially, in order to characterize the antennas, one should use a family of beam patterns measured in many points of the range, a family of polarization characteristics measured in different directions in space and at different frequencies, etc.

One can introduce generalized characteristics, generalized complex beam patterns of the antenna. These characteristics must describe the polarization and frequency properties of the antenna at a certain solid angle. The generalized characteristics can be constructed in polar and Cartesian coordinate systems in linear or logarithmic scales.

This article examines the methods of automatic measurement of generalized beam patterns of antennas. The article consists of two parts. The first part, published in this collection, examines the methods of automatic measurement of amplitude-polarization and amplitude-frequency characteristics of the antennas. The second part of the article will examine the methods of automatic measurement of phase-polarization and phase-frequency characteristics of-antennas.

We will examine the method which permits combination on one graph of the polarization, amplitude and frequency characteristics of antennas and to make automatic measurement of these parameters.

Measurement of Amplitude-Polarization Characteristics of Antennas

Generally, the elements of the antenna array should be viewed as antennas with elliptical polarization. Particular cases are linear or circular polarization of the emitters which are easily obtained from the general.

Antennas of elliptical polarization are characterized by a large number of parameters. The main are the following:

1. Beam patterns (amplitude and phase) with different polarizations are measured on several frequencies in the range.

2. The coefficients of amplification are measured with different polarizations in a range of several frequencies.

3. Polarization characteristics: coefficient of ellipticity, orientation of the polarization ellipse and direction of polarization vector rotation are measured at different frequencies and in different directions in space (at different points of the beam pattern).

4. Coefficient of running wave in the frequency range.

The methods of measuring the listed characteristics are known and are extensively described in the literature [1, 2].

Publication [2] describes the methods for measuring the beam patterns and polarization characteristics of antennas with indication of the measurement results on an oscillograph screen.

The beam patterns on fixed polarization and frequency are usually taken during rotation of the tested reception antenna.

Polarization characteristics of the tested antenna are taken by rotating the transmitting, linearly-polarized antenna around the electric axis with a fixed tested antenna. The linearization characteristics of the linearly-polarized antenna on the oscillograph screen look like a figure eight, the elliptically-polarized--an ovaloid, and antennas with circular polarization--a circle [2]. The characteristics obtained in this case make it possible to determine the orientation of the polarization ellipse and the coefficient of ellipticity. However, in order to determine the polarization characteristics in limits of the entire beam pattern, it is necessary to make very labor-intensive measurements.

The entire process of measurement can be considerably accelerated and a convenient graph can be obtained when the following technique is employed. If circular scanning is not used during the rotation of the transmitting antenna, then one can obtain on the oscillograph screen or on the recording milliampere meter a certain segment of the

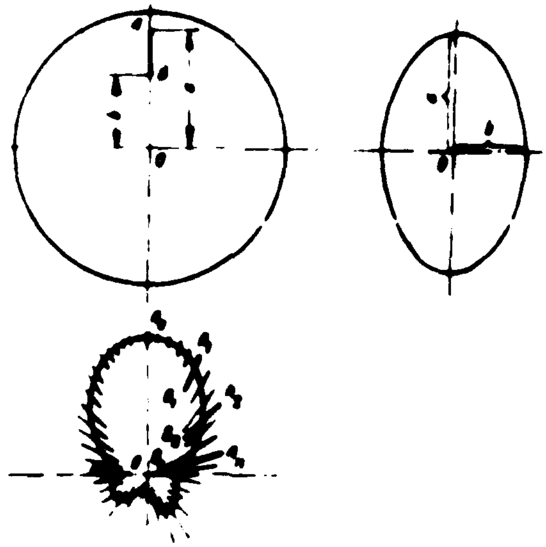

Figure 1.

line, and the coefficient of ellipticity will be determined by the ratio of the segment OB to the segment OA (fig. 1a):

$$K_э = \frac{OB}{OA} = \frac{\text{small axis of polarization ellipse}}{\text{large axis}} \quad (1)$$

In the logarithmic scale

$$K_э = (OA - OB),\ дб = AB,\ дб. \quad (2)$$

We record the beam pattern on a certain (for example, horizontal) polarization, and we plot on it the segments which characterize the coefficient of ellipticity in different points of the pattern with a definite interval (fig. 1).

The obtained graph characterizes many parameters of the tested antenna. The envelopes yield the maximum and minimum signals which correspond to the large and small axes of the polarization ellipse. Calibration provides the coefficients of amplification with different linear polarizations for any direction.

In addition, if the pattern on fixed polarization is plotted on the graph, for example, horizontal, one can determine the orientation of the polarization ellipses. The polarization characteristic is the geometric site of the maximum projections of the rotating electromagnetic vector onto the corresponding direction of the linearly polarized transmitting antenna.

If we know the semiaxes of the polarization ellipse a and b and the size of the projection of the electric vector p on the horizontal direction, we can determine the angle between the large axis 2a and the horizontal direction

$$\cos \alpha = \sqrt{\frac{p^2 - b^2}{a^2 - b^2}} . \qquad (3)$$

where a--large semiaxis of the polarization ellipse.

b--small semiaxis of the polarization ellipse.

p--projection of the electric vector on the horizontal axis.

α--angle between horizontal axis and large axis of the polarization ellipse.

Since $a > p > b$, the inequality $1 > \cos \alpha > 0$ is always fulfilled, and formula (3) has meaning for any realized values of a, b and p.

In the case of linear polarization (b=0), formula (3) acquires the following appearance

$$\cos \alpha = \frac{p}{a} . \qquad (4)$$

In figure 2, in the polar coordinate system, the beam pattern is presented on horizontal polarization (solid curve) on which segments AB are plotted in each direction. The outer envelope of these segments (hatched line) is the envelope of the large axes of the polarization ellipses. The inner envelope (dot-dash line) is the envelope of the small axes of the polarization ellipses.

By having the graphs (fig. 2) where the quantities $a_i = OA_i$, $b_i = OB_i$ and $p_i = OC_i$ are plotted, one can, by using formula (3), determine the orientation of the polarization ellipse at any point of the pattern. The figure presents the examples of constructing polarization ellipses. In the 0° direction there is circular polarization; 45°--elliptical and 90°--linear polarization. Analogous constructions are made in fig. 3 for the beam patterns in the Cartesian coordinate system.

Thus, the presented graphs make it possible to obtain complete amplitude-polarization characteristics of the antennas of elliptical polarization, with the exception of the direction of polarization rotation which is usually known, or can be defined additionally with

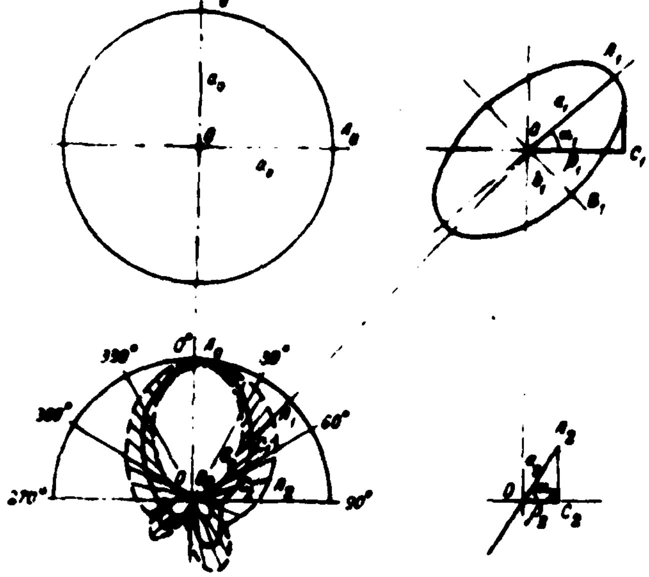

Figure 2.

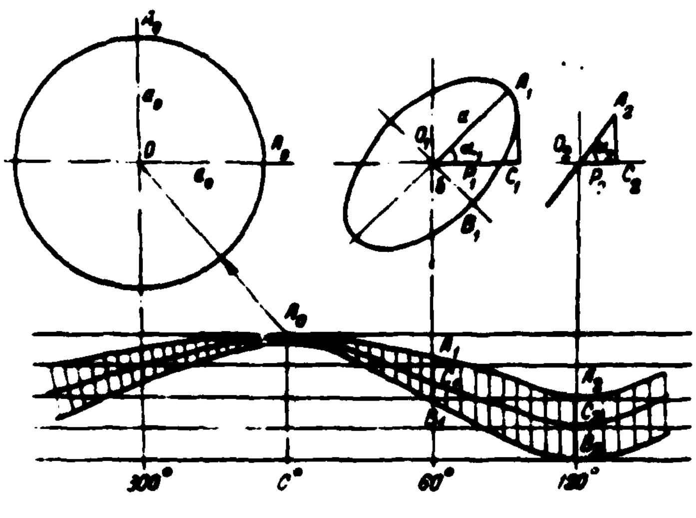

Figure 3.

the help of two antennas of rotating polarization.

Essentially, the measurement of the amplitude-polarization characteristics can be made with the help of a unit that consists of two parts: transmitting and receiving (fig. 4). The transmitting part consists of generator 1 of standard signals, rotating joint 2,

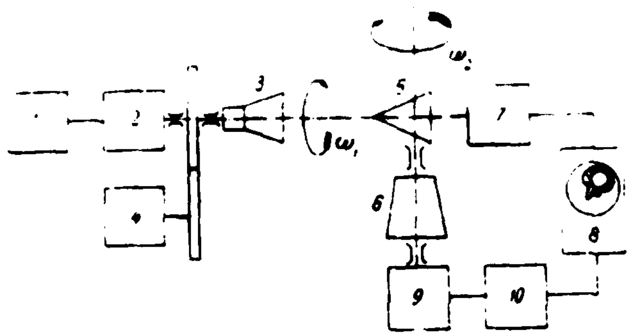

Figure 4.

transmitting linearly-polarized antenna 3, and mechanism 4 for rotation of the antenna around the electric axis.

The receiving part consists of the tested elliptically-polarized antenna 5, radio-transparent turning device 6 which permits antenna 5 to rotate around the vertical axis, as well as around the two other axes perpendicular to the vertical, receiver 7, automatic recording instrument 8 (or oscillograph) and sensor for the turning angle of antenna 9. Indicator 9 is connected to the turning device 6 by servo-system 10 which is made on selsyns.

The process of constructing graphs (fig. 2 and 3) with the help of the equipment in block diagram fig. 4 can be implemented continuously and rapidly through simultaneous rotation of the transmitting antenna 3 and the tested reception antenna 5. At the same time, the transmitting antenna 3 must rotate with a velocity of ω_1, considerably exceeding the velocity ω_2 of the rotation of the tested reception antenna 5.

During rapid rotation of the transmitting antenna, the beam pattern of the tested antenna is modulated by the polarization characteristics. The rotation velocity of the transmitting antenna ω_1 should be selected so that on each loop of the beam pattern of the tested antenna, there are several periods of the signal polarization modulation.

Figures 5-9 present in a logarithmic scale the generalized amplitude-polarization characteristics of certain antennas that were measured according to the indicated technique with ω_1=100 ω_2.

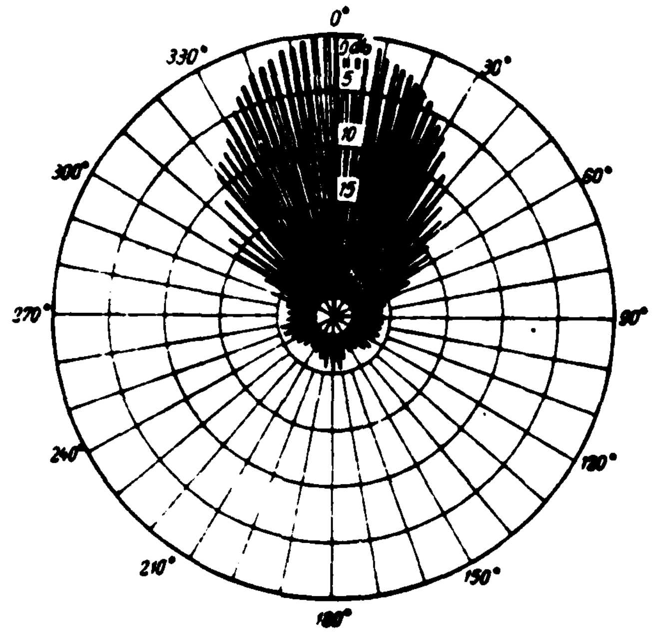

Figure 5.

Figure 5 presents the generalized pattern of a linearly-polarized antenna. It is natural that the envelope of the polarization characteristics coincides with the pattern on the vertical polarization, while the depth of the polarization modulation equals 100%.

Figure 6 presents the pattern which is modulated by polarization characteristics of a seven-loop cylindrical spiral antenna. It is apparent that the pattern on the horizontal polarization does not coincide with the envelopes of the small and large axes of the polarization ellipses. In addition, a certain asymmetry is visible in the distribution of the coefficients of ellipticity in relation to the axis of the pattern which is governed by the position of the final and first loops of the spiral.

Figure 7a presents the pattern (in the plane containing the antenna axis) of the slit two-pass conical spiral antenna which has the following parameters: angle of taper $2\Theta=20^\circ$, angle of spiral elevation 48°. It is apparent that the pattern on the horizontal polarization does not coincide with the envelopes of the polarization characteristics.

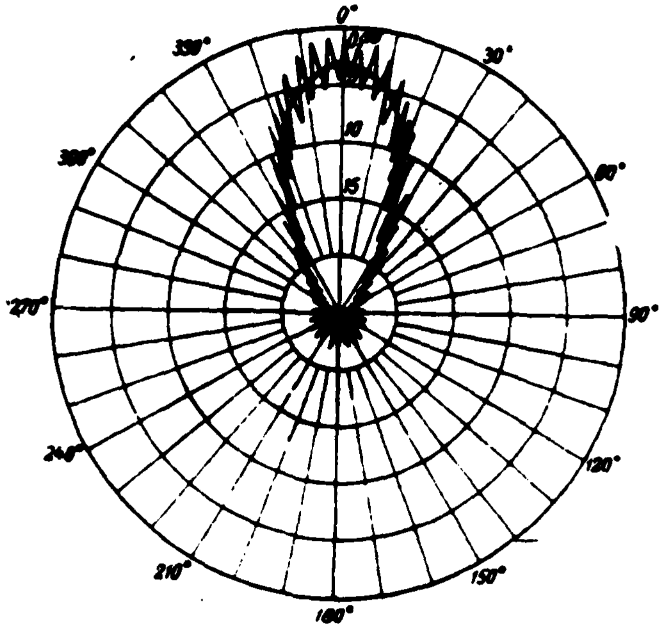

Figure 6.

Figure 7b presents a generalized pattern of the same antenna, measured in a plane perpendicular to the spiral axis (in direction 90°-270°, fig. 7a).

Figure 8 presents generalized amplitude-polarization characteristics of the planar two-directional logarithmic spiral antenna. It is apparent that in the sector near the electric axis of the antenna, the polarization approaches circular, and in the plane of the antenna, the polarization is linear.

Figure 9 presents a generalized pattern of the antenna system which consists of two two-pass logarithmic spiral antennas. It is apparent that the pattern approaches in its shape to the nondirectional, however, there is a sector with clearly pronounced interference.

Measurement of Amplitude-Frequency Antenna Beam Patterns

Measurement of the amplitude-frequency beam patterns (afp) of antennas is analogous to the measurement of amplitude-frequency characteristics of any quadripole. The difference lies in the method of indication. Whereas in automatic measurers of the apf of quadripoles, the amplitude is usually recorded on the oscillograph screen

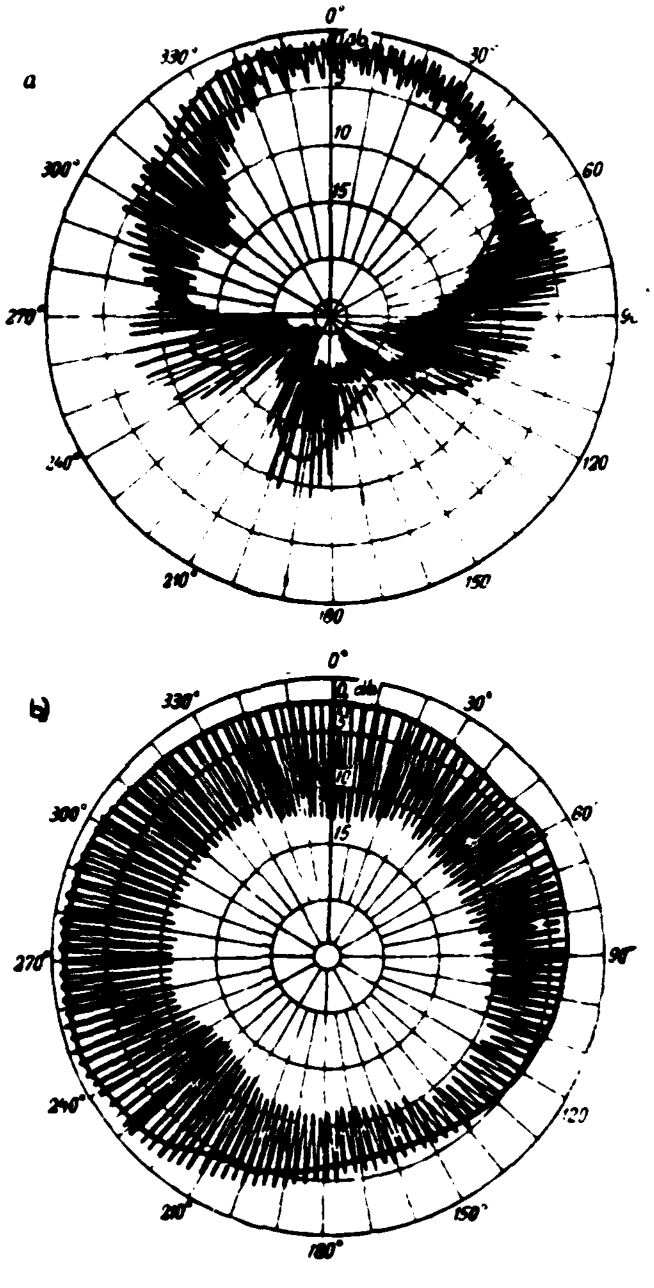

Figure 7.

or other indicators on one coordinate (for example, the amplitude of the reflected signal during measurement of congruence), and the frequency is measured on the other, the measurement of the beam patterns of

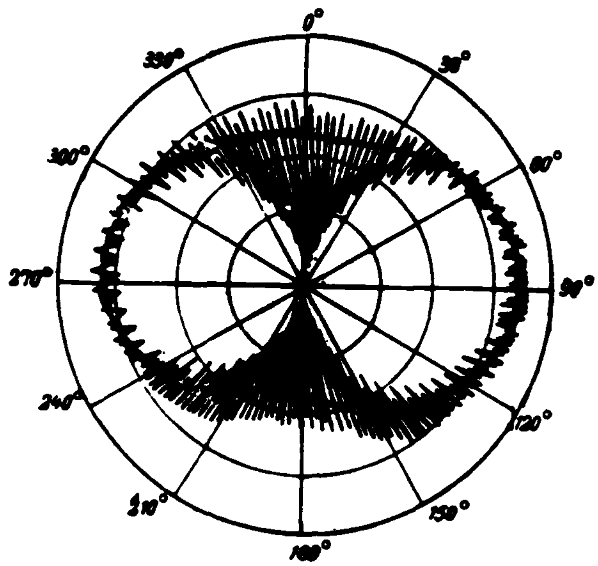

Figure 8.

the antennas requires yet another coordinate to record the spatial angle. However, there are no three-coordinate indicators. Therefore in measuring the afp of an antenna and with the use of the two-coordinate indicator, one can record amplitude on one, and the angle in space on the other coordinate. Then with a change in the frequency in the assigned range for a certain antenna position (in space), a segment will be recorded on the indicator which characterizes the change in signal amplitude (maximum and minimum signals). In a similar manner, one can record the other spatial angles. As a result, a pattern is obtained which has an appearance similar to fig. 1c.

Measurement of the afp of an antenna can be made in practice with the help of a unit whose block-diagram is illustrated in fig. 10. It consists of a generator of oscillating frequency 1, transmitting antenna 2, tested antenna 3, turning device 4, receiver 5, indicator 6, feedback device 7 which keeps constant the ratio between the receiver sensitivity and the power of the generator of the oscillating frequency in the entire tuning range.

In order to measure the beam patterns and the coefficients of amplification of the antennas in the frequency range, the tested antenna is rotated around the horizontal axis. In this case, the

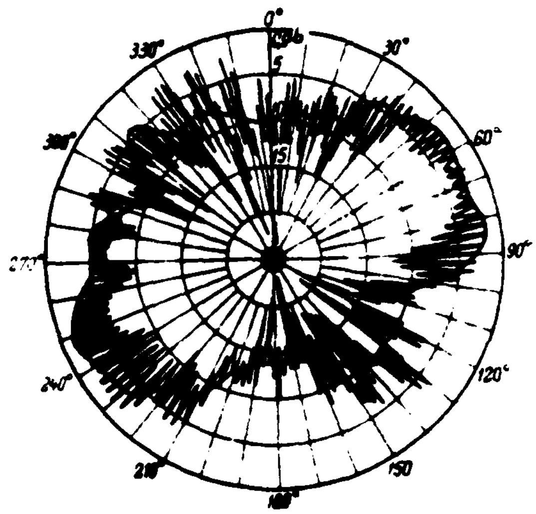

Figure 9.

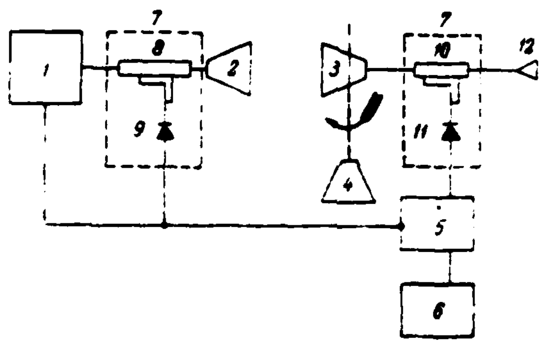

Figure 10.

change in wavelength (frequency) of the oscillating frequency generator guarantees that an illuminated band will be obtained on the oscillograph screen. All the patterns of tested antenna 3 in the range of tuning the oscillating frequency generator 1 lie within the illuminated band. Therefore the photograph obtained from the oscillograph screen makes it possible to determine the maximum and minimum coefficient of amplification, the width of the beam pattern, the greatest level of lateral loops, and the depth of dips in the patterns in the studied wavelength range.

In order for the measurements to be correct, it is necessary to satisfy the following conditions:

1. The effective surface of the transmitting antenna S_{nep} in the studied frequency range (range of tuning the oscillating frequency generator) must be constant:

$$S_{nep}(\lambda) = \text{const.} \qquad (5)$$

2. The ratio of receiver senstivity to the power of the transmitter in the studied frequency range must be constant:

$$\frac{P_{np}(\lambda)}{P_{nep}(\lambda)} = \text{const.} \qquad (6)$$

Then the error of measuring the coefficients of amplification of the tested antenna will not depend on the change in frequency:

$$G_{np} = \frac{4\pi R^2 P_{np}}{S_{nep} P_{nep}}, \qquad (7)$$

where R--distance between the receiving and transmitting antennas.

The horn antenna whose length L is considerably greater than the flare angle has a constant effective surface. The length satisfies the condition

$$L \quad \frac{2D^2}{\lambda}, \qquad (8)$$

where L--length of the horn,

D--flare angle of the horn.

The ratio $\frac{P_{np}}{P_{nep}}$ is kept constant through the use of two equal directional couplers 8 and 10, and detector sections 9 and 11 in the transmitting and receiving parts of the unit (fig. 10).

We will evaluate the error in measuring the parameters of the antennas according to the suggested technique, in the case where the conditions (5) and (6) are fulfilled approximately. The standard error in measuring the coefficient of amplification of the studied antenna

$$\Delta G_{np} = \sqrt{2\left(\frac{\Delta R}{R}\right)^2 + \left(\Delta\frac{P_{np}}{P_{nep}}\right)^2 + (\Delta S_{nep})^2}\,. \qquad (9)$$

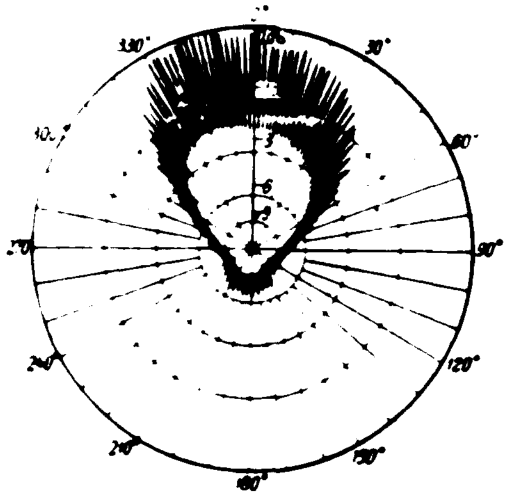

Figure 11.

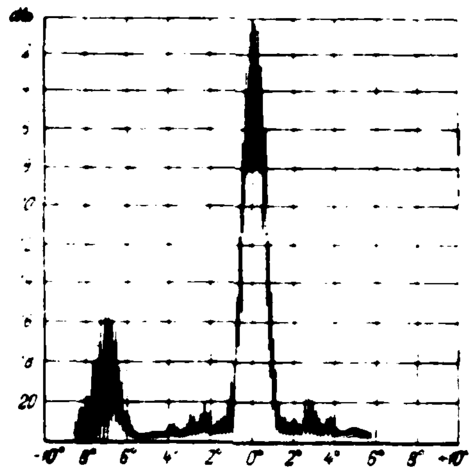

Figure 12.

where ΔR--error in measuring distance,

ΔP_{np}--error in measuring receiver sensitivity,

ΔP_{nep}--error in measuring transmitter power.

ΔS_{nep}--error in measuring effective surface of transmitting antenna.

The error $\Delta R/R$ in measuring the distance between the antennas is not greater than 1% if the phase centers of the antenna are known.

The effective surface of the transmitting antenna S_{nep} in the case of using the horn antennas can be measured and maintained in a

50% band of frequencies with accuracy no less than 5%.

The ratio $\Delta P_{\text{np}}/\Delta P_{\text{nep}}$ because of the use of identical detector sections in the receiver and in the feedback circuit (to maintain the power level constant) of the oscillating frequency generator can be maintained with accuracy to 10-15%.

Thus, the standard error in determining the coefficient of amplification in the range of waves will be a quantity on the order of 15%.

The suggested method for measuring the beam patterns in the antenna amplification coefficients in the frequency range is distinguished by the fact that the process of measurement is done continually and fairly rapidly. With measurement simultaneously with rotation of the tested antenna, the wavelength of the transmitter changes, and during one rotation of the antenna, the wavelength changes several hundred times in the selected range. This is guaranteed by the oscillating frequency generator. The measurement results are recorded by photographing the oscillograph screen.

Characteristic generalized patterns measured in the range of waves are presented in figures 11 and 12.

Figure 11 presents a generalized amplitude-frequency pattern of two-pass conical spiral-logarithmic antenna (angle of taper $2\Theta=20°$, angle of spiral elevation $\alpha=45°$) measured in the decimeter range in the 50% frequency band in a plane which contains the spiral axis.

Figure 12 presents a generalized amplitude-frequency pattern of an array consisting of 10 elements of open ends of the wave guides, measured in the centimeter range with a change in the wavelength by 50%.

If desired, one can naturally take the modulation of the controlling voltage from the oscillating frequency generator and measure the patterns on any fixed wave.

Conclusions

Generalized amplitude-polarization and amplitude-frequency patterns of antennas provide a graphic idea on the polarization and frequency properties of the antennas in the limits of the entire beam pattern.

The suggested technique for automatic measurement of these characteristics guarantees a significant increase in the labor productivity.

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