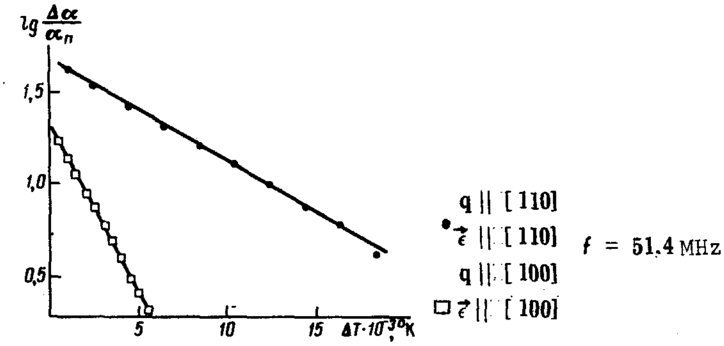

Fig. 3

time. If we assume $\tau \sim \ell/v_F$, then $\Delta T_c \sim 10^{-2}$ °K. In this temperature region one cannot exclude the probable appearance of inclusions of the superconducting phase, with a lifetime $\sim\tau$, which can lead to the observed effect.

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USE OF NONSTATIONARY HOLOGRAPHY TO IMPROVE THE DIRECTIVITY OF LASER RADIATION

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It is well known that pumping produces in the interior of the laser medium inhomogeneities of the refractive index, and these distort the radiation diagram of the laser. One of the possibilities of correcting the laser radiation is to use holography methods. Thus, singly-exposed holograms were used in [1] to improve the radiation diagrams of a laser. The use of such a scheme would make it possible to compensate for static inhomogeneities, but could not correct inhomogeneities that develop in the course of time. In principle, dynamic holography [2] could be useful in this case, but the existing thermal dynamic holograms make it possible to follow only slow processes ($\sim 10^{-3}$ sec), and high powers are needed to obtain holograms on the basis of low-inertia effects.

We propose here to compensate for the inhomogeneities dynamically by using continuous holographic recording and reproduction of nonstationary optical fields (see [3, 4]). In this scheme, a special reference wave is used, and the recording is by means of a light-sensitive three-dimensional element (much progress has been made recently in the development of three-dimensional materials for holography [5]). We note that the efficacy of the proposed compensation method depends on the reproducibility of the conditions in successive cycles of laser operation.

Assume that we have an amplifier whose dielectric constant $\varepsilon' - i\varepsilon''$ is inhomogeneous over the cross section and varies in time. We assume that when a monochromatic plane wave of frequency ω passes through the amplifier it assumes the form

$$\exp\left\{-i\omega t + i\frac{\omega}{c}2L\epsilon'(x, y, t) + \frac{\omega}{c}2L\epsilon''(x, y, t)\right\} \equiv \equiv F(x, y, t)e^{-i\omega t} \quad (1)$$

(L is the length of the amplifier).

To record a hologram of a nonstationary signal F(x, y, t) it is necessary to use three-dimensional light-sensitive material. Let this material occupy the volume $|x| \leq (D/2)$, $|y| \leq (D/2)$, $|z| \leq (\ell/2)$. An image of the output signal of the amplifier is produced on the plane z = 0 with the aid of a lens, and the form of the image in this plane is given by $f(x, y, t)\exp(-i\omega t)$. We assume that the wave front of the signal is quasi-plane, namely, it occupies the angle interval $\theta < \sqrt{\lambda/\ell}$ (λ is the wavelength). Then the field can be represented in the entire thickness of the recording element in the form

$$f\left(x, y, t - \frac{z}{c}\right)e^{-i\omega\left(t - \frac{z}{c}\right)}. \quad (2)$$

We apply to the recording element a reference wave

$$Ae^{-i\omega\left(t - \frac{x}{c}\right) - iaz\left(t - \frac{x}{c}\right)}. \quad (3)$$

Such a wave, with a frequency that varies over the diameter, can be shaped with a special electro-optical cell or a rotating mirror. The rate of rotation of the wave front, which is characterized by the constant a, should be high enough to satisfy the condition $a\ell > \Delta\omega$, where $\Delta\omega$ is the spectral width of the recorded signal. The action of waves (2) and (3) produces on the light-sensitive material an exposure proportional to the intensity of the field of these two waves

$$S = \int dt'\left\{A^2 + |f(x,y,t')|^2 + Ae^{-i\frac{\omega}{c}(x-z) + iazt'}f(x,y,t') + Ae^{i\frac{\omega}{c}(x-z) - iazt'}f^*(x, y, t')\right\}. \quad (4)$$

Formula (4) is written under the assumption that the time of propagation of the light wave through the hologram is much shorter than the characteristic time of variation of the signal, viz., $D/c \ll 1/\Delta\omega$ and $\ell/c \ll 1/\Delta\omega$. The exposure results in a coordinate-dependent increment $\Delta\varepsilon(x, y, z) \sim S(x, y, z)$ to the dielectric constant of the material.

The signal can be reconstructed by using a wave of the same type as the reference wave, but propagating through the hologram in the opposite direction, $A\exp[-i\omega(t + x/c) + iaz(t + x/c)]$. The diffraction of the reconstructed wave by the three-dimensional hologram produces in the direction of the negative z axis (and at small angles to this direction) scattered radiation in the form

$$E(X,Y,Z,t) = \text{const}\int dx\,dy\,dt'\,e^{-i\omega\left(t - \frac{R}{c}\right)}f^*(x, y, t')\times \times\sin\left[\frac{a\ell}{2}\left(t - \frac{R}{c} - t'\right)\right]\Big/\left[\frac{a\ell}{2}\left(t - \frac{R}{c} - t'\right)\right] \quad (5)$$

$$|x| < D/2$$
$$|y| < D/2 ,$$

where $R = [(X - x)^2 + (Y - y)^2 + (Z - z)^2]^{1/2}$.

We note that a contribution to the scattering is made only to the ε-increment proportional to the last term in (4). The contribution due to the remaining terms is negligibly small, since the corresponding sources contain rapid spatial oscillations. We take into account the condition $\Delta\omega < a\ell$, which means that the function $f^*(x, y, t)$ varies with time more slowly than the function $\sin[a\ell(t/2)]/[a\ell(t/2)]$, and replace (5) by the expression

$$E(X, Y, Z, t) = const \int dx\, dy\, e^{-i\omega\left(t - \frac{R}{c}\right)} f^*(x, y, t), \quad |x| < D/2, \; |y| < D/2 \tag{6}$$

It follows therefore that the wave propagating from the hologram to the amplifier has in the plane $z = 0$ the form $f^*(x, y, t)$. If the same lens as used in the recording is placed in the path of this wave, then we obviously obtain at the input to the amplifier the field $F^*(x, y, t)$.

Since the phase shift of the reconstructed wave at each instant of time is the opposite of the phase shift introduced by the amplifier, the phase front of this wave turns out to be plane after passing through the amplifier. The divergence of the radiation will then be determined only by the inhomogeneities of the amplitude. In a power amplifier operating in a strong saturation regime, the amplitude inhomogeneities become equalized and are determined only by the pump inhomogeneities.

It must be emphasized that the accuracy with which the wave front $f^*(x, y, t)$ is reproduced is limited. The number $N_T \equiv \Delta\omega t_{tot}$ of time-resolved elements is $\sim 0.1(\ell/\lambda)$, and the number of resolved spatial elements is $N_x = N_y \simeq (D^2/\lambda\ell)^{1/2}$. The proposed scheme will operate effectively if the number of elements significantly resolved in time and in space does not exceed the corresponding values N_T, N_x, and N_y indicated above. For a hologram in the form of a cube with $D = \ell = 1$ cm and a wavelength $\lambda = 10^{-4}$ cm we find that the permissible number of signal elements is large enough: $N_T = 10^3, N_x = 10^2, N_y = 10^2$.

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