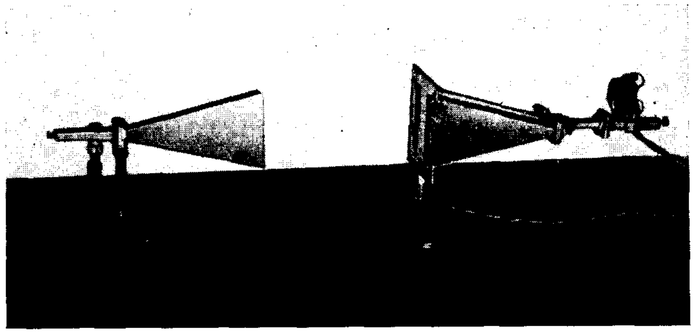

FIG. 3

increased or decreased in proportion. The radial waves from the radiator slits are received by a single E-plane sector horn mounted at a distance 1–2 m from the radiators. The amplification and the observation of the signal are effected by the already described method.

Demonstration. When the radiating system is rotated to the right or to the left from the central position and the klystron supply is disconnected but the horizontal sweep is turned on, the spot on the oscilloscope screen moves in synchronism.

When the klystron is turned on and the radiating system is slowly rotated, one observes visually (and by ear) the signal from the detector of the receiving antenna; the amplitude of the signal depends on the phase difference between the interfering waves from the two slits. An oscillogram of the phenomenon is shown in Fig. 4. The slight asymmetry of the outermost maxima is due to the nonlinear dependence of the voltage picked off the potentiometer on the angle rotation of the radiating system.

In conclusion we note that the experiment can be performed also in a different variant (which would be difficult to realize in the optical band), in which the radiator is a single horn, and the radio waves are received by a double antenna. To this end it is sufficient to interchange the waveguide segments containing the klystron generator and the detector. By rotating the receiving double antenna, it is possible to observe a similar interference pattern as in the first variant.

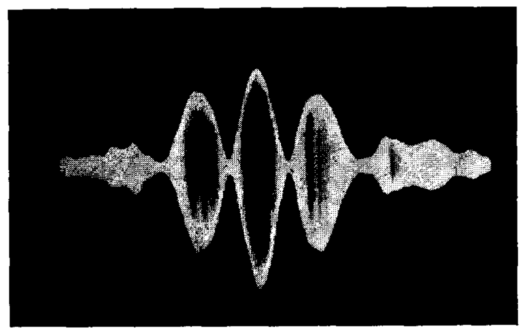

FIG. 4

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LECTURE DEMONSTRATIONS OF ACOUSTIC PHASE ZONE PLATES

B. Sh. PERKAL'SKIS and V. L. LARIN

Tomsk State University

Usp. Fiz. Nauk 96, 374–376 (October, 1968)

A zone plate, which blocks the sound-wave-front path sections corresponding to even or odd Fresnel zones, was proposed already by Rayleigh[1]. A description of its construction and use can be found, for example, in[2]. The construction of the zone plate that rotates the phase of the oscillations of half the zones is a much more complicated matter. The reason lies in the fact that the acoustic resistance ρ_c of any substance is so much larger than the corresponding value for air, that the sound waves are reflected from solids practically completely. A phase zone plate was constructed in the Physics Department of the Tomsk University. The method proposed by W. Kock[3,4] for the preparation of waveguide lenses was used. In this method the waves are made to move between inclined plates. In this case the path traversed by the sound in the waveguide was $1/\cos\theta$ times longer than its direct propagation in the medium, corresponding to an effective refraction index $n = 1/\cos\theta$ in the waveguide section of the path.

This principle was used to prepare at first plates introducing path differences $\lambda/2$ and λ between the sections of a wave front propagating through a plate and in free space. To this end, inclined strips of cardboard or tin plate were mounted in wooden frames at an angle of 45° to the surface of the frame. The width l of the strips was determined from the usual relation $d(n-1) = \lambda/2$ (or λ), which in our case, at $n = 1/\cos\theta$ and a strip width $l = d/\cos\theta$ takes the simple form $l - d = \begin{cases}\lambda/2 \\ \lambda\end{cases}$ (Fig. 1). For a half-wave plate and a wavelength $\lambda = 3/2$ cm, the width of the strip is 5.4 cm; for a full-wave plate the width is 10.8 cm (Fig. 2). The intervals

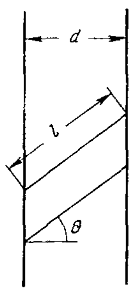

FIG. 1. Side view of plate.

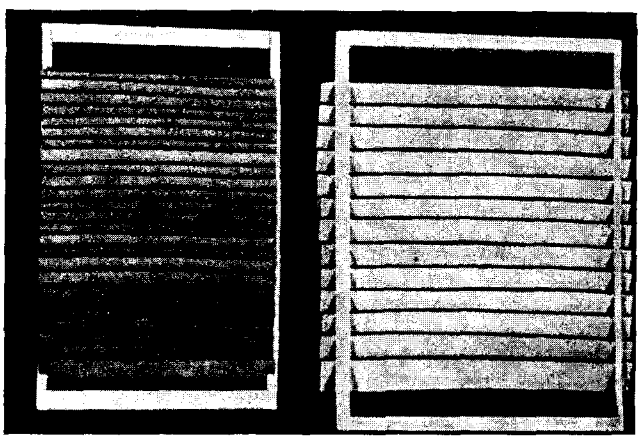

FIG. 2

between the plates are 2 cm and 4 cm* measured along the frame. The source of the sound is a dynamic speaker 2GD-21 fed from an audio generator. The generator frequency is chosen close to 10 kHz, so as to make the wavelength 3.2 cm. The frequency of the sound is adjusted after the plate is finished. To this end, it is desirable to have a sufficiently continuous control of the audio-generator frequency. The experiment is performed as follows: The dynamic speaker is placed at the focus of a spherical mirror so as to obtain a plane acoustic wave. The reception is with a 1-MD-35 microphone located in the focus of another spherical mirror. The voltage from the microphone is fed to a low-frequency amplifier 28IM (U2-1A), and then to an oscilloscope S1-1 (EO-7)† with the time sweep disconnected.

1. The plate introducing a path difference $\lambda/2$ is placed between the section of the wave front passing through the plate and another section propagating in free space, in such a way as to lengthen the path of half the wave front traveling to the microphone; it is observed that the reception amplitude decreases practically to zero (at the proper frequency). Covering the entire wave front by this plate demonstrates that the intense reception of the sound wave is resumed.

2. When a plate introducing a path difference λ between the section of the wave front passing through it and the section of the front moving in free space is employed, the reception is weakened very little if either the entire front or half the front is covered by the plate. When the plates are installed, it is important to prevent occurrence of intense standing waves between the dynamic speaker and the zone plate.

3. To prepare a zone plate with reversal of the oscillation phase, a cross piece is used, on which three rings of brass tubing are mounted; the ends of the tube are secured by means of a rod soldered in them. A tube of suitable length is first bent on a cylindrical surface. Strips of tin plate, producing an additional phase shift of 180° for waves passing on the inclined path between the strips, are soldered to the rings at an angle of 60°. Spherical acoustic waves are used (the mirror forming the plane wave is removed in this case). The dimension of the rings is calculated for spherical waves with $\lambda = 3/2$ cm, and for distances of 1 m each from the zone plate to the sound source and to the receiver. The radii of the central and succeeding Fresnel zones are in

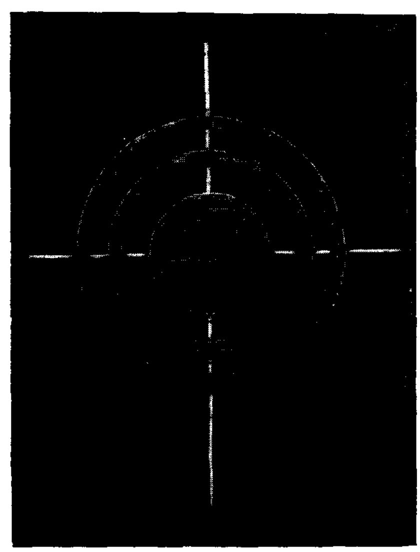

FIG. 3

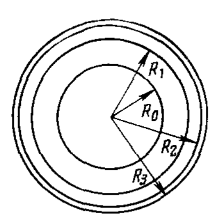

FIG. 4

*An interval of 4 cm was taken for a wave plate in order to weaken the reflection of the acoustic waves from the broad inclined plates.

†It is possible to modulate the 10 kHz carrier frequency by a lower audio frequency, and then, after amplification and detection, the low-frequency signal can be fed to the dynamic speaker.

this case $R_0 = 12.67$, $R_1 = 17.95$, $R_2 = 22.03$, $R_3 = 25.48$, $R_4 = 28.54$, $R_5 = 31.80$, and $R_6 = 32.70$ cm.

In our setup, the phase shift was produced on the area of the central, second, and fourth Fresnel zones (Figs. 3 and 4).

By placing the phase zone plate in the path of spherical waves, half-way between the microphone and the dynamic speaker, it is demonstrated that the zone plate increases greatly the received amplitude to more than double the value obtained when the even zones are covered by rings of plywood or tin plate and no waves pass through them at all, i.e., in the case of an amplitude zone plate[2].

4. For the fourth experiment, the following instrument was prepared: a sheet of plywood was mounted on a stand and an opening of radius $R_3 = 25.40$ cm was cut in it; four Fresnel zones fit inside this hole. On a cross piece left when sawing out the hole, it was possible to mount with the aid of posts an aluminum disk and rings with radii R_0, R_1, R_2, and R_3 as indicated above. The stand was placed half-way between the microphone and the dynamic speaker, the distance between which was 2 m, just as in experiment 3. By removing the disc covering the central Fresnel zone, it is demonstrated that the amplitude of the received sound wave has doubled compared with the case when the wave front is completely exposed. By removing the next ring, it is verified that reception drops to zero. When the second Fresnel zone is uncovered, the reception is restored, but it is greatly weakened when the third zone is uncovered.

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Translated by J. G. Adashko