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Investigation of disk resonators at super-high frequency

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In 1958 prof. A. M. Prokhorov made a suggestion to use two parallel planes, for example, in the shape of disks, as a resonator on millimetre and submillimetre waves [1].

Later on a resonator of this type was used as an absolute wavemeter (with accuracy of the order of 10^{-3}), absorbing cell of a radio spectroscope and resonator for masers [2, 3, 4].

A quality factor of such a resonator for the case of infinitive planes is given by the formula

$$Q = \frac{2\pi L}{\lambda} \Big/ 1 - K$$

where L—distance between the planes

λ —wavelength

K—reflection factor.

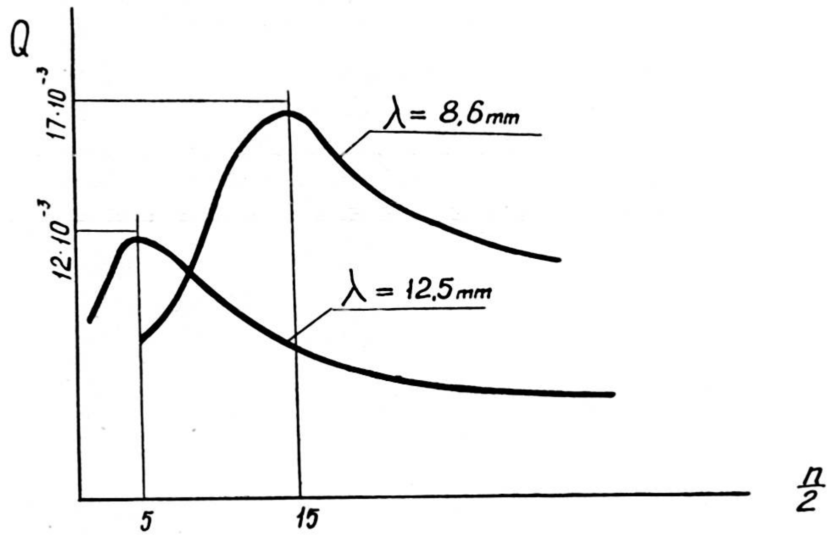

Fig. 1.

For the given system a linear character of dependence of the quality factor on the distance between the planes takes place until the energy is being lost only at reflections. At a sufficiently large L radiation losses of the energy also take place.

Figure 1 presents an experimental dependence of a quality factor of the resonator consisting of two parallel disks ($\mathcal{D}$ = 190 mm) on the distance between them for two wave—lengths.

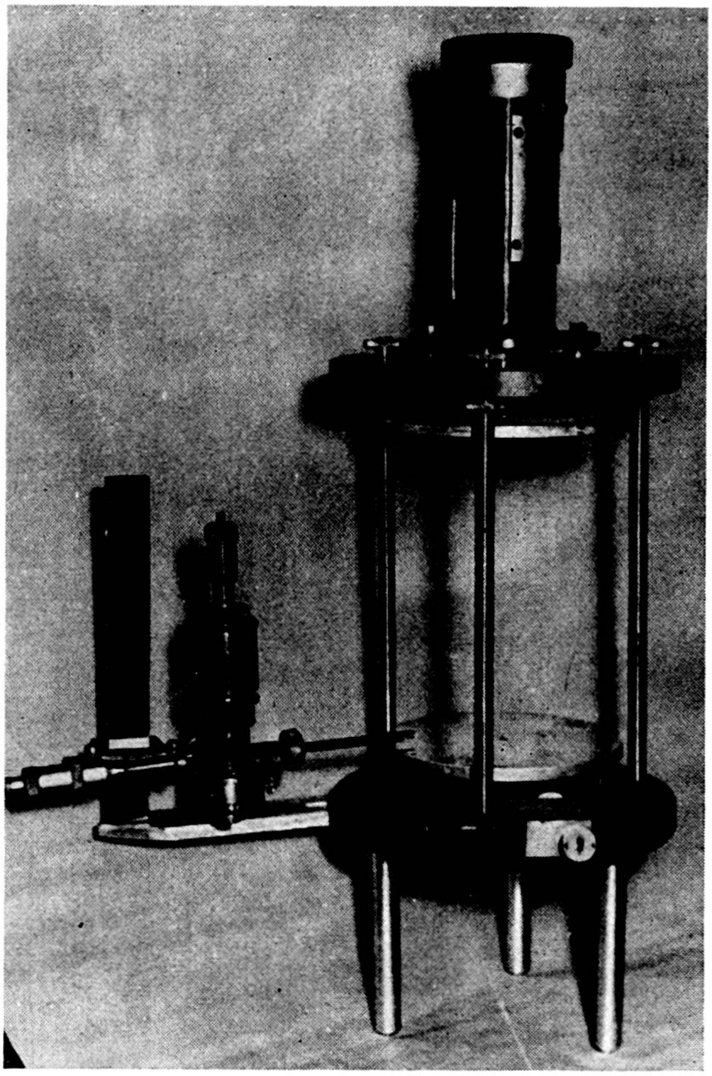

Fig. 2.

The value of the quality factor strongly depends on parallelism of the disks and on the cleanness of their surfaces. Considering the scheme, one can notice that the shorter the wavelength which excites the resonator, the greater the distance between the disks at which the maximum value of the quality factor is achieved. From the physical point of view it means that with decrease of the wavelength for the given system the electromagnetic field is compressed towards the central part of the resonator.

An investigation of the electromagnetic field structure in the disk resonator showed that wavelength in the resonator, in the direction normal to the plane of disks coincides with wavelength in a free space with the accuracy of 10^{-3}. This makes possible to use disk resonators as absolute

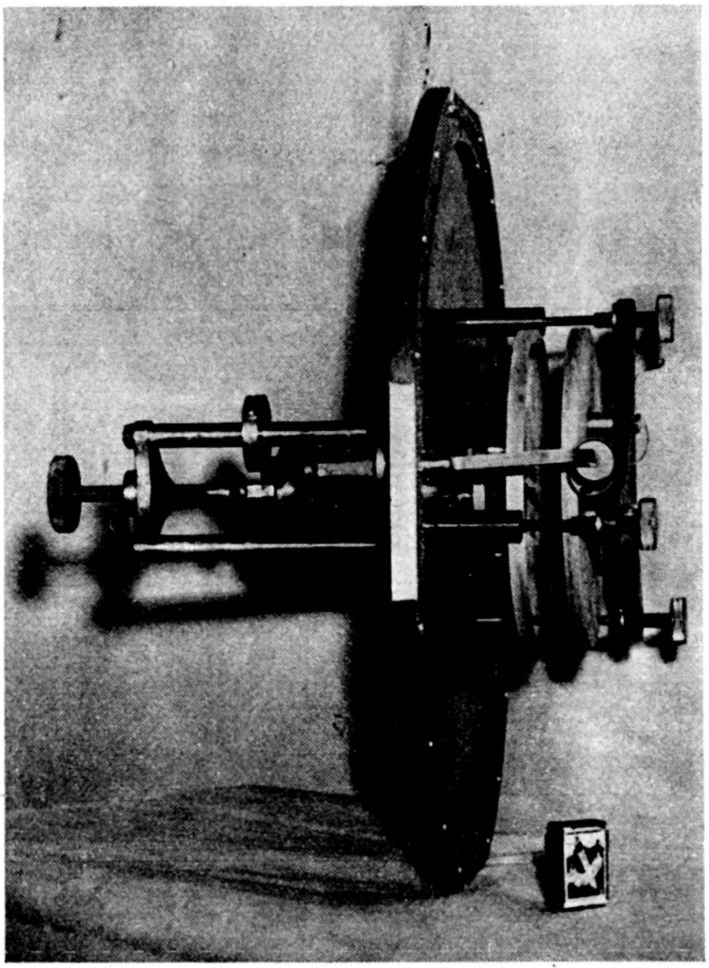

Fig. 3.

wavemeters. The number of types of oscillations excited in the disk resonator depends on the relation between the wavelength, disk size and distance between the disks. One can always select such relations that practically only one type of oscillations will be excited.

Figure 2 shows a disk resonator for the millimeter wavelength range. In gas spectroscopes with the Stark modulation disk resonators can be used as absorbing cells for measuring dipole moments of molecules. The absorbing cell of the type of a disk resonator has the advantage comparing to a waveguide cell that it does not require a preliminary calibration of the value of the modulating magnetic field. The electric modulating field is distorted only near the edges of the disks where an electromagnetic field is practically absent. Using the disk resonator as an absorbing cell of the gas spectroscope, we measured a dipole moment of the molecule of $CH_3 G_e H_3$. The obtained value $\mu = 0{,}644 \pm 0{,}005\ D$ coincides with the previously obtained values with the accuracy within the error.

Figure 3 shows the absorbing cell of a radio spectroscope. At present we carry out the work on investigation of the disk resonators for the purpose of designing masers. One of the advantages of the disk resonators in this application is that they allow to work with many beams and, thus, make it possible to oversize intensity of generation. In our installation designed for using 18 beams of ammonia (the line $J = 3$, $K = 3$) the line of an induced radiation is observed with 3 beams in operation (other beams are not mounted yet).

Accuracy of tuning the disk resonator on a maximum of the line is attained by means of using a rubber spacer between the micrometric screw and one of the disks. The distance between the disks is fixed by quartz poles with the lengths $L = \frac{\lambda}{2}$, where λ—operating length of the wave. Thus, by means of a slight pressing on one of the disks through the rubber spacer, it is easy to carry out a smooth retuning in a sufficiently wide region near the spectral line.

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