TELEPHONE 0734

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cc. Ivan Cindrich

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Dear Lew,

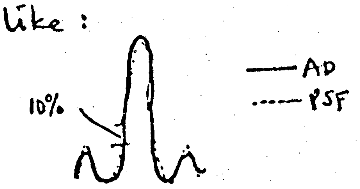
OK, here we go at last. I hope I'm not too late! — the story of delays in starting is too long to relate. Here are some first comments and questions. The comments show some of my initial thoughts (including what I might do next), while the questions cover areas which in which missing information is important. First the three main questions:

<u>Question 1</u>: How big is the input plane diameter? I appreciate that this may not finally be settled, but the figures quoted in my documentation range from 30mm to 70mm. This is a very large range in terms of the implication on aberrations — could you tie down a typical figure that I could work around.

<u>Question 2</u>: This 1% map-error criterion! What do the astronomer's really mean? It sounds a bit like an easy generalisation which might cost a hell of a lot in design effort. ~~Does it mean that the~~ Suppose the liquid gate is blank (or an unmodulated carrier) so that the output is a PSF close to the ideal Airy disc. Since <u>absolute</u> intensity measurements are pretty difficult, it seems likely that what is important is the closeness in <u>shape</u> of the PSF to the Airy disc (i.e. allowing the PSF to be

PSF has its first ring (sidelobe) with a maximum value of .04, compared to the Airy disc value of .02 — is this interpreted as a 100% error? (or a 2% error?). If it is the former, then the spec. could be <u>really</u> tight — the example quoted for the 100% error corresponds to the case of enough spherical aberration to give a Strehl ratio of 0.8.

Another similar point: suppose the AD & PSF (renorm) are like:



so that a very small difference in shape on a region of steep gradient could give a very large difference in values. Would this really represent a 10% error to the astronomers?

<u>Question 3</u> : Is there a distinct experimental preference for either one of the two modes of operation described in your notes as AXIAL & OFF-AXIAL? (see also comment below).

Now for some comments:

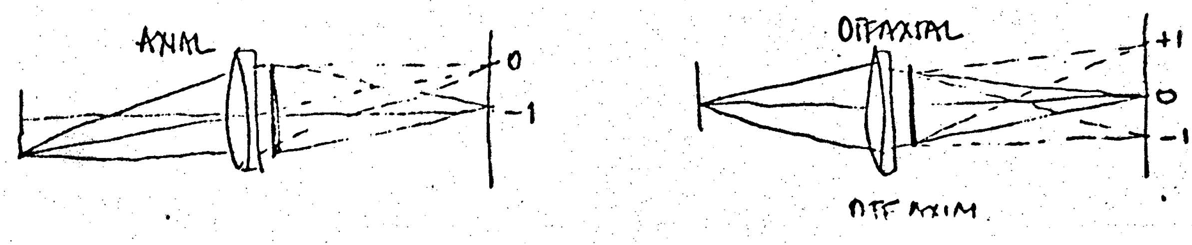
Suppose we take an input ∅ of 30mm diameter, 5 20μm-spaced samples across an Airy disc central peak, a 100 c/mm spatial carrier, and a 100mm square diffracted map size. Then we get, for a SINGLE-COMPONENT lens,

F = 1m F# = 66.7 (for imaging beam)

F# = 33.3 overall

and a 126 mm separation of diffracted orders.

<u>Comment 1</u> : The two modes of operation that you refer to as AXIAL and OFFAXIAL are:



In the AXIAL case, the aberrations affecting the transform comprise

[EXTRA-AXIAL ABNS OF (LENS + ENTR. HALF OF LIQ. GATE) FOR $\eta' = 126$mm]

+ [AXIAL ABNS OF EXIT HALF OF LIQ. GATE].

While in the OFFAXIAL case, they comprise

[AXIAL ABNS OF (LENS + ENTR. HALF OF LIQ. GATE)]

+ [EXTRA-AXIAL ABNS OF EXIT HALF OF LIQ. GATE FOR $\eta' = 126$ mm]

In addition, the nonstationary aspect of the aberration function (with respect to image-plane coords.) is due to the different oblique paths of diffracted beams through the exit half of the liquid gate. This comprises

ABERRATIONAL VARIATION OF EXIT HALF OF LIQ. GATE OVER IMAGE-COORD RANGE $\eta' = \pm 71$ mm (AXIAL CASE) OR $\eta' = 76$ to 182mm (OFF-AXIAL CASE).

Neglecting inhomogeneities & other production errors, these aberrational constituents can be roughly approximated for a SINGLET lens solution and a 25mm thick liquid gate as follows:

ALL WAVE ABERRATIONS

AXIAL LENS ABN: 1m F/33.3 ~ 0.08λ spherical aberration at best shape

AXIAL $\frac{1}{2}$ LIQ. GATE ABN: 12mm F/66.7 ~ $-3 \times 10^{-5}\lambda$ spherical abn.

EXTRA-AXIAL LENS ABN: $\eta' = 126$mm $H = 0.95$mm

~ zero coma

~ 0.7λ astigmatism

~ 0.25λ petzval field curvature

~ zero distortion

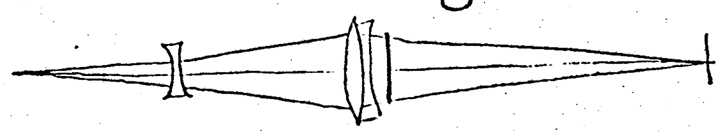
EXTRA-AXIAL $\frac{1}{2}$ LIQ. GATE ABN: $\eta' = 126$mm $\bar{u} = .0\overline{63}$ $u = .1575$

~ $1.3 \times 10^{-4}\lambda$ coma

~ $10^{-3}\lambda$ astigmatism

It is clear that the theoretical abns of the liquid gate (both on & off axis) will be dominated by production-error "aberrations" (expect $\lambda/4$ to $\lambda/20$).

The figures indicate that for the "OFFAXIAL" mode of operation, it might be possible to get away with a contacted doublet design (depending on results of diffraction calculations — see comment #2), while for the "AXIAL" arrangement, it is certain that a separated 2 or 3 component system will be necessary to reduce the astigmatism & field curvature; say like:



Comment 2 : WHAT I COULD DO (AS I SEE IT)

INPUT : (1) Hopefully, some information on input plane size, what map error is acceptable, and any preference on AXIAL/OFFAXIAL operation alternatives.

OUTPUT : (1) Do compute diffraction calculations of effects of various small abns. on PSF, so as to be able to translate "acceptable map error" into abn. magnitudes — or else into some physically-based criterion of required optical performance.

(2) In the light of the results of (1), draft out a design format (or a complete design).

(3) Tolerance this design

(4) Other considerations of system, not discussed in this letter (less important, probably).

I look forward to your comments and answers. Please say what areas of the problem you think I've misunderstood or ignored (at great peril).

Best wishes,

John.