SYNTHESIS OF QUASI-OPTICAL RADIATING SYSTEM

N.N. Voitovich*, V.P. Tkachuk*, Yu. N. Kasantsev**
*Institute of Applied Problems of Mechanics and Mathematics
of the Ukrainian Academy of Sciences, Lvov, USSR
**Institute of Radioengineering and Electronics of the USSR
Academy of Sciences, Moscow, USSR

At the radiating system the segment of an open quasi-optical line (Fig. 1) can be used, each element of which is the semi-transparent mirror with the variable reflection R_n and transmission T_n factors.$^{1-3}$ The pattern of such a system is formed by the combination of wave beams, reflected by individual mirrors.

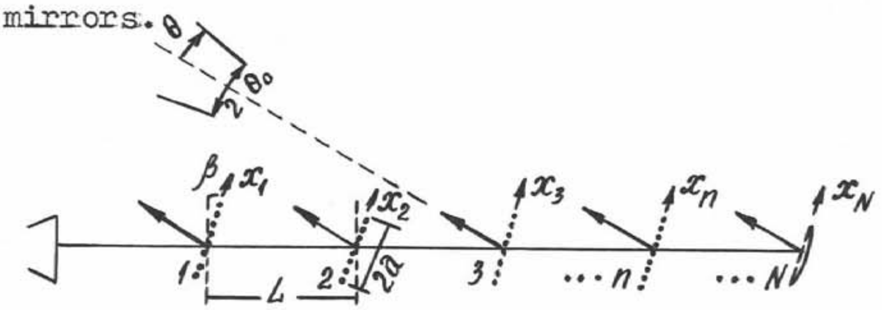

Fig. 1

Let's suppose that the wave dimensions of mirrors and the distance between them to be sufficiently great: $ka \gg 1$, $kL \gg 1$. The field in the imput of the nth mirror is fully determined by the field at the imput of the (n-1)th mirror and its trasmission factor T_{n-1}:

$$u_n = K_{n-1}\left[u_{n-1}T_{n-1}\right], \tag{1}$$

and the pattern of the nth mirror is determined by the field u_n incident upon it and the reflection factor K_n:

$$f_n = A_n\left[u_n R_n\right]. \tag{2}$$

Here K_n and A_n are the known linear integral operators. The complete pattern is the sum of partial patterns:

$$f = \sum_{n=1}^{N} f_n . \tag{3}$$

The optimal variable parameters of mirrors $R_n(x_n)$, $T_n(x_n)$ are calculated in order to form the desired pattern F ($\|F\|=1$). The patterns proximity meassure is characterized by the value

$$\varkappa = |(F,f)| = \Big|\sum_{n=1}^{N} (F,f_n)\Big|. \qquad (4)$$

To maximize $\varkappa$ it is necessary to provide the equiphasing of all the addends in (4) and the moduli maximum of each of these addends. The problem is solved by the successive approximations method, on every step of which the parameters of one (jth) mirror are being improved, the rest mirrors parameters being fixed. The functional (4) is divided with this purpose in two addends

$$\varkappa = \Big|\sum_{n=1}^{j-1} (F,f_n) + Q_j\Big|, \quad Q_j = \sum_{n=j}^{N} (F,f_n). \quad (5)$$

The first addend in (5) doesn't depend on the functions $R_j(x_j)$ and $T_j(x_j)$; this addend can be considered real and positive. The functions $R_j(x_j)$ and $T_j(x_j)$ must be chosen so as to make the Q_j value real, positive and having the maximal modulus. The expression for Q_j can be transformed to such a form, so that the influence of functions R_j and T_j will be shown evidently. For this purpose it is to change the order of integration in the multiple integral, by which Q_j is represented with regard to (1) and (2), until he is reduced to the inner product over the jth mirror:

$$Q_j = (w_j R_j^{*}, u_j) + (v_j T_j^{*}, u_j) . \qquad (6)$$

Here $w_j = A_j^{*}[F]$; the function u_j is calculated by means of the recurrent formula (1) and $v_j = K_j^{*}[w_{j+1}R_{j+1} + v_{j+1}T_{j+1}]$; A_j^{*}, K_j^{*} are the operators, conjugated to A_j and K_j. The functions w_j, u_j and v_j are indepedent on parameters of the jth mirror and are known at the given step of the iteration process.

Presentation of the functional Q_j in the form of (6), where the depedence of $R_j(x_j)$ and $T_j(x_j)$ is shown evidently, makes it possible to optimize the parameters of the jth mirror. For the case of arbitrary choosing of these parameters ($|R_n|^2 + |T_n|^2 = 1$), their optimal values are determined in the evident form. Changing of j from 1 to N consequehtly improves all the line elements; repeating of this procedure is necessary for their full optimization.

Alongside with the case, when the pattern F and the exciting field u_0 are fully prescribed by their amplitude and phase distributions, it is possible to state the problems, in which the phases of one or both of these functions are free; in some cases amplitude distributions may not by prescribed, too.

Semi-transparent mirrors can be realized in the form of small-periodic grating. In this case the reflection and transmission factors have the form

$$R_n = -1 \,/\, (1 + iP_n), \quad T_n = iP_n \,/\, (1 + iP_n), \qquad (7)$$

where P_n is the variable transparence parameter to be optimized. By substituting (7) in (6) the functional Q_j is reduced to the form

$$Q_j = \left(\int_{-a}^{a} u_j(w_j - v_j)dx_j - \int_{-a}^{a} u_j(w_j + v_j)e^{-i\sigma_j}dx_j\right)/2, \quad (8)$$

where its depedence on $P_j(x_j)$ is concentrated in the phase function $\sigma_j(x_j)$: $P_j = tg(\sigma_j/2)$. The function σ_j, which maximizes the functional (8), is chosen from the condition for the subintegral expression in the second integral to have in each point the phase, opposite to the first integral phase. Alongside of the case of arbitrary continuous distributions of transparency $P_n(x_n)$, the continuous distributions with limitations and discrete distributions are considered as well.

As the example we shall demonstrate the results of calculation of a quasi-optical line consisting of 10 mirrors in the form of gratings. Curve 1 in Fig. 2 shows the prescribed amplitude pattern $F(\theta) = \xi^{-1}\sin\xi$, $\xi = \pi \sin\theta / \sin\theta_0$; curve 2 is the amplitude pattern of the quasi-optical line with the optimal grating parameters without any limitations. Corresponding distributions of mirror transparency are shown in Fig. 3. Curves 3-5 in Fig. 2 describe the amplitude pattern in the problem in which the maximum of capacity was to be directed into the angle $[-\theta_0, \theta_0]$: curve 3 corresponds to the case of optimal parameters P_n without any limitations; curve 4 - to the case with the limitation $P_n(x_n) > 0$;

curve 5 - to the case of discrete values $P_n(x_n)$.

The above-described line can be used as one of the elements of a radiating or focussing system. Scanning is carried out by the change of exciting coefficients phases as well as a sligh frequency change.

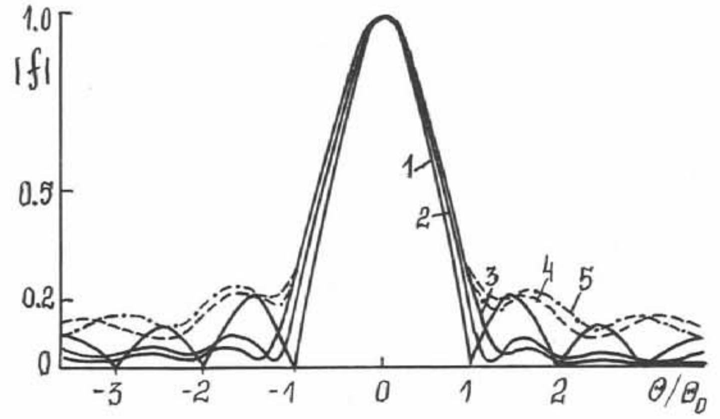

Fig. 2

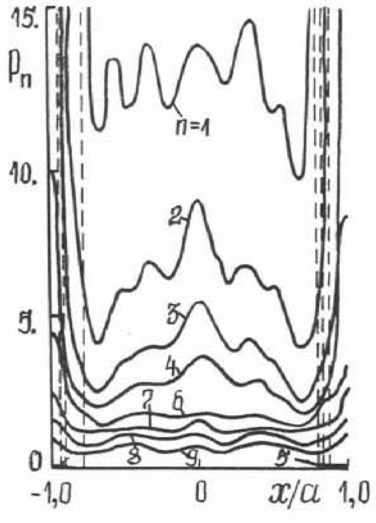

Fig. 3

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