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## THE NEW METHOD OF ELECTRONIC SCANNING

В статті розглядається можливість використання реверсивних середовищ в антенній техніці, що дозволяє вдосконалити характеристики антенних систем, а саме, отримувати діаграму спрямованості антени необхідної ширини та форми, а також керувати її формою під час сканування за заданим законом.

This article investigates the possibility of using the reversing mediums in the antenna engineering that gives us the ability to improve characteristics of the antenna systems; particularly we can receive the adjusted form and width of the directional diagram in the microwave range and we can also command the directional diagram while scanning within the adjusted rule.

**1. Introduction.** The antenna systems are integral parts of modern radio aids. They are used to define the direction for the evolving source or investigating positions of many evolving sources in the ambient space. Thus, the problem of operative scanning and manipulation of the directional diagram form is one of current importance for today. Accordingly, the antennas have turned into one of the determinant link of radio systems. They are not just the equipment for extension of the radio communication distance. The limit possibilities of the modern radio-locating stations, particularly, their radio communication distance, exactness of direction-finding and many other characteristics depend on technical conditions of antenna systems, above all they depend on the width of the directional diagram ray. The most difficult modern antenna systems in combination with the multi-channel routes have turned into the technical

analogue of the human eye. This ensures that we can have the radio-wave imaging [1].

Today the antenna engineering runs up to the ripe degree. As a result of this fact the further development of the antenna systems does not follow the path of creation of fundamentally new antenna types, but improvement of their characteristics and introduction of new methods of their application. For all that, the appearance of new ideas in the antenna engineering is stimulated by the necessity of creation of radio systems with certain characteristics.

This article investigates the possibility of using the reversing mediums in the antenna engineering that gives us the ability to improve characteristics of the antenna systems; particularly we can receive the adjusted form and width of the directional diagram in the microwave range and we can also command the directional diagram while scanning within the adjusted rule [2].

**2. Method of electronic scanning.** Scanning is the transference of a ray in the space. There are a lot of different methods to realize it, such as mechanical, electromechanical and electrical ones.

The mechanical method of scanning is realized at the expense of turning the whole antenna construction. That's why the speed of survey is very limited, and as a consequence the energy expenses are rather high.

The electromechanical method of scanning is realized at the expense of using electromagnets or electric motors that turn one or more elements of the antenna construction. This method is based on turning the equiphase surface in the fixed antenna aperture. The electromechanical method provides a higher operating speed than the mechanical one, because moving elements have less weight than that of the whole antenna construction.

However, mechanical and electromechanical methods of scanning can not satisfy modern demands of round-up's speed and possibility of tracing for transference of many objects at the same time.

The electrical method of scanning provides the highest speed of scanning. This method is based on regulation of gain-phase distribution of the illumination in the fixed antenna aperture with the help of electronic-operated devices, such as semi-conducting or ferrite phase shifters and commutators. The operation speed of scanning is limited by the response time, which is caused by the time constants of electrical links. This response time is noticeably lower than the mechanical response time in two previous methods.

The electrical method of scanning can be used to solve such problems as dynamic space scanning in the wide sector of angles forming directional diagrams with the necessary form, possibility of cophasal composing of signals, more complete extraction of the information from the incoming signals owing

to implementing modern methods of handling the signals, possibility of conducting the effective reflective surface of objects.

As a rule, electrical scanning is realized in the multiunit antenna array. There are phase, amplitude and frequency electrical scanning.

The phase method implies regulation of phase shifts on the lead in of separate senders of the antenna array while the amplitude distribution is almost fixed. The transference of the ray in the amplitude method is based on shifting the lead in of multi-beam antenna system. Thus, we have the commutation of partial directional diagrams.

The frequency method of electrical scanning implies conducting the phase shifts of antenna array's units based on shifting only the oscillation frequency, which demands creating special frequency-dependent schemes of illumination of the array units.

The implementation of this method is quite difficult because of some difficulties, such as phase errors in the antenna aperture caused by mistakes of some governors, increment of phasing adjustment, error and correlation of units while scanning; additional microwave capacity loss evolving in the governors; relative bandlimitedness connected with the possibility of appearing the secondary principal maximums, high initial and operational costs [3, 4, 5].

This article offers the method of electronic scanning of the directional diagrams of the reflector antennas which implies making the antenna reflector of reversing materials. The peculiarity of the reversing medium is that it is radioparent, but after experiencing the influence of the keying signal, it acquires the features of the reflective surface.

We know that the structure of the energy spectrum is the main factor which determines the electroconductivity of some substances. Dielectrics have a wide forbidden gap, that's why transition of the electrons to the conducting band while the influence of the thermal excitation is impossible. Metals do not have the forbidden band. Semi-conductors have the forbidden band of 0.01 – 5 electronvolt in width.

When the temperature is low and the power supply is absent, the semi-conductor does not conduct current, i.e. it is an insulator. When energy is supplied from outside, for example, while heating a crystal, there appears the possibility of the electrons transfer from the valence band to the conducting band.

The insignificant amount of admixture added to the pure semi-conductor can dramatically increase its electroconductivity. Its nature changes while the temperature is growing. As a result, the electroconductivity takes on mixed nature. While the temperature is growing, impurity levels weaken. Finally, at

the certain temperature the electrons transfer only from the valence band to the conducting one.

The increase of the admixture concentration in the semi-conductor decreases the size of the transition region between the impurity conductance and self-conductance. While the further increase of the admixture share, the energy of the active impurity center decreases. At some level of concentration it turns into zero, i.e. the semi-conductor becomes a semimetal. Such materials, when they experience low temperatures, show the features of metals; when the temperature is high, they show the features of dielectrics. Thus, the semi-conductor saturated with the admixtures can be used as the reversing medium which is conducted by the temperature [3].

We can see the similar effect when the semi-conductor is influenced by the light or electronic ray. While the constant temperature and absence of evolving, the electroconductivity of the pure semi-conductor or impure semi-conductor is called the dark conduction. After lighting the semi-conductor by some light with the energy of the photons, which is higher than the width of the forbidden gap of the pure semi-conductor or higher than ionization energy of the impure semiconductor, the additional nonequilibrium carrier of the charge appears in the conducting band. As a result, the electroconductivity of the semi-conductor grows.

The appearance of the photo-carrier causes the local changes of all the electromagnetic parameters of the material, such as reflection, refraction and transmission coefficients of the electromagnetic wave. Under the absence of light, the reversing medium possesses the small dark illumination and it is the radioparent medium.

We offer the method of scanning, which is based on the lighting the surface of the reversing medium with the intensive light spot of the necessary size and shape. Changing this size leads to changing the width of the directional diagram and its shape in the given plane. It is obvious that the width of the directional diagram of the antenna depends on the size, shape and orientation of the light spot, e.g. it becomes narrower with the growth of the light spot. During the transference of the light spot on the surface of the reflector, we implement scanning of the directional diagram in the space. At the same time, the speed of scanning is limited only by the transmission speed of the reversing medium from the non-conducting state to the conducting, i.e. it is determined by the life time of nonequilibrium carriers of current, and by the speed of the light spot transfer; the rule of shift of the light spot disposition, as well as the directional diagram, can be arbitrary.

Thus, this method both makes it possible to generate the directional diagram with the given form and width in the microwave range and to

command the directional diagram while we are scanning, using the adjusted rule, that ensures the trajectory flexibility and the scanning high speed.

Semi-conducting material has to meet to some special demands including time lag, spectrum characteristics and mechanical properties. Moreover, it has to have the high amplitude and phase uniformity [6].

**3 Models of antenna systems.** The method of scanning suggested is the base of functioning of some antenna systems such as the multibeam reflector antenna and the multibeam spherical reflector one. In these systems the changes of electrodynamic parameters of different regions of the reversing material occur with the help of the influence of command signals on the inside reflector surface, that makes possible scanning the directional diagram in the space.

**3.1 Multibeam reflector antenna.** The reflector of the multibeam reflector antenna is the inside surface of the rotation body of the parabolic generator around the axis that is perpendicular to the focal axis and which passes through the focus of parabola. The reflector is made of the radioparent material, but its inside surface is covered by the reversing material. The antenna system has a source of command signals. The antenna system provides the possibility of the feed elements moving along the focal axis that passes through the focus of parabola. The structural arrangement is pictured on the figure 3.1.

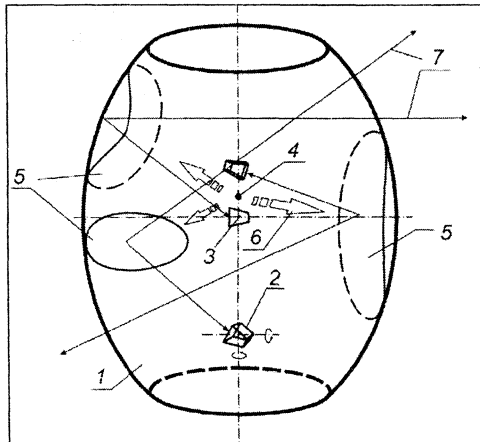


Fig. 3.1 – The multibeam reflector antenna

The device functions in the following way. The feed elements 2 are moved along the axis that is perpendicular to the focal axis, and passes through the focus of parabola 3. The source of the command signals 4 influences on the surface of the reversing material in regions 5 with the help of signals 6 on the reflector 1. The reversing medium possesses small dark illumination in the nonexcited state that's why the reversing medium is radioparent in this state. The intensive light spot influences on the reversing material and in these regions of the reversing surface we can observe the sudden changes of all parameters of the reversing material. They are conditioned by generating the nonequilibrium carriers of current, which change the electromagnetic characteristics of the reversing material. Thus, the reversing material acquires metallic features that makes possible to reflect electromagnetic waves. That's why more than one ray of the directional diagram is formed.

We can change in turn the conductivity of different regions of the semiconductor with the help of moving the spots of the command influence. As a result we have a circular scanning of the directional diagram rays in the space. The width of the directional diagram depends on size, form, and orientation of the excited regions.

Thus, the multibeam reflector antenna makes possible to form the multibeam directional diagram in the space with the circle scanning of the directional diagram rays [7].

**3.2. Multibeam spherical reflector antenna.** This antenna system has some imperfections; particularly we can not make the spherical scanning of the directional diagram in the space. This imperfection is removed in the multibeam spherical reflector antenna. The reflector of this antenna is formed with the help of rotation of the circle generator. At the expense of it the geometric form of the excited region of the reflector does not depend on the direction of influence of the command signal. That makes it possible to do the spherical scanning of the directional diagram rays in the space. Moreover, we can move the feed elements round the focal center sphere [8]. The structural arrangement is pictured on the figure 3.2.

**3.3. Multibeam scanning antenna.** The scanning method suggested is also used in the multibeam scanning antenna. This antenna system has a reflector, that is the inside surface of the rotation body of the parabolic generator around the line of symmetrization and the feed elements that are situated on the focal ring. The reflector is made of the radioparent material, but its surface is covered by the reversing material. The antenna system has the source of command signals. The antenna system provides the possibility of moving the feed



**3.4. Multibeam scanning double-reflector antenna.** This antenna system has some imperfections. We can not make the scanning sector wider, because the angle of the antenna aperture is constant for the reflector with a fixed diameter. Furthermore, the amplification and the width of the directional diagram are limited by the geometric size of the antenna reflector.

These imperfections are removed with the help of leading the additional parabolic reflector. The main reflector is situated in the aperture of the additional reflector. The focal center of the main reflector concurs with the focal center of the additional reflector. The inside surface of the main reflector and outside surface of the additional reflector are covered by the reversing material. Moreover, the antenna has the additional source of the command signals, which is situated on the underside of the additional parabolic reflector.

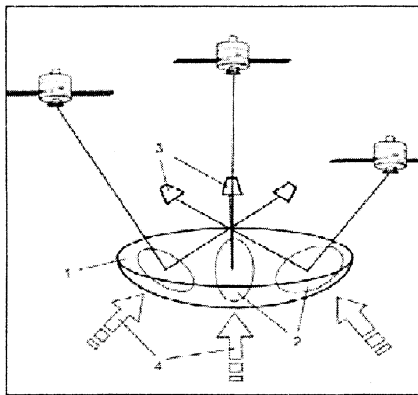


Fig. 3.3 – The multibeam scanning antenna

We can choose the necessary reflector and source of the command signals in accordance with the adjusted scanning sector and amplification. At the same time, another reflector is radioparent. The feed elements ensure forming more than one ray of the directional diagram. The possibility of choosing the parabolic reflector that will reflect the electromagnetic rays makes it possible to widen the scanning sector and form the directional diagram rays with a different width. The structural arrangement is pictured on the figure 3.4.

Thus, the method of electronic scanning offered in this article has some advantages which appreciably extend the possibilities of its further use that we



can see in the offered models of the antenna systems. The further development of the antenna engineering will expect increasingly fast-acting and flexible systems with expanded functions of the data handling that can ensure only electronic scanning. The result of this investigation is the offered method of electronic scanning with the help of reversing mediums which can be used in the radio engineering complexes [10].

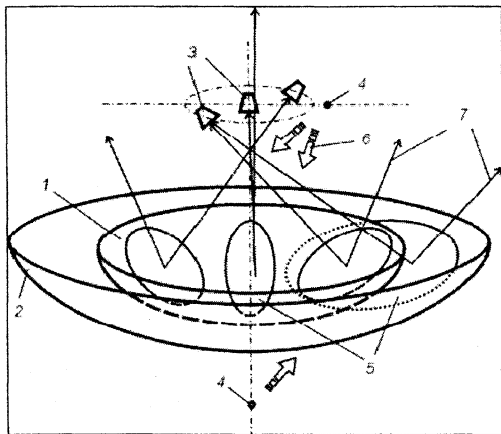


Fig. 4 – The multibeam scanning double-reflector antenna

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