ERIM

FORMERLY WILLOW RUN LABORATORIES, THE UNIVERSITY OF MICHIGAN

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MEMORANDUM TO: VLA Optical Processor File

FROM: James R. Fienup J. F.

SUBJECT: Arbitrary Bias in Non-Track Areas

In a previous memo (J. R. Fienup, "Basic Limitations of Encoding Methods", 21 September 1976), the case of using a negative film was analyzed. In that case the transmittance would be unity in those areas between the tracks, introducing additional on-axis undiffracted terms. In this memo we analyze the case for which the between-track areas have a bias transmittance. This, in fact, will be the case when we record a transparency using data from data perturber offset generator.

For simplicity, let $A'(u,v) = \{1$ in areas covered by one or more tracks; 0 in areas not covered by a track$\}$ be the aperture associated with the elliptical tracks, ignoring the effect of track overlap (i.e., assuming compensation for track overlap). The corresponding impulse response (dirty beam) is $a'(x,y) = \mathcal{F}\{A'(u,v)\}$. The signal recorded in the simple carrier method is then $A'(u,v) \cdot [B_o + 2|V(u,v)|\cos(\omega_o u + \phi(u,v))]$ where B_o is a bias, $\omega_o u$ is the carrier term, and $V(u,v) = |V(u,v)|e^{j\phi(u,v)}$ is the complex visibility function. If the between-track areas are given a bias transmittans, β, then an additional term, $\beta[1 - A'(u,v)]$ is introduced. To spatially limit this term, a large aperture $A_o(u,v)$ is introduced. Then the transmittance of the transparency becomes

$$H(u,v) = A_o(u,v)\cdot\left\{A'(u,v)\left[B_o+2|V(u,v)|\cos(\omega_o u+\phi(u,v))\right]+\beta\left[1-A'(u,v)\right]\right\}$$

$$= A_o(u,v)\left\{\beta+A'(u,v)\left[(B_o-\beta)+2|V(u,v)|\cos(\omega_o u+\phi(u,v))\right]\right\}$$

Letting $a_o(x,y)$ be the impulse response due to $A_o(u,v)$, we find the following terms in the output plane:

$$\beta\, a_o(x,y)$$

$$+(B_o-\beta)a_o(x,y)\ast a'(x,y)$$

$$+ a_o(x,y)\ast a'(x,y)\ast B(x-x_o,y) + \text{conjugate image.}$$

If the aperture $A_o(u,v)$ is larger than the outermost track, then $A_o(u,v)A'(u,v) = A'(u,v)$ and $a_o(x,y)\ast a'(x,y) = a'(x,y)$ and in the output plane we find

$$\beta\, a_o(x,y)$$

$$+(B_o-\beta)\, a'(x,y)$$

$$+ a'(x,y)\ast B(x-x_o,y) + \text{conjugate image.}$$

In either case there are two strong on-axis terms with sidelobes that will extend into the image area. There is a tradeoff between these two terms, depending on the value of β chosen. For $\beta \simeq 0$, the first term above is minimized and the second is maximized. For $\beta \simeq B_o$, the first term is made large and the second term is minimized. For $\beta = 1$ (the negative film case considered in the previous memo), both terms are maximized. Thus the best choice of β is between 0 and B_o. What determines the optimum choice of β is the nature of the sidelobes of $a_o(x,y)$ and $a'(x,y)$. We have little control over the sidelobes of the "dirty beam" $a'(x,y)$, but we have great control over the sidelobes of $a_o(x,y)$. Thus, the lowest possible sidelobe noise would be achieved if we chose $\beta = B_o$, eliminating the $(B_o-\beta)a'(x,y)$ term. However, this would be done at the expense of increasing film noise and noise due to dust, etc., in the system. Thus, depending on the relative amounts of film, etc., noise and sidelobe noise, the optimum choice of β would be equal to, or somewhat less than, B_o. For the purpose of illustration, Figure 1 shows two hypothetical plots of total noise at a given image position as a function of β. These curves do not necessarily indicate the actual relative amounts of noise present.

JRF:sd

cc: C. Aleksoff
I. Cindrich
W. Colburn
A. Klooster

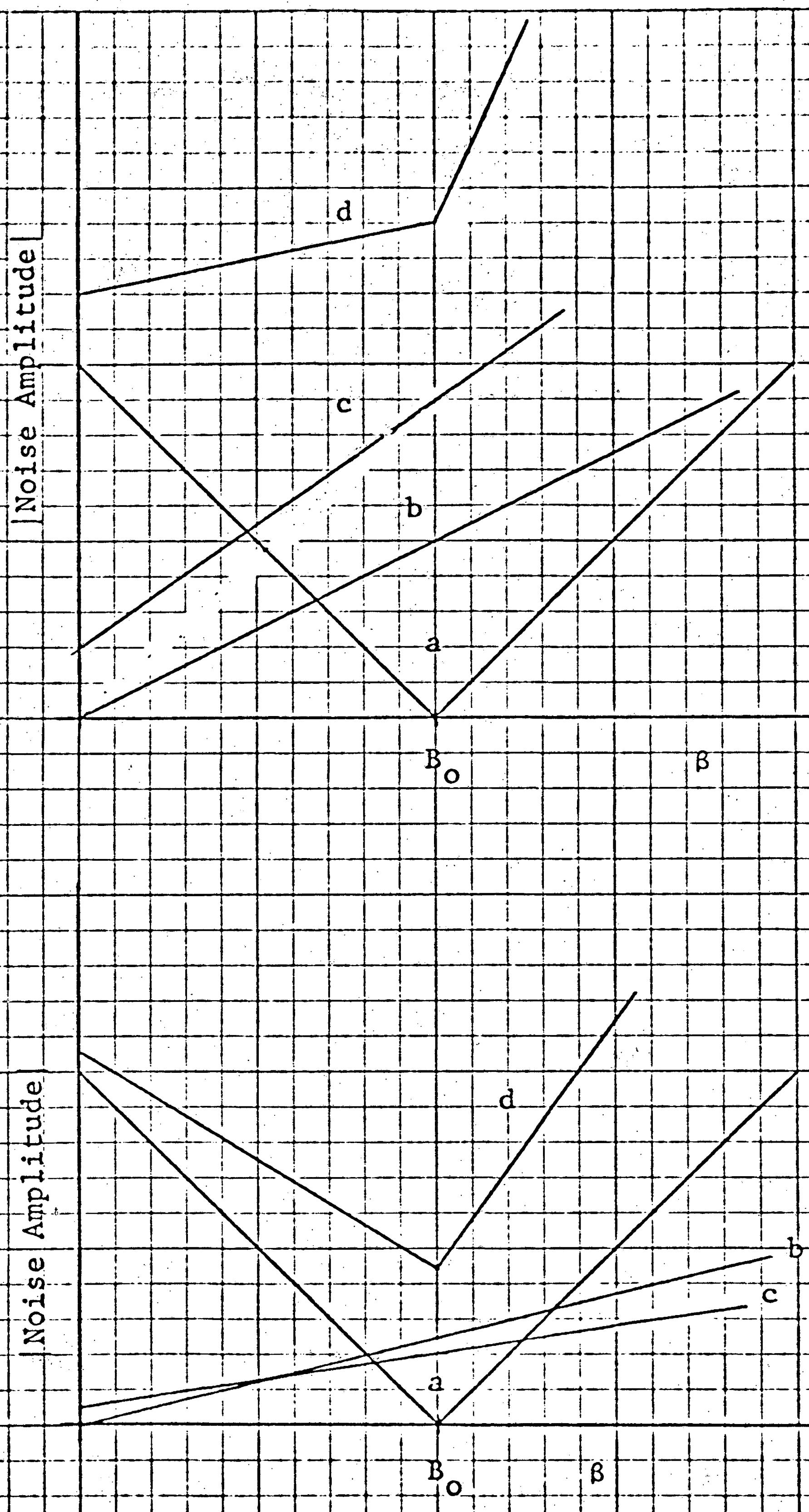

Figure 1. Amplitude of Noise vs Bias β: a (x,y) term (a), a_o(x,y) term (b), film, etc., noise term (c), and total noise (d). Both hypothetical cases are for purpose of illustration only.