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THE MAIN DEVICES FOR GENERATING AND PROCESSING MICROWAVE SIGNALS AND FIELDS

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A B S T R A C T	K E Y W O R D S
The article presents microwave devices used in non-destructive testing. They are built on the basis of waveguides, which is typical for the three-centimeter and eight-millimeter microwave ranges.	Phase shifters, valves, attenuators, sewage devices, attenuator.

Introduction

Such devices include: emitting and receiving devices, attenuators, valves, phase shifters, directional couplers, detector sections, tees, resonators, matched loads, specially shaped waveguide segments, measuring lines and waveguides.

Most of these microwave devices used in video resolution control are based on waveguides, which is typical for the three-centimeter and eight-millimeter microwave ranges.

The emitting and receiving devices (antennas) used in radio wave monitoring can be made in the form of a horn, an open section of a waveguide , slits or a waveguide with a dielectric insert , which is determined by the required locality of control, the required sensitivity of the equipment and the specifics of the specific task. For example, an emitter and receiver in the form of a horn provides good alignment of the waveguide path with the external space and with the controlled object, which provides large signal amplitudes, but leads to a deterioration in the locality of control.

Types of emitting and receiving devices used in radio wave control: a is the horn; b is the flange of the waveguide; c is the section of the waveguide; d is the tapering end of the waveguide; e is the slit; e is the waveguide with a dielectric insert The use of a slit device in the form of a narrowing waveguide, on the contrary, increases the locality of control if the monitored object is located directly at the slit, but significant reflections of microwave vibrations from a narrow slice occur, which reduces the sensitivity of the equipment and leads to masking of the useful signal. Near the slice of the emitting or receiving device, the area that determines their interaction with the controlled object is approximately equal to the slice area. As the object moves away from the antenna, the irradiation zone expands in the form of a cone, the opening angle of which is greater the smaller the antenna size, i.e. approximately corresponds to the width of its radiation pattern. The area where microwave vibrations are emitted is most often filled with dielectric inserts in radiators and receivers, which improve the operation of these devices, as well as prevent the penetration of foreign objects and various contaminants into them. Based on the devices shown, more complex emitting and receiving devices can be created, for example, two-element ones that implement the self-comparison method in flaw detection or in the form of multielement antenna arrays. As follows from the principle of reciprocity, the same device can be used as a radiating or receiving device. The channeling devices of the waveguide or segments of coaxial lines with different cross-sections transmit the energy of microwave oscillations from the generator and the radiator or from the receiving device to the primary measuring transducer. Coaxial lines are used for the transmission of microwave energy over short distances. Strip lines are well combined with modern printing technology for the production of electronic equipment. Rectangular waveguides are most often used in radio wave monitoring devices , and sometimes round. In the field of the short-wave microwave range (eight millimeters and shorter), dielectric waveguides and devices based on them can be used.

The attenuator is used for discrete or smooth adjustment of the amplitude of microwave signals by changing the size of the cross-section of the waveguide, introducing inserts in which microwave oscillations are attenuated, or by using the polarization features of microwave oscillations.

The valve passes microwave energy only in one direction, i.e. only the incident wave, which is necessary for the operation of the microwave path in traveling wave mode and to eliminate the influence of the load on the oscillation source. The phase shifter makes it possible to change the phase of microwave oscillations to a fixed value discretely or smoothly and is a segment of a long line of adjustable length or with variable electrical parameters of the medium (c or e), which allows you to adjust the electrical length of the segment and leads to an additional phase shift, depending on the ratio of the electrical length of the segment to the wavelength.

The directional coupler has one input and two outputs, to which it transmits a certain part of only the incident or reflected wave to the desired waveguide of the microwave path. It can be used as a power divider in a certain proportion, as well as for adding or subtracting signals. The detector section (amplitude detector, rectifier) converts microwave oscillations into direct current signals or into signals proportional to the envelope of microwave oscillations. It is performed on the basis of a microwave rectifier device with a semiconductor diode. To increase the values of the output signals, the detector section usually contains a resonator part, which is tuned by a special piston to the resonance mode at the operating frequency. In equipment with analog signal processing, a sensitive microammeter, amplifier, or recording device is usually connected to the detector section. The mixing section is similar to the detector section, but it has two inputs to which microwave oscillations of two different frequencies are connected. As a result of their superposition and rectification, a component of the difference frequency oscillations is released at the output of the mixing section, which is much lower than the frequency of microwave oscillations and signal processing is much simpler. The tees have three or more waveguide branches and serve to separate the microwave energy flow or, conversely, to sum (subtract) microwave oscillations. The radio wave monitoring equipment uses an E-tee, an H-tee and a double tee . Consider the typical cases of using tees in radio wave monitoring equipmen. The direction of the electric field strength vector is shown). Let the microwave energy of the generator be supplied to branch 3 in the tee . Then, on branches 1 and 2 in cross sections equidistant from the center of the tee, the amplitudes of the electric field strengths will be the same, and the phases will be the same for the H—tee and have a 180° shift for the E-tee . In this case, the microwave energy will be divided equally between the two waveguides. If, on the contrary, two streams of microwave energy are supplied to branches 1 and 2, then microwave oscillations in waveguide segments 3 and 4 will be formed taking into account their phase. In particular, equal energy flows with the same oscillation phases will lead to a doubling of the oscillation energy in the branch of the 4 H tee and to the absence of vibrations in the branch of the 3 E tee. When the microwave oscillations in branches 1 and 2 are out of phase, the effect on the passage of microwave energy will be reversed - there will be no oscillations in branch 4 for the H-tee and a doubling of energy in branch 3 for the E-tee. The double tee (microwave bridge, double T-bridge) shown in Fig.3b has the features of both an E- and an H-tee and, in addition, allows signal processing in the microwave range. It is easy to see that microwave energy does not pass from the E-branch to the H-branch and vice versa. The simultaneous appearance of microwave oscillations in the E and H branches is possible only when microwave oscillations are applied to waveguides 1 and 2 with different amplitudes or with a phase different from 0 or 180 °. The properties of a double tee are often used in radio wave monitoring to obtain two channels necessary for comparing information from the control object and the sample (reference object). The quality of the double tee operation is characterized by the level of direct transmission of signals from E- to H-shoulder (or from H- to E-shoulder), which is usually 40-70 dB and occurs due to the asymmetrical arrangement of the elements of the double tee. To reduce the direct passage of microwave energy due to imperfections in technology, correction plates or adjustment pins are installed in the area of the junction of the E- and H-branches. When using polarization methods (to analyze the polarization of vibrations, parameters of an elliptical wave, etc.), a turnstile connection is used [2], which is usually implemented in the form of four cross-shaped branches and a circular waveguide located perpendicular and axially symmetrical to them.

Resonators [3] are essentially resonant circuits and with their help it is possible to perform the same signal transformations as with resonant circuits: to isolate vibrations of the required frequency, coordinate various elements with each other, change the values of currents or voltages, etc. Resonators can be made in the form of three-dimensional structures or segments of waveguides and long lines. Microwave resonators are rebuilt using pins, plungers, short-circuit pistons, plates and flexible diaphragms.

Matched loads are designed to be connected to the microwave path in order to absorb the incident wave and thereby eliminate reflections of microwave vibrations. They are made in the form of a blind segment of a long line, which has an active resistance equal to the resistance of the line (ZH = ZL).

The measuring lines are a segment of a long line with a slot for inserting the probe of the detector section. A probe is inserted into the slot of a segment of a long line, which can be moved along the line, which allows it to be placed in a place where the necessary ratio between incident and reflected waves is achieved and, accordingly, certain values of microwave oscillations (maximum, minimum, average) are obtained. The measuring line is precisely calibrated and allows you to measure many quantities that characterize microwave oscillations.

Waveguides are devices for determining the frequency or wavelength of microwave vibrations (in the simplest case, it is a short-circuited measuring line with calibrated element sizes).[4] .

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