THE RECTANGULAR-GROOVE GRATING USED AS AN INFRARED POLARIZER

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This paper deals with the surprising polarizing effect of a well choosen grating, when the metal is perfectly conducting.

A theoretical study of the rectangular-groove grating has recently been made in our laboratory [1] to complete and discuss interesting results published by Hessel and collaborators [2]. All the data obtained during this numerical study have not been used in our first report [1], in which, for example, we did not speak of the well-known polarizing properties of this type of grating [3].

The aim of this short paper is therefore to give a precise idea of the possibilities of a lamellar grating used as a polarizer in the infrared or more generally in any wavelength range for which the grating can be considered as perfectly conducting. Heuristic or theoretical considerations are not reported. We thought that the best we have to do to draw the reader's attention is to relate in detail the performances of a particular but well chosen device. Of course further information could be obtained using our computer programs.

Let us start with the symmetrical profile of fig. 1

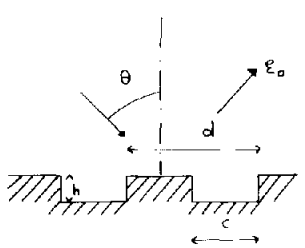

Fig. 1. A perfectly conducting rectangular-groove grating used as a polarizer. The grating works as a mirror: we use the grating order $n = 0$, $h/d = 0.275$, $c/d = 0.5$.

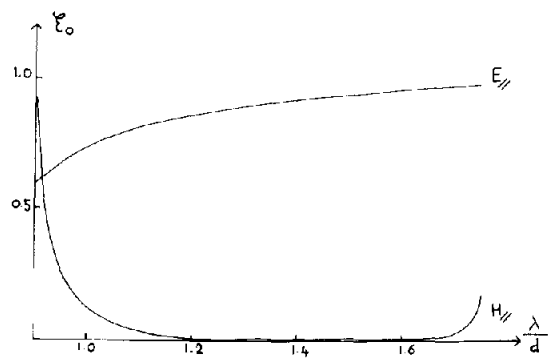

Fig. 2. $E//$ (resp. $H//$) means that the electric (resp. magnetic) field is parallel to the grooves. The groove profile is shown in fig. 1.

illuminated by a plane wave under the incidence angle $\theta = 50°$, the incident wave vector being orthogonal to the grooves. Fig. 2 gives the reflectance (efficiency in the zero order) versus the ratio λ/d of the wavelength over the grating period. We notice a surprising polarizing effect on a large wavelength interval. Is this result very sensitive to the incidence or, in other words, is it possible to use an incident beam of large angular aperture? The answer is given by fig. 3 which indicates that θ is not a critical parameter. Now, what about the role of the profile? Is the filtering still observed when we modify the profile described in fig. 1? Again the computer gives a satisfactory reply as shown in figs. 4, 5, 6 and 7 which correspond to some profiles that we can obtain when trying to rule the pro-

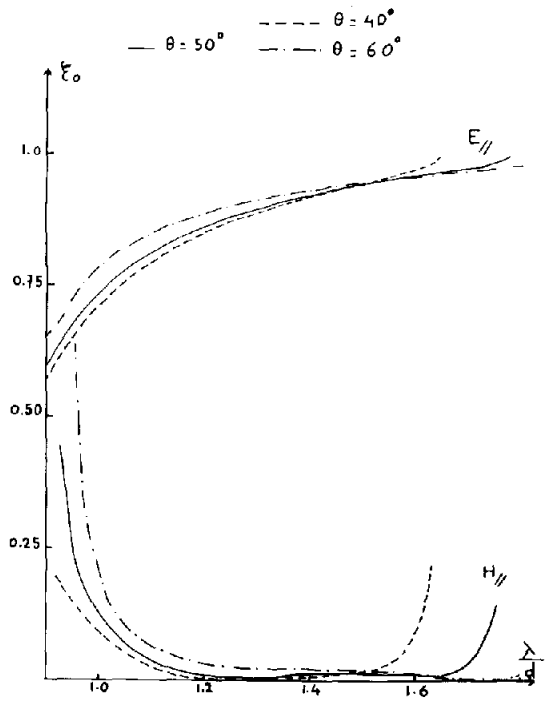

Fig. 3. Efficiency in the zero order for different values of the incidence angle θ.

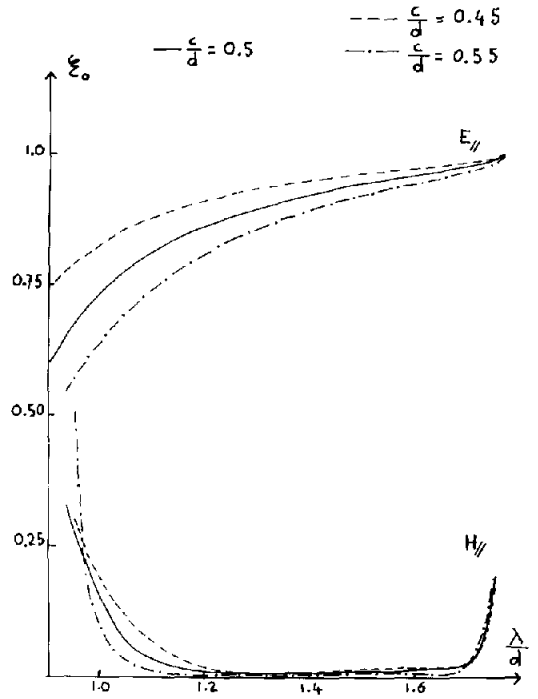

Fig. 4. Efficiency in the zero order for different values of the ratio c/d and for $h/d = 0.275$.

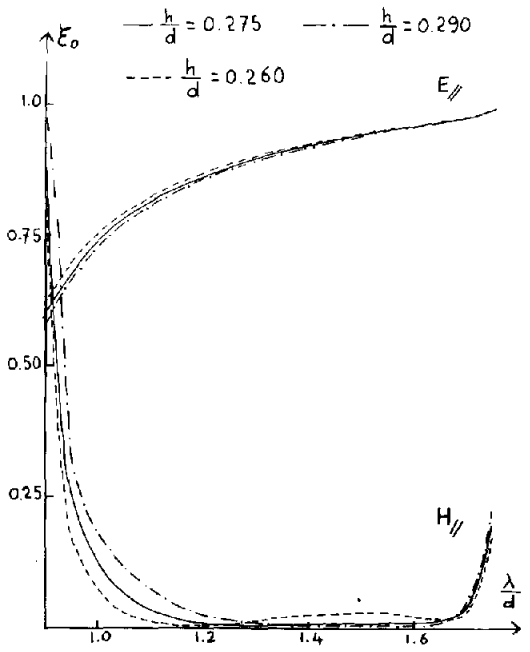

Fig. 5. Efficiency in the zero order for different values of h/d and for $c/d = 0.5$.

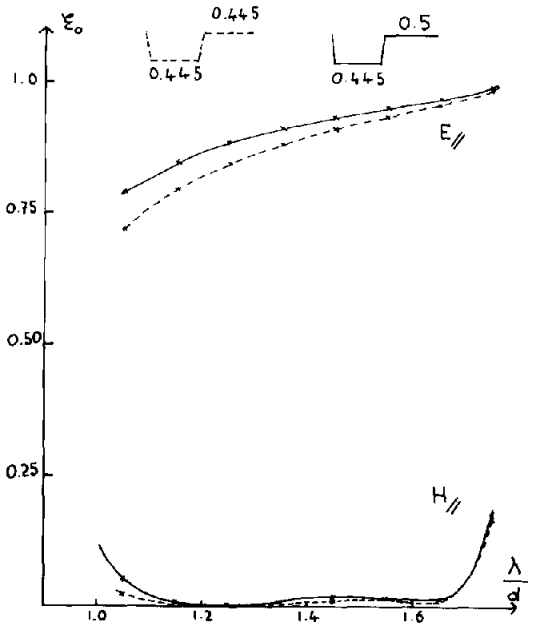

Fig. 6. Efficiency in the zero order for different symmetrical profiles; $h/d = 0.275$, but the grooves are not exactly rectangular. Practically it is impossible to distinguish the solid line from the one obtained when using the profile of fig. 1.

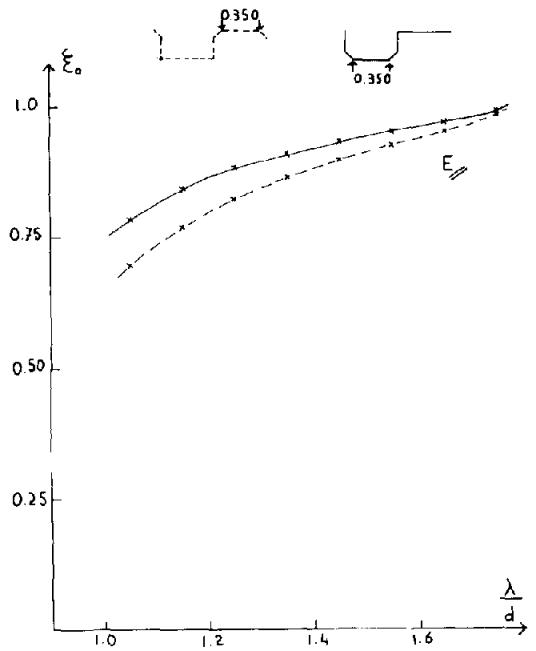

Fig. 7. Efficiency in the zero order if the edges have been cut.

file of fig. 1. Neither the depth or the width of the grooves should be achieved with precision (figs. 4 and 5). Fig. 6 shows that the groove walls must not be rigorously vertical. It is even impossible in this figure to distinguish the solid line from the one related with the profile of fig. 1.

Lastly fig. 7 tells us that square edges can be destroyed without suppressing the expected polarizing effect. It must be noted that in the $E\|$ case it is again practically impossible to distinguish the solid line from the one obtained using the profile of fig. 1. No results are given for the $H\|$ case because the destruction of square edges causes in this case only very slight modifications in the efficiency curves.

Let us repeat that all the results we mention are theoretical ones. Unfortunately our laboratory equipment does not allow us to make experiments in the infrared. We hope that somebody will be interested and perhaps will try!

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References

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