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ANTENNAS FOR RADIO COMMUNICATION, BROADCASTING AND TELEVISION

by

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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

*<u>ye</u> initially, after vowels, and after ъ, ь; <u>e</u> 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

GRAPHICS DISCLAIMER

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ANTENNAS FOR RADIO COMMUNICATION, BROADCASTING AND TELEVISION.

G. Z. Ayzenberg, S. P. Belousov.

The first antenna was proposed by the inventor of radio our compatriot A. S. Popov. It was vertical asymmetric radiator/resonator/element. This antenna, until now, finds wide application on the long, average/mean, short and ultrashort waves.

Simultaneously with the development of radio engineering was developed antenna design, which represents the now independent manifold and complicated region of radio engineering.

Antenna installations technique depends substantially on the region of its use/application (connection/communication, broadcasting, radar, radio astronomy, etc.). Let us pause predominantly at the antenna to technology for the connection/communication and the broadcasting.

Long-wave and medium-wave antennas for radio broadcasting.

For the transmission in the waves longer than 2000-3000 m the diverse variants of wire antennas with the developed horizontal parts of one or the other form are applied. These antennas do not differ substantially from the antennas, which were being applied by of the development of radio engineering, when connection/communication was realized on the long waves.

For radio broadcasting in the range 200-2000 m, beginning from the 30's, mast antennas and antenna-towers with the isolated/insulated foundation and the developed radial grounding/ground were adopted. The absence of passive supporting/reference masts and hoisting cables, which distort radiation pattern and which lower efficiency, is the advantage of such antennas.

In the process of the development of antennas of this type the series/row of the new original diagrams, which differ significantly from initial ones, was developed and introduced. Abroad the antenna of shunt feed [1] was developed. In the Soviet Union are developed the antenna of upper feed [2], the antenna of the expanded wave band [3] and slot antenna [4]. The absence of stand-off insulators is the distinctive special feature/peculiarity of the antenna of shunt feed and antenna of upper feed, which in many instances is very important. Usual mast antennas are unworkable on the waves of shorter than 1.4 H (H - height/altitude of mast). The antenna of the expanded wave band because of special driving circuit can work, beginning from the waves with a length of 0.9 H. This makes it possible to utilize one mast antenna in entire broadcast range 200-2000 m.

Slot antenna is suspended on the low supports. For example, antenna for the range 200-600 m requires for the suspension of the support with a height/altitude of 25-30.

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The introduction of antifading mast antennas was the very important reaching/achievement medium-wave of antennas technique. These antennas have the height (0.5-0.55) λ and respectively narrowed radiation pattern in the vertical plane with the very small side-lobe level and the increased factor of amplification ($\epsilon \approx 1.6$ in comparison with the low vertical radiator/resonator/element). The antenna of the expanded wave band is one of the versions of antifading antenna, which has the best antifading properties on the wave of approximately 1.25 H. In the significant part of the range this antenna has the increased factor of amplification (to 2-3 in comparison with the low radiator/resonator/element). The use/application of antifading antennas leads to the increase in the distance from the transmitting station, on which are absent deep fadings of field and, into the details, pronounced selective fading.

The narrow wave band (10-20%) is a deficiency/lack in the antifading antennas, within limits of which antifading properties are retained. In many instances it proves to be necessary to ensure the antifading operating mode and the increased amplification factor in the wider wave band. This requirement is satisfied during the use/application of mast antennas with the adjustable current distribution (ARRT). Antennas of such type were proposed in the USSR in 1939 [2]. Subsequently the antenna circuit with the adjustable current distribution (Fig. 1), after undergoing some changes, began extensively to be used at the radio centers of the Ministry of Connection/communication [5, 6]. Current control is conducted by displacing the shorting device K. Mast antenna with the height/altitude of 250-300 m during the appropriate selection of the site of installation of shorting device can ensure work in entire broadcast range 200-550 and 750-2000 m. In this case not less than in the twofold range (for example, 250-550 m) it is possible to obtain antifading mode/conditions. The maximum factor of amplification of mast antenna attains 3.5.

An increase in the amplification factor 2 times can be obtained, performing antennas of two mast antennas, one of which is reflector. Such antennas found considerable use/application in the USSR and abroad.

Further increase in the amplification factor is achieved by the creation of cophasal gratings from the mast antennas. Utilizing known methods, it is possible to control the direction of maximum antenna radiation. The use/application of antenna arrays with comparatively narrow radiation patterns, besides an increase in the amplification factor, makes it possible to decrease interstation interference.

In the system of the Ministry of Communications the directional medium-wave log-periodic antennas from vertical radiators/resonators/elements [7] for the work in the range 200-600 m were developed.

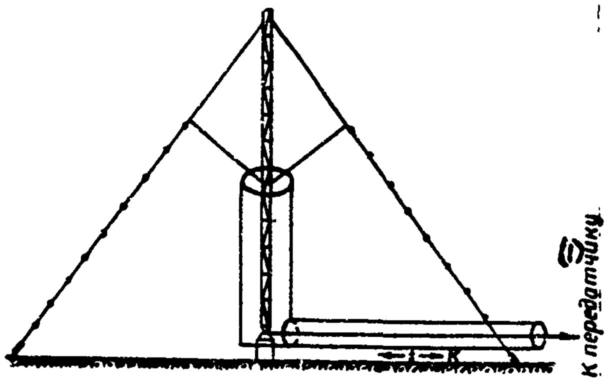

Fig. 1. Key: (1). To the transmitter.

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These antennas, in contrast to the cophasal gratings, have virtually constant/invariable radiation pattern in entire operating range and good natural agreement with the feeding line. The schematic of a similar antenna is shown in Fig. 2. In the case of necessity on one support it is possible to hang up 3-4 antennas, each of which has their direction of maximum radiation/emission. The cophasal excitation of all antennas, suspended/hung from the support, makes it possible to obtain nondirectional radiation in the horizontal plane.

The development of technology of durable polymer films creates conditions for developing the new constructions/designs of medium-wave antennas. In particular, are prospects of applying the pneumatic mast antennas from the polymeric materials. This antenna is the cylinder, made from high-strength film, supported by excess air pressure. As the radiating wires it is possible to apply metallic delays or system of the vertical condutors, which cover cylinder. Rapid installation/setting up, possibility of controlling of height/altitude, etc are the advantages of such mast antennas. Fig. 3 shows the general view of the pneumatic mast antenna, developed in the system of the Ministry of Communications of the USSR.

For the professional/occupational reception/procedure on the average/mean and long waves vertical radiators/resonators/elements (with the horizontal part or without it), goniometric antennas and single-wire antennas of the taking wave are applied.

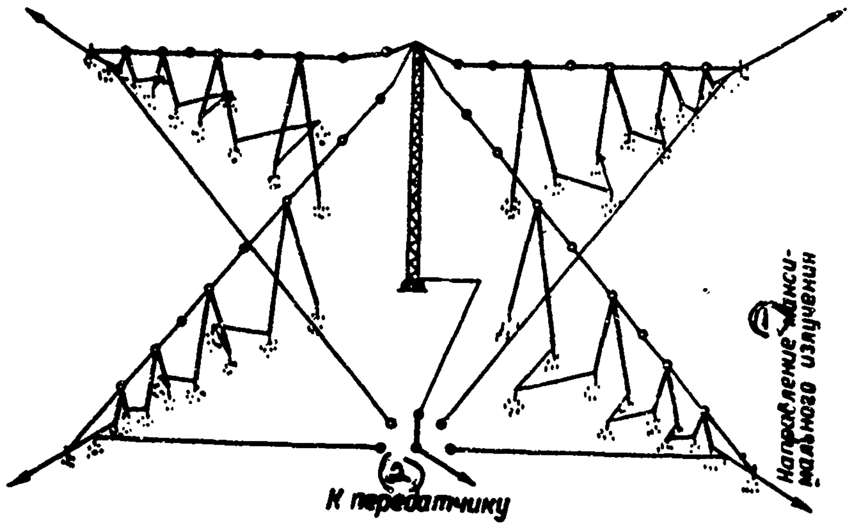

Fig. 2. Key: (1). Direction of maximum radiation/emission. (2). K to transmitter.

Fig. 3.

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For the individual reception/procedure, besides the simple wire antennas, the ferrite rods antenna, installed into the housing of receiver, extensively are used.

In recent years the antennas for the collective reception/procedure of radio broadcasting are developed. The use/application of such antennas makes it possible to select the most advisable site of installation of antennas, in which the best audibility and the minimum level of man-made interferences are provided.

Short-wave antennas for the radio communication and the broadcasting.

For the radio communication on the short waves range symmetrical radiators/resonators/elements and dual rhombic antennas developed in the USSR are commonly used.

As the transmitting antennas for radio broadcasting cophasal broadband antennas with the passive reflectors are constructed predominantly. A number of landings and sections of these antennas is selected depending on the length of the route of radio broadcasting. Wide application obtained broadside antenna arrays with the aperiodic reflector, made in the form of grid from wires [8].

The general view of two-section four-storied antenna with the aperiodic reflector is shown in Fig. 4.

The absence of tuning elements, the possibility of the suspension of two fabrics of antenna along both sides from the reflector and very low radiation level in the rear quadrants are the important special features/peculiarities of these antennas. Antenna with the aperiodic reflector can effectively be utilized in the twofold wave band, and with some assumptions relative to the form of radiation pattern - in considerably the wider wave band.

In recent years in the USSR the broadside antenna arrays with the range reflector are developed and introduced. There are two versions of these antennas: antenna with bridge circuit of the feed of reflector [9, 10] and antenna with feed of the reflector through directional coupler [11, 12]. The fact that tuning/adjusting reflector is retained in the sesqui-di-fold range, is the distinctive special feature/peculiarity of these antennas. Antennas have a good natural agreement with the feeding line in the operating range indicated. By a deficiency/lack in the antennas is loss 10-30% of energy in the absorbing lines, necessary for their normal operation.

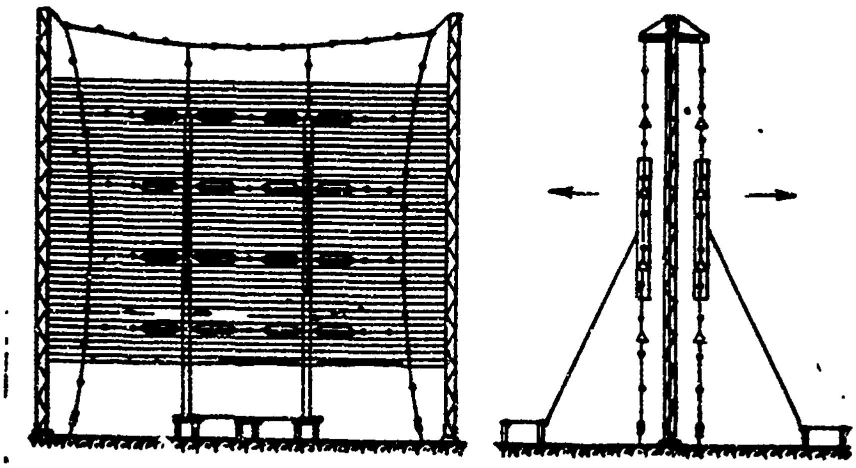

Fig. 4.

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Abroad for radio broadcasting on the short waves considerable use/application obtained log-periodic antennas from the horizontal dipoles. Just as medium-wave log-periodic antennas, short-wave log-periodic antennas have the independent of the wavelength radiation pattern. This special feature/peculiarity of log-periodic antennas is important for radio broadcasting, where the irradiation of the sector of the specific width usually is required. The schematic of inclined log-periodic antenna is shown in Fig. 5 [13].

In the USSR the original version of log-periodic antenna [14] is developed. The fabric of this antenna is oriented vertically. Antenna has aperiodic reflector, which makes it possible to hang up two antennas, which have mutually opposite directions of maximum radiation/emission, on one and the same supports. Antenna consists of the 3rd in parallel connected fabrics, which is made for the purpose of an increase in the antenna gain.

On the short waves as the nondirectional vertical radiators the pneumatic antennas, made analogously with the described above pneumatic medium-wave antennas are applied also.

For the professional/occupational-reception/procedure of connection/communication and programs of radio broadcasting in the receiving centers the predominantly doubled antennas of the taking wave with the effective resistance to the connection/communication between the radiators/resonators/elements and collecting line [15] are utilized. These antennas are characterized by very low side-lobe level and by respectively high interference shielding. For further increase in the interference shielding the spaced antennas, which consist of three dual antennas of taking wave [16], are constructed. Antenna is usually supplied with phase inverter for the control of radiation pattern in the vertical plane.

Experience of operating the antennas of the taking wave with the effective resistance to connection/communication showed that they on the interference shielding considerably exceed rhombic antennas, including dual rhombic antenna, and also antenna of the taking wave with the capacitive coupling, used abroad.

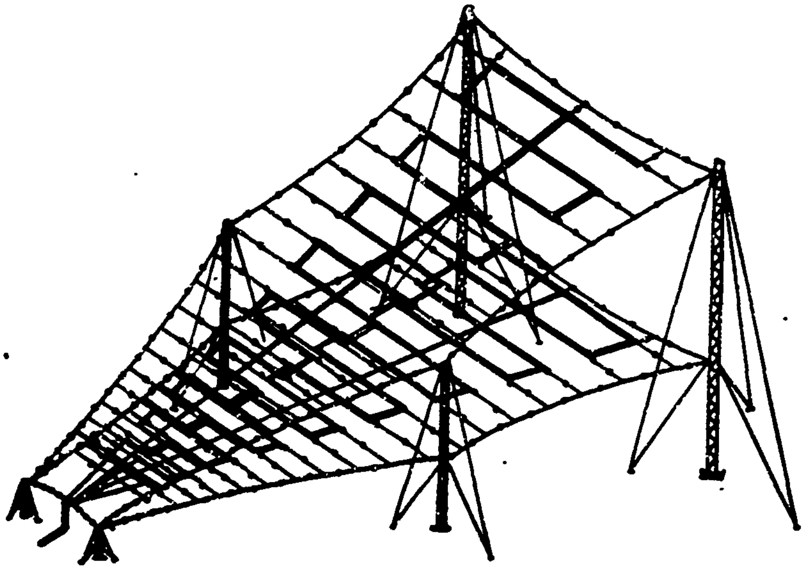

Fig. 5.

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It should be noted that for guaranteeing the stable work of these antennas it is necessary that the coupling resistance would be designed for scattering of considerable power. Otherwise their combustion with the thunderstorms is possible. The use of coupling resistance, designed for scattering of the power of 10 W, virtually removes the danger of combustion with the thunderstorms.

A very interesting trend in development of receiving short-wave antennas is the creation of the universal strongly directed antenna systems, suitable for the simultaneous work of many receivers on different waves and in different directions. The use/application of such antennas makes it possible to save means and to shorten the territory of antenna field.

The short-wave lens of Luneberg, which is the cylinder, filled with medium with the variable/alternating/variable phase speed, is one of the versions of an antenna of such type. Phase speed increases in proportion to movement from the center to the periphery. During irradiation of this cylinder by the source of cylindrical wave at the output of lens under the specific law of a change in the phase speed the wave front becomes flat/plane. Respectively radiation pattern is narrow, moreover the width of radiation pattern is narrower, the greater the diameter of cylinder. The direction of maximum radiation/emission depends on the site of installation of irradiator (Fig. 6).

This lens can be used for the simultaneous independent work in different directions.

In the USA is developed Luneberg's lens [17] for the range of short waves. For the creation of medium with the variable/alternating/variable phase speed are utilized two circular disks, made from spark arrestor. The variable/alternating/variable phase speed in the space between the disks is achieved by the appropriate change in the distance between the disks. Disks pass into the cylindrical horn, whose height/altitude determines the form of radiation pattern in the vertical plane.

For the normal work of this antenna the high accuracy of the execution of grids and the retention/preservation/maintaining the invariability of their layout under any weather conditions are required. Furthermore, the work of lens can be disrupted during the coating with its ice-covered surface or with snow.

The circular antenna, which consists of the vertical radiators/resonators/elements, arranged/located in the circle/circumference around cylindrical aperiodic reflector [18], is one of the versions of the receiving antenna, which ensures simultaneous work in different directions. Each radiator/resonator/element is equipped with the range amplifier and decoupler, through which the energy is supplied to a large number of receivers. Each receiver or the group of the in parallel working receivers has its system of the phase inverters, by which the individual direction of maximum reception/procedure is created. Such system allows/assumes simultaneous work of tens of receivers, moreover to each receiver or to the group of the in parallel working receivers corresponds its direction of maximum reception/procedure. The directed properties of antenna system increase with an increase in the diameter of cylinder.

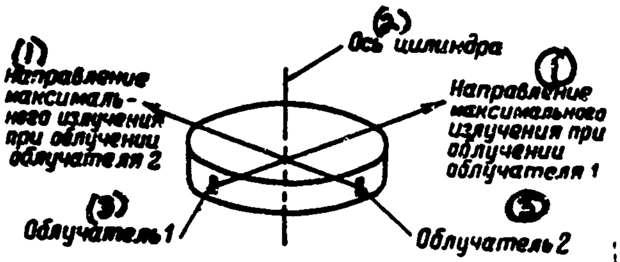

Fig. 6. Key: (1). Direction of maximum radiation/emission during irradiation of irradiator. (2). Axis of cylinder. (3). Irradiator.

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The use/application of the reception/procedure diverse of the polarization is one of the methods of space saving, occupied by antennas. The investigations conducted in the USSR showed that in the majority of cases the correlation of fadings with the diversity in the polarization differs little from the correlation of fadings with the three-dimensional/space diversity.

The diverse polarizational reception/procedure can be realized on the base of the use/application of two traveling-wave antennas, of which one is made from the horizontal ones and, etc. of vertical radiators/resonators/elements [16]. Latter/last antenna for space saving can be established/installed under the fabric of the first. The system of the diverse polarizational reception/procedure can be also realized on the base of the use of broadside antenna arrays, which consist of the horizontal and vertical radiators/resonators/elements with general/common/total aperiodic reflector [16].

In recent years the tendency of use/application in the region of the shortwave communication of cophasal horizontal antenna arrays with amplitude distribution according to the sections according to the law of Dol'f -Chebyshev was outlined. This amplitude distribution makes it possible to significantly lower side-lobe level. These antennas with the aid of the system of phase inverters can be used for the simultaneous reception/procedure in different directions.

Should be noted another outlined method of the solution of the problems of the suppression of the minor lobes of cophasal multivibrator antennas, based on the use/application of nonequidistant antennas, i.e., the antennas, which have the different distances between the sections. The distance between the sections increases from the middle to the edges, which gives the effect, analogous to the effect, created with the reduction of the amplitudes of excitation from the middle to the edges.

Antennas for the connection/communication on the ultrashort waves.

One of the forms of remote radio communication in the range of ultrashort waves is the connection/communication, based on the phenomenon of the dissipation of energy heterogeneities in the ionosphere.

To the antennas, which work on such lines, stringent requirements with respect to the suppression of the side-lobe level and maximum contraction of major lobe/lug are presented, that also determined the character of antennas for the ionospheric lines. On these lines are applied multistage binomial arrays, complicated Yagi antennas, corner optical-type antennas, antennas in the form of parabolic cylinders [19], etc. The antenna gain reaches to 400-500. The suppression of minor lobes can be intensified by appropriate amplitude distribution according to the sections of antenna.

When it is not possible to use the types of antennas indicated due to their high cost/value, are constructed antennas with the smaller factor of amplifications, which consist usually of several parallel-connected Yagi antennas.

For the essential propagation passed decade the connection/communication on the ultrashort waves, which is based on the use of a phenomenon of reflection from the meteor trails, was obtained. The antenna systems of such lines frequently are made from the Yagi antennas, connected in such a way that the diagram has two large lobes/lugs with the maximums at angle of 15° to each other. The latter is caused by the fact that on the meteor lines into the point of reception/procedure the signals, which are propagated at angles of 6-8° to the forward direction, fall predominantly. The form of radiation pattern indicated can be obtained, for example, by parallel connection of two spaced Yagi antennas, supplied with phase displacement, equal to 180°.

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For the connection/communication to the VHF wide application the helical antennas, antennas with the ground wave, log-periodic antennas, rhombic antennas, cophasal gratings, etc found. Helical antennas emit the field of the rotating polarization. This proves to be advisable when it is impossible to predetermine the most advisable orientation of the vector of the strength of field.

For the conference service on VHF are utilized the antennas, similar to antennas for VHF ChM broadcasting (see below).

On the edges of moving objects slot antennas, cap antennas, cavity antennas, usual vibrator and optical-type antennas, etc are applied.

Antennas for television and VHF ChM of broadcasting.

In the early period of the construction of television centers multistage doughnut antennas were applied predominantly. Each landing of this antenna is satisfied of two mutually perpendicular radiators/resonators/elements, supplied with phase displacement, by the equal to 90°. This provides near-circular radiation pattern in the horizontal plane.

Essential deficiency/lack in the doughnut antennas - limitedness of the virtually attainable amplification factor. This is determined by the fact that the radiators/resonators/elements of antennas are fastened to the metal tubes of a small diameter and a sufficient mechanical strength can be achieved/reached at the overall height of the antenna, which does not exceed 12-15 m. Virtually the factor of amplification of doughnut antennas lies/rests within limits of 3-10. The inconvenience of maintenance/servicing and the impossibility of the antenna location of one above another are supplementary deficiencies/lacks in the doughnut antennas.

Because of the development of multiprogramming television and the emergent need for the installation/setting up of several antennas on one support, and in connection with the tendency to also raise the effectiveness of antennas by an increase in the number of landings developed the diverse variants of panel antennas.

In the USSR is developed the version of the panel antenna, which consists of of the supported by the metallic struts symmetrical cylindrical radiators/resonators/elements with the aperiodic flat/plane reflector. Nondirectional radiation in the horizontal plane can be obtained during the arrangement/position around the support of four panels. Panel antennas can be assembled on the supports of large cross section, which makes it possible to make antennas with the high amplification factors and to have available several antennas one above another on one support. The coefficient of overlap of panel antennas ranges from 1-1.4 to 1-1.7, amplification factor reaches to 20-50.

The version of antenna developed in the USSR is very convenient in structural/design sense with the radial bolt radiators/resonators/elements, adjusted directly on the support (Fig. 7). During the arrangement/position on the support with a diameter of 0.7 λ of eight bolt radiators/resonators/elements in one landing, supplied on the diagram of rotating field, it is possible to obtain sufficiently uniform radiation/emission in the horizontal plane and sufficiently good agreement in the band of frequencies of order ±8%. Antenna with the radial radiators/resonators/elements is realized at the all-Union radiotelevision station in Moscow.

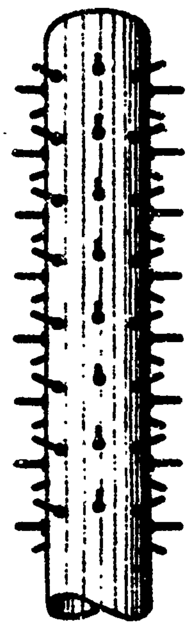

Fig. 7.

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Are of interest antennas in the form of the spiral, wound up around the square or circular support (Fig. 8). During the correct selection of the diameter of turn, space of coil/winding and number of turns this antenna has a good diagram in the vertical plane and uniform radiation/emission in the horizontal plane.

In the range of decimeter waves slot antennas frequently are applied. The antenna, made from the tube with the vertical slots gashed in it is most typical slotted antenna, which obtained wide application abroad. Antennas of such type are very light. The factor of amplification of slot antennas attains 20-30 in comparison with the half-wave dipole. Slot antennas have comparatively narrow of passband and therefore for each channel individual antenna is required.

Considerable attention in recent years was paid to questions of an improvement in the directed properties of antennas in vertical plane [20]. If we do not take special measures, then on the earth's surface 30-40% of emitted power fall only, and the remaining emitted energy is lost uselessly. Furthermore, in a radius of several kilometers from the antenna are formed the zones of poor reception/procedure, which correspond to the directions of deep minimums in the antenna radiation patterns.

Were developed the methods of obtaining the radiation patterns without deep minimums and with the direction of maximum radiation/emission, inclined toward the earth/ground. The most ideal method is the power supply of the landings of antenna with such phase displacements, in which their fields store/add up cophasally at angle of 2 θ, where θ - angle of the visibility of the horizon/level from the point of antenna location. In this case on the earth's surface 60-70% of emitted power fall. A sufficient filling of the minimums in the antenna radiation pattern is obtained, if in one or two landings of antenna the currents, out of phase on 90°, are created.

During the development of the schematics of antenna feed and feeding lines primary attention is paid to the decrease of reflections. Large positive effect gives the method of mutual multiple-echo compensation, based on what the uniform elements/cells of circuit, supplied in parallel, are connected by the sections/segments of the lines, which differ along the length on λ/4.

With VHF ChM broadcasting are applied the same antennas, as for the television, only with a comparatively small number of landings.

The feed of television antennas is supplied almost exclusively along the coaxial hermetically sealed lines.

For the reception/procedure of television are applied symmetrical radiators/resonators/elements, Yagi antennas, etc., usually adjusted on the roofs of houses or on the high supports. The antennas widely used in the USSR for the collective reception/procedure of television consist of strictly antenna, high-frequency amplifier and distribution feeders, which supply energy to separate television sets [21]. The possibility of the selection for them of the most advantageous site of installation is the most important advantage of master antennas, during which the intensity/strength of the field of ray/beam, which goes directly from the television station, has maximum value, and the strength of the field of the rays/beams, reflected from the surrounding buildings, is minimum. In the Soviet Union for the collective reception/procedure of television are applied predominantly the Yagi antennas. In order to distribute energy with the minimum losses are utilized the directional couplers. In recent years the tendency toward the creation of the systems of collective reception/procedure, houses operating group was outlined.

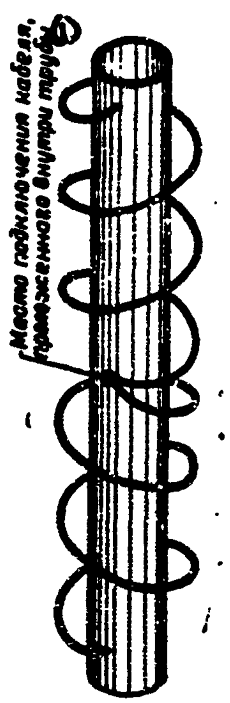

Fig. 8. Key: (1). Place of the connection of the cable, laid inside labor/work.

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Antennas for the radio relay lines.

On the radio relay lines of sight the transmitters of a comparatively small power (1-10 W) are applied. This fact and high requirements for the quality of the transmission of television, telephony and other forms of information, transmitted by the radio relay lines, lead to the need for applying antennas with the high factor of amplification (30-45 dB) and respectively greater effective surface. The use of antennas with considerably larger amplification factors is hindered/hampered by the need for the installation/setting up of these antennas on the pads, placed on the towers or the masts by height/altitude to 100 m and more. Frequency modulation requires the careful agreement of all elements/cells of the antenna-waveguide circuit to avoid the appearance of the waves reflected.

On the main-line radio relay lines frequently for the work of transmitters and receivers in both directions are applied only two frequency bands. In this case the extremely high requirements for the protective action of antennas are presented. Receiving antennas must weaken/attenuate the reception of the signals, which arrive from behind, on 65-70 dB. The analogously transmitting antennas must to the same degree weaken the signals, emitted in the opposite direction.

The facts indicated led to the wide application on the radio relay lines of the USSR of horn-parabolic antennas [22]. Fig. 9 shows the general view of horn-parabolic antennas. Horn feed directly is poured in the common construction/design with parabolic reflector therefore, and also to the presence in the antenna of two side metallic walls ("jaws") is created a good radiation pattern. Lobes/lugs in the rear quadrants are weakened to the level - (65-80) dB. Is very low general/common/total sidelobe level. Antenna will agree well with the feeding waveguide. The opening/aperture of antenna is usually closed by sheet from the foam plastic or another special material for the protection from the sediments/residues and moisture.

The plumbing, which feeds antenna, and sometimes also antenna itself thoroughly they are hermetically sealed and are filled by dried air, which has overpressure for the preservation of the penetration of moisture.

In recent years on RRL of the USSR the two-mirror antennas of Cassegrain began to be introduced. The schematic of this antenna is shown in Fig. 10.

Fig. 9.

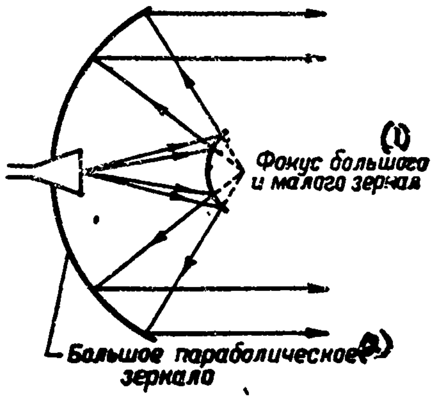

Fig. 10.

Fig. 10. Key: (1). Focus of large and small mirrors. (2). Large parabolic reflector.

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Antenna consists of fundamental parabolic reflector and small auxiliary mirror. Energy is supplied to the horn, placed at the apex/vertex of paraboloid. The radiation/emission of horn is directed toward the auxiliary mirror, which has the form of the hyperboloid of rotation, usually. The rays/beams, reflected from the auxiliary mirror, have phase center in the focus of hyperboloid. If this center is combined with the focus of paraboloid, then antenna system works in the manner that if the phase center of irradiator was combined with the focus of paraboloid. The installation/setting up of irradiator at the apex/vertex of paraboloid makes it possible to feed/conduct the feeding waveguide by more convenient shape to it. Furthermore, and this is especially important, auxiliary mirror facilitates the selection of the most favorable amplitude distribution in the aperture of paraboloid and a comparatively high coefficient of the use of a surface (KIP) of mirror provides thereby. KIP of two-mirror antennas with their careful fulfillment reaches to 0.55-0.65. Two-mirror antenna in comparison with the usual parabolic antenna has the lower level of lobes/lugs in the rear quadrants, which, as it was indicated above, is very important during the use of these antennas on RRL, which work along the two-frequency system.

In recent years in the USSR improved two-mirror antenna [23] is developed. Antenna circuit is shown in Fig. 11.

Antenna relates to the class of two-mirror antennas. Large mirror is the body of revolution of the sections/segments of paraboloid with the focus, placed near a small mirror. A small mirror is the body of revolution of elliptical line. In each this plane one of the foci of ellipse coincides with the phase center of horn feed. In the space the focal circle/circumference is formed, whose each point is focus for the appropriate irradiated line of paraboloid.

Fig. 11 shows the passage of the rays/beams, which fall from the phase center of irradiator on the extreme points of elliptical line. Return flow of energy is passed by irradiator and it does not fall into the feeding line. The absence of return flow of energy creates conditions for the high antenna matching with the feeding line over a wide range of waves.

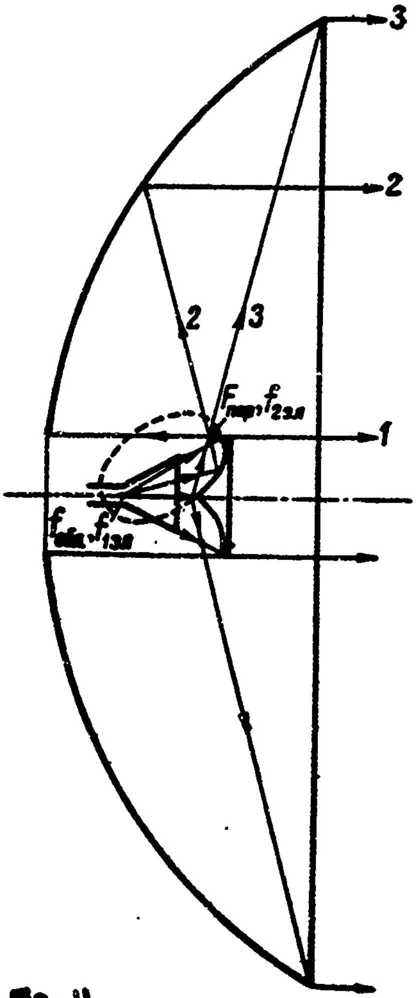

Fig. 11.

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If horn feed has maximum radiation/emission in the direction of its axis, then in the selected diagram a comparatively uniform irradiation of large mirror is obtained, since an increase in the path length of rays/beams to the edges of large mirror and weakening caused by this of the strength of field to a considerable degree is compensated by the form of the amplitude radiation pattern of irradiator. The more even distribution of amplitude of the strength of field in the aperture of mirror makes it possible to obtain comparatively high KIP of antenna. The described antenna system was proposed independently in the USSR and abroad (France, USA).

On the radio relay lines, which use four service bands of frequencies, the decoupling between the signals, which go from right to left and from left to right, is provided by the frequency selectivity of high-pass filters [24] and receiving equipment. On such lines it is not presented such stringent requirements for the suppression of lobes/lugs in the rear quadrants. This makes it possible to apply less qualitative antennas, for example periscopic and paraboloids of revolution.

The investigations, which have an improvement in the parameters of periscopic antennas, as a goal are conducted in order to create the possibility of their use for they are two-frequency RRL.

The antennas of radio relay line, as a rule, are connected with the transmitting and receiving equipment by waveguides. Circular waveguides most frequently are applied. One such waveguide replaces two waveguides of rectangular cross section, intended for transmission channels and reception/procedure. The decoupling between the transmitting and receiving channels in the circular waveguide increases because of the mutually perpendicular orientation of the transverse structure of electromagnetic field of the wave of transmission channels and reception/procedure.

In recent years elliptical waveguides are developed. They have a section of elliptic form and are made from the fluted copper tape (Fig. 12). Mechanical flexibility is the special feature/peculiarity of these waveguides, which makes it possible to fulfill them in the form of the homogeneous tube (without the collars) of virtually any length, coiled up. This facilitates the assembly of waveguides on RRL lines.

The distance between the adjacent points/items of tropospheric radio relay lines is 200-350 km. Between their antennas there is no straight/direct visibility, and connection/communication is supported via the reception/procedure of the rays/beams, scattered by the troposphere. With this character of connection/communication there is no necessity for the installation/setting up of antenna at the high altitude as on the radio relay lines of sight. It suffices to establish/install antenna so that the surrounding locality/terrain would not block the passage of horizontal rays/beams. This facilitates the use/application of antennas with the large effective surface of aperture - to 200-400 m^2. Preferred propagation received paraboloids of revolution and parabolic antennas with the outlying irradiator.

On the tropospheric lines the doubled reception/procedure on two diversity-reception antennas usually is conducted. Therefore on the intermediate points/items of relaying four antennas are established/installed. For the transmission the same antennas are utilized. The transmitting and receiving circuits are untied on the base of frequency and polarizational selection [24]. Fig. 13 shows the general view of the antennas of the tropospheric line of communications.

Very important direction in RRL region is the use of passive relaying, i.e., the points/items, on which the receiving-transmitting equipment is absent. Signal in them is accepted and is transmitted only by antenna systems.

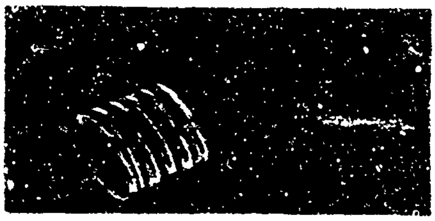

Fig. 12.

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There is special interest in the use/application of passive relaying in the mountain areas, where frequently are encountered the almost inaccessible places, in which the installation/setting up of active relaying is extremely undesirable. Furthermore, the mounting of active points/items in such places requires large capital investments.

Passive relaying sometimes is made in the form of two antennas (Fig. 14a). The second form of passive relaying is shown in Fig. 14b. Passive relaying consists of two flat reflectors. This form of passive relaying is convenient in structural/design sense. However, the use/application of these passive relaying is accompanied by great difficulties. The fact is that the replacement of active point/item by passive leads to a sharp decrease in the energy potential of line, since the receiving-transmitting equipment increases the energy potential of line on 60 dB and more. Partly energy potential is compensated by an increase in the effectiveness of antennas on the active points/items; however, in essence this compensation must be achieved by use/application on the passive points/items of antennas with the high amplification factor. The antenna gain on the passive points/items must be many times of more than the antenna gain on the active points/items. Respectively many times the surface of passive relaying must be more. The latter leads to a sharp increase in the cost/value of passive relaying, which substantially limits the region of their use/application.

In the Soviet Union is proposed the original diagram of passive relaying of the type "obstruction" [25, 26], characterized by very low cost/value, even if the surface of these antennas many times of more than the surface of the antennas of active points/items.

Fig. 13.

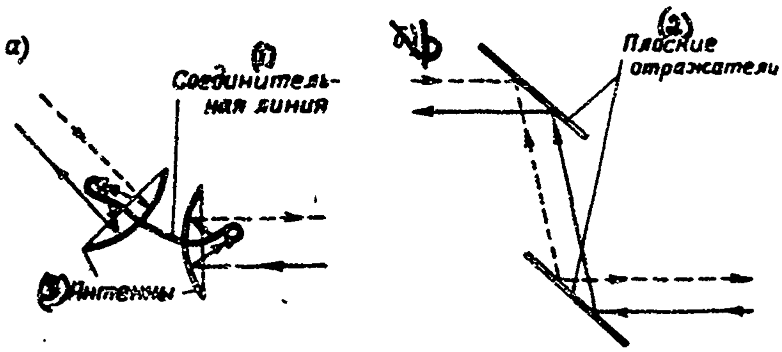

Fig. 14. Key: (1). Junction. (2). Flat reflectors. (3). Antennas.

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The high cost/value of the antennas, shown in Fig. 14, is explained by the fact that they require the high accuracy of fulfillment, also the high rigidity of the construction/design of both the antenna and the supports. Passive relaying of the type "obstruction" does not require a precise and rigid execution of antenna. The diagram of passive relaying of the type "obstruction" is shown in Fig. 15. Relaying is metallic lattice ("obstruction"), impenetrable for the radio waves, suspended/hung from two supports of those adjusted between the active points/items.

Because of the wire gauze in the front of the wave, which passes in its plane, is formed the region, where the strength of field is equal to E=0. According to the complementarity principle of Babinet this front emits just as the front, in which field intensity in the region of grid is equal to certain value of E, and in the remaining plane E=0. Thus, the darkened region operates as the excited antenna with the area of the same value. Since wire gauze must only block the passage of wave, then it is not required its precise fulfillment.

Height/altitude and curvature of the edges of obstruction are selected so that the region of blackout would coincide with one of the Fresnel zones for the active points/items, between which it was established/installed.

The area of passive relaying reaches S_n =500 the m², i.e., 50-60 times more than the area of antenna aperture S_a of active point/item and into the same number of times has larger amplification factor. Since one passive relaying replaces receiving and transmitting antennas, then general/common/total gain in the amplification factor is equal to $\left(\frac{S_n}{S_a}\right)^2$. Fig. 16 shows the general view of the passive relaying, established/installed in the mountains on one of RRL.

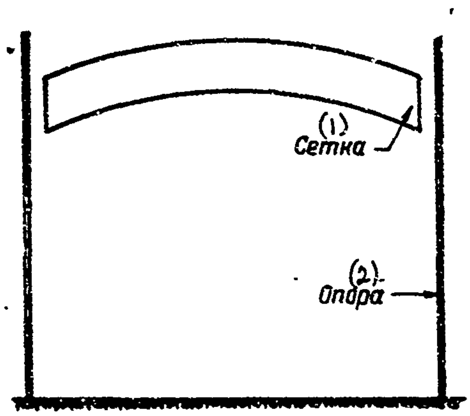

Fig. 15. Key: (1). Grid. (2). Dough.

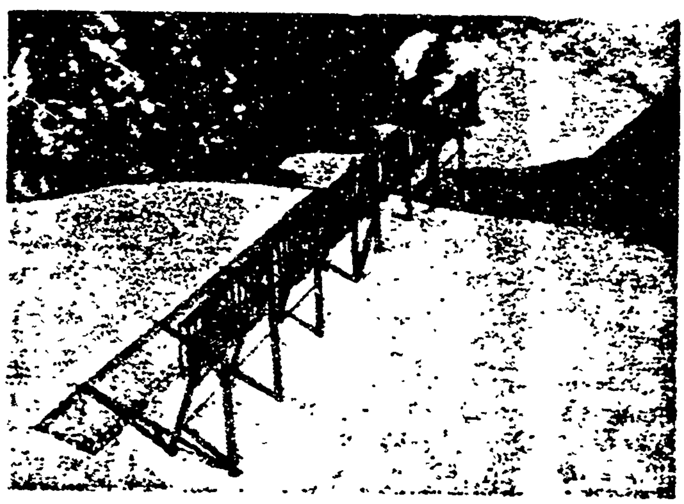

Fig. 16.

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Antennas for the space communication.

Onboard antennas for the space communication have wide radiation pattern and respectively low amplification factor. This fact, and also the large removal/distance of satellite from the ground-based antenna requires use/application at the ground station of the transmitter of large power and antenna with the high amplification factor.

Antennas with area on the order 100-450 m² in practice are applied. In view of the high cost/value of ground-based antennas for the space communication, as a rule, one and the same antenna is utilized for the transmission and the reception/procedure. For the tracking the satellite, on which relay equipment is established/installed, rotary devices/equipment, and also automated homing system are necessary.

In order to decrease the noise temperature of antenna, and also to reduce to a minimum of interference between the system of satellite communications and land lines of communications, should be decreased the side-lobe level of ground-based antennas. The stability of connection/communication with a change in the polarization on the satellite lines of communications is provided by the use/application of antennas with the circular polarization of field.

The horn-parabolic and axisymmetric two-mirror antennas (see above), most fully satisfy the stated requirements.

The first lines of space communication were constructed on the base of the use of horn-parabolic antennas. However, subsequently only two-mirror antennas were adopted.

During the first stage of the introduction of space communication were applied the antennas with the radio-transparent shelter, intended for their protection from atmospheric precipitations (snow, sleet), and also for decreasing the wind load on the antenna. Wind pressure can deform the profile/airfoil of antenna and worsen/impair its parameters, and sometimes cause the complete disturbance/breakdown of connection/communication. But in the process of operation it came to light, that the radio-transparent shelters sharply increase noise temperature during the rain. Therefore on the space lines for the transmission televisions and connection/communication from the use/application of such shelters refused. This, naturally, it led to the need for the execution of antennas and rotary device/equipment with the increased rigidity.

For the Soviet communication system "orbit" are developed single-reflector antennas with the irradiator in the form of helical antenna [27]. The finish of radiation system, and also the high accuracy of the profile/airfoil of mirror made it possible to obtain the very good electrical parameters. KIP of the antenna of system "orbit" is equal to 0.65-0.7, the noise temperature at the orientation of antenna in the zenith - 30°K. The antennas of system "orbit" are suitable for the work under any climatic conditions.

The general view of the ground-based antenna of system "orbit" is shown in Fig. 17.

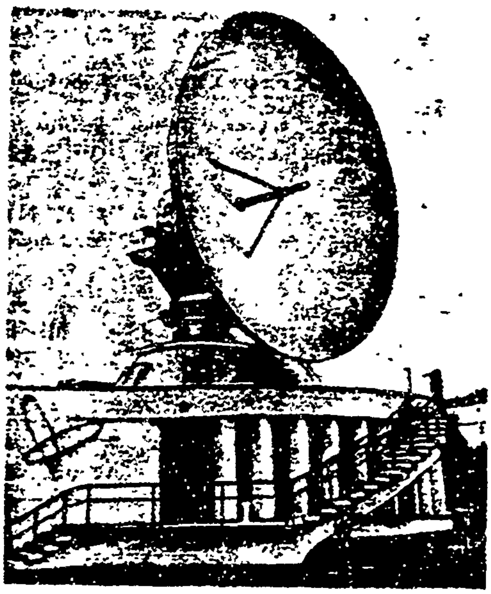

Fig. 17.

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