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Edwin F. Erickson
Donald W. Strecker, Ames Research Center, Moffett Field, California

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Ames Research Center
Moffett Field, California 94035

ENGINEERING TESTS OF THE C-141 TELESCOPE

Edwin F. Erickson and Donald W. Strecker

Ames Research Center

SUMMARY

Data on image quality, chopper performance, and the closed-loop operation of the 91 cm telescope of the Kuiper Airborne Observatory which were obtained in September 1977 are presented.

INTRODUCTION

During the KAO engineering test flights of September 14, 27, and 29, 1977, time was allotted to evaluate: 1) the image quality of the telescope, 2) the efficiency of the chopping secondary mechanism and 3) ADAMS program (called "Peaker") which maximizes the detector signal by pointing the telescope at the infrared source in a closed-loop mode.

The secondary mirror was a new one with a diameter of 185 mm which yields an image with 90% of the light in a one arc-second circle, as measured on a Hindle sphere by D. A. Loomis. The image quality tests utilized the Ames Airborne Infrared Group (AIAG) - KAO standardized photometer. An adapter was designed to hold a razor blade at the nominal f/17 back focal distance of the KAO 91 cm telescope. This "knife edge" and the fiber optics/TV focal plane camera permitted Foucault pictures to be recorded on the ground and airborne as a function of various parameters.

The AIAG cooled circular variable filter spectrophotometer (CCVF) was used to evaluate the image quality. The filter covers the wavelength ranges 1.2-2.4 and 2.9-5.8 μ. The detector is InSb operated in the photovoltaic mode. The system has reflecting Fabry field optics and a variable focal plane diaphragm of 3, 2, 1, 1/2, or 1/4 mm diameter.

TEST PROCEDURE AND RESULTS

A. Visual Image Quality

The visual image quality was evaluated by a visual inspection of the image sizes, both on the ground and in flight, of various bright and faint stars. Also, in flight, the unchopped image of the double star HR 8687 (primary $m_v = 7\overset{m}{.}1$, secondary $m_v = 7\overset{m}{.}2$, separation $\sim 6\overset{''}{.}4$) was observed in the focal plane camera. The image was definitely elongated, and some observers felt they could marginally resolve the two components on the TV screen. Knife-edge tests were performed both on the ground (αUMi) and in flight at high elevation angles (γ Cyg, 74°) and at low elevation angles (α^2 CAP, 34°), and with reduced primary mirror support pressure. The results of these tests were video taped from the focal plane TV camera.

The in-flight knife-edge image was "soft" in that the spiders and secondary were not sharply defined. One quadrant was quite dark, and a bright zone extended from the secondary edge out to perhaps two-thirds the diameter of the primary in the other three quadrants, indicating possible spherical aberration or misalignment. The knife-edge image was insensitive to elevation angle or primary mirror support pressure.

In the absence of the knife edge the out-of-focus image was quite symmetrical, indicating reasonable alignment. The focused image appeared to have about a 1/2-mm-diameter core with soft halo extending to nearly 1 mm, which is consistent with the observed infrared image size discussed below. The focused image was observed to be roughly the same in flight and on the ground.

B. Infrared Image Quality

The infrared image quality was evaluated using the CCVFW spectrophotometer. The filter wheel was set near 1.6 μ and the telescope was focused for maximum unchopped IR signal on the bright IR source α Tau. The d.c. output of the detector preamp was recorded with the star in and out of the field-of-view as the focal plane aperture was varied. Figure 1 displays the results of this test. The efficiency is the observed signal amplitude as a function of aperture relative to the signal measured with the 3-mm aperture.

C. Chopper Performance

The efficiency of the chopping secondary mechanism was tested as a function of chopping frequency, chopping amplitude, and detector aperture. The results for efficiency versus aperture at a fixed frequency and fixed throw are also plotted in figure 1. The results are normalized to 38% (50% is ideal) on the 3-mm aperture. The value of 38% is derived from visual inspection of the signal waveform on an oscilloscope and estimating that the source is in the signal beam about three-eighths of the time. The chopping efficiency is also plotted versus frequency and beam separation in figures 2(a) and 2(b). These values have been normalized to the value obtained at 2 mm, 27 Hz and 5-1/2 mm throw. Therefore, for some combinations of parameters, the efficiency shown is greater than 100%.

D. Peaker Operation

An infrared signal maximization program called "Peaker" has been developed for the ADAMS. The input to the ADAMS is the celestial IR source d.c. voltage level from the phase lock amplifier. The program can maximize or minimize the signal (+ or - beam) by moving the telescope. Peaker was debugged and tested for the first time during these flights. Use of Peaker significantly increased our integration time on dim objects. For example, a low signal-to-noise source (one beam signal to peak-to-peak noise on the strip chart of about 2 to 1) such as Io had been previously observed. Our former procedure was to integrate for about 4 min in one beam, beam switch, and manually maximize the signal (which took about 2 min) and integrate anew. This method resulted in about a 67% integration efficiency. Using Peaker, the beam switching and automatic peaking time is reduced to about 1 min, which results in an 80% integration efficiency. Over the space of 1 hour, the use of the peaker program gained about 20% in integration time over the older method. Further improvements to Peaker foreseen by its use during these engineering flights should increase its efficiency by a factor of ~ 2.

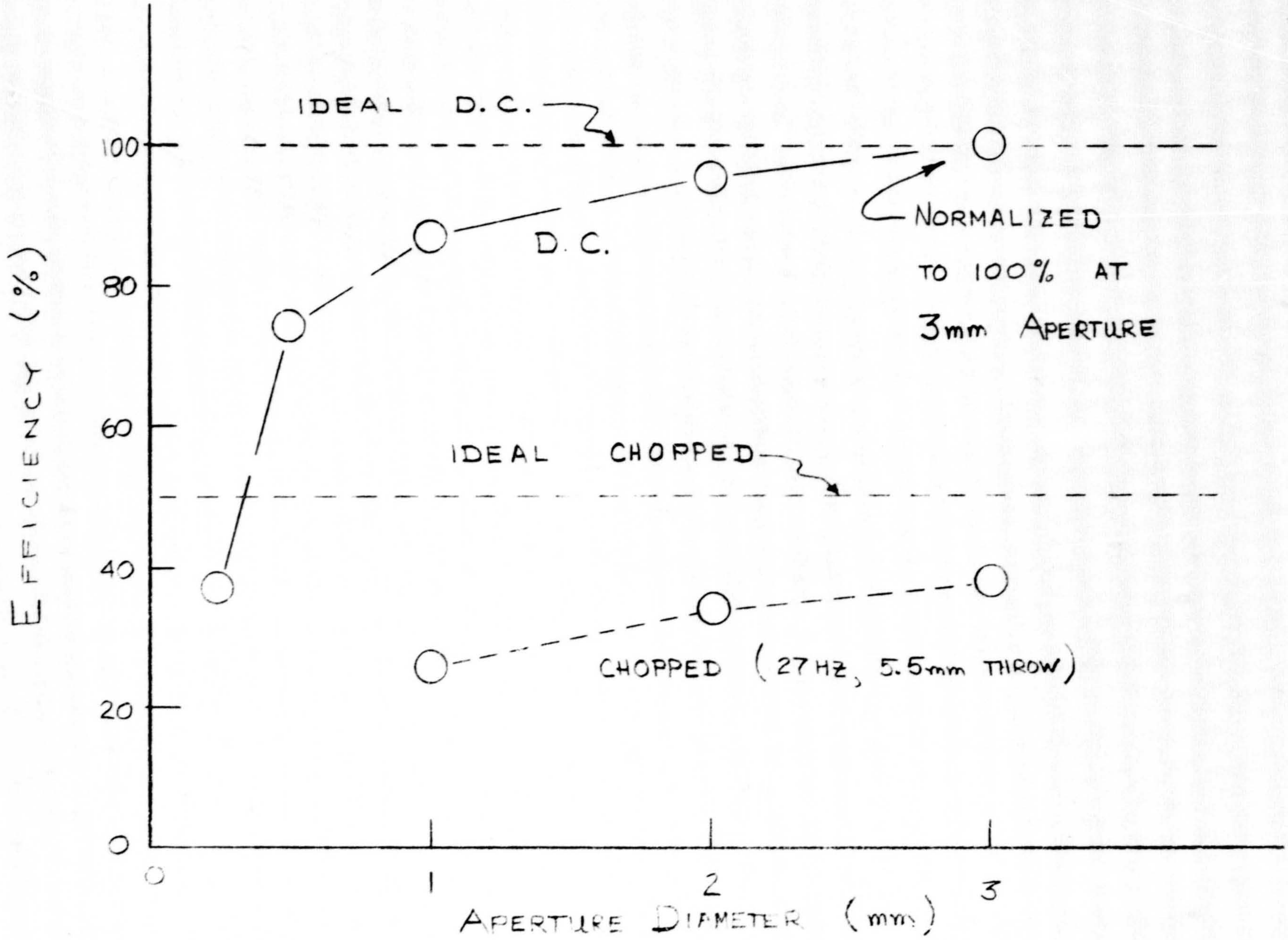

Figure 1.- Optical efficiency vs aperture diameter. The plate scale was about 14 arc seconds/mm for these measurements.

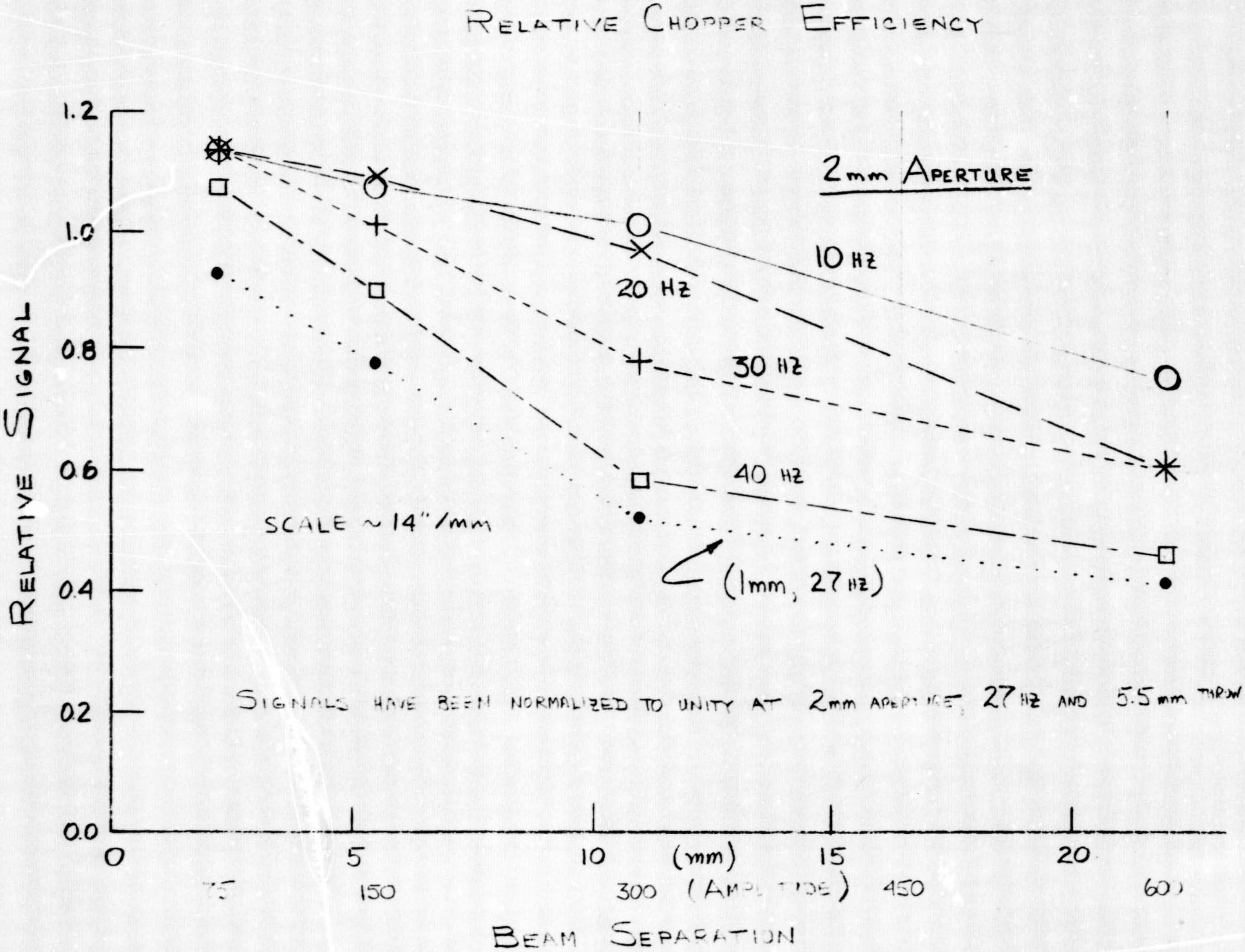

Figure 2.- Relative dropper efficiency vs chopped amplitude for 1 and 2 mm diameter apertures.

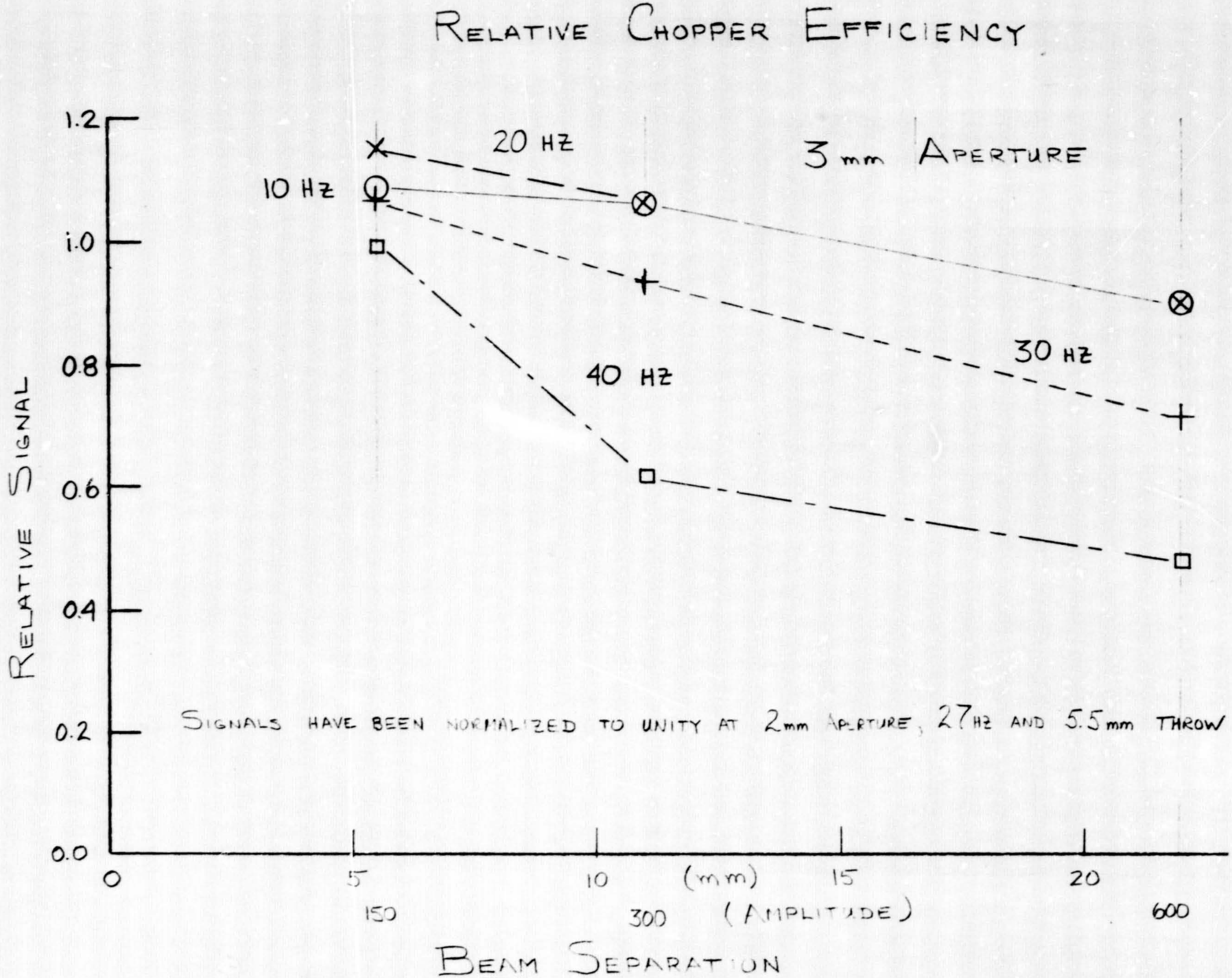

Figure 3.- Relative dropper efficiency vs chopped amplitude for the 3 mm diameter aperture.

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16. Abstract

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