Double Stars and Space Telescope

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With the success of the Shuttle it seems now the Space Telescope will become a reality. The author wrote a study for the Langley Research Center in the summer of 1963 on the astronomical uses of a large space telescope which formed the basic document for the National Academy of Sciences Woods Hole study in 1965. This study recommended construction of a large space telescope scaled to use a Saturn V as the launch booster.

The initial study included some astrometric applications. Among these were various double star applications which is the subject of this symposium.

In its initial program, there are six science teams. The astrometry team is composed of W. Jefferys (Chairman), R. Duncombe (Secretary), F. Benedict, P. Hemenway, P. Shelus, O. Franz, W. van Altena and the author. It will make use of the fine guidance system. This has some advantages and some disadvantages, but on the whole the advantages outweight the disadvantages. Of course, astrometric studies are not dependent entirely on the fine guidance system, the various cameras and spectrographs can be used as well where their use can be justified.

The focal plane of the space telescope is shown in Figure 1. The fine guidance sensors pick off the field in the three sectors around the central field. These sectors are referred to as "pickles" because when a rough sketch is made the three sectors often look more like gherkins than the neat sectors shown in the figure. Two of the guidance heads are required to hold the telescope. The third is for redundancy and the rare case where there is no guide star available in one of the pickles.

The fine guidance system uses an orthogonal set of Koesters prisms in each head. A single prism forms an interference pattern out of one face and its complement out of the other face as shown in Figure 2. These are detected by two photomultipliers and the ratio of the difference to the sum is formed. The idea is to locate the zero and hold the telescope there. As a star moves across the field of a sensor, the transfer function has the approximate form $(\sin^2 x)/x$ as shown in Figure 3.

One of the proposed studies (Franz) is to search every star in a given field for multiplicity. This would be done by comparing the observed transfer function to the single star transfer function. While the two sectors are being used for guiding, the third can be used for the multiplicity search. This can be done without interfering with the primary science instrument of the moment, because the output of the sensor comes down the engineering data stream -- not the science data stream.

Modelling by O. Franz and L. Wasserman indicates that the binary detection at the 10 or 20 arc-millisecond level is feasible. This is of course dependent upon the relative magnitudes of the pair.

The limiting magnitude for such studies is seventeen (visual). Close pairs of high astrophysical interest will be studied. Among such systems would be astrometric binaries unresolved from the ground, low luminosity binaries, binaries consisting of degenerate objects and the like.

The figures have been adapted from originals furnished by the Perkin-Elmer Corporation.

SPACE TELESCOPE f/24 FOCAL PLANE

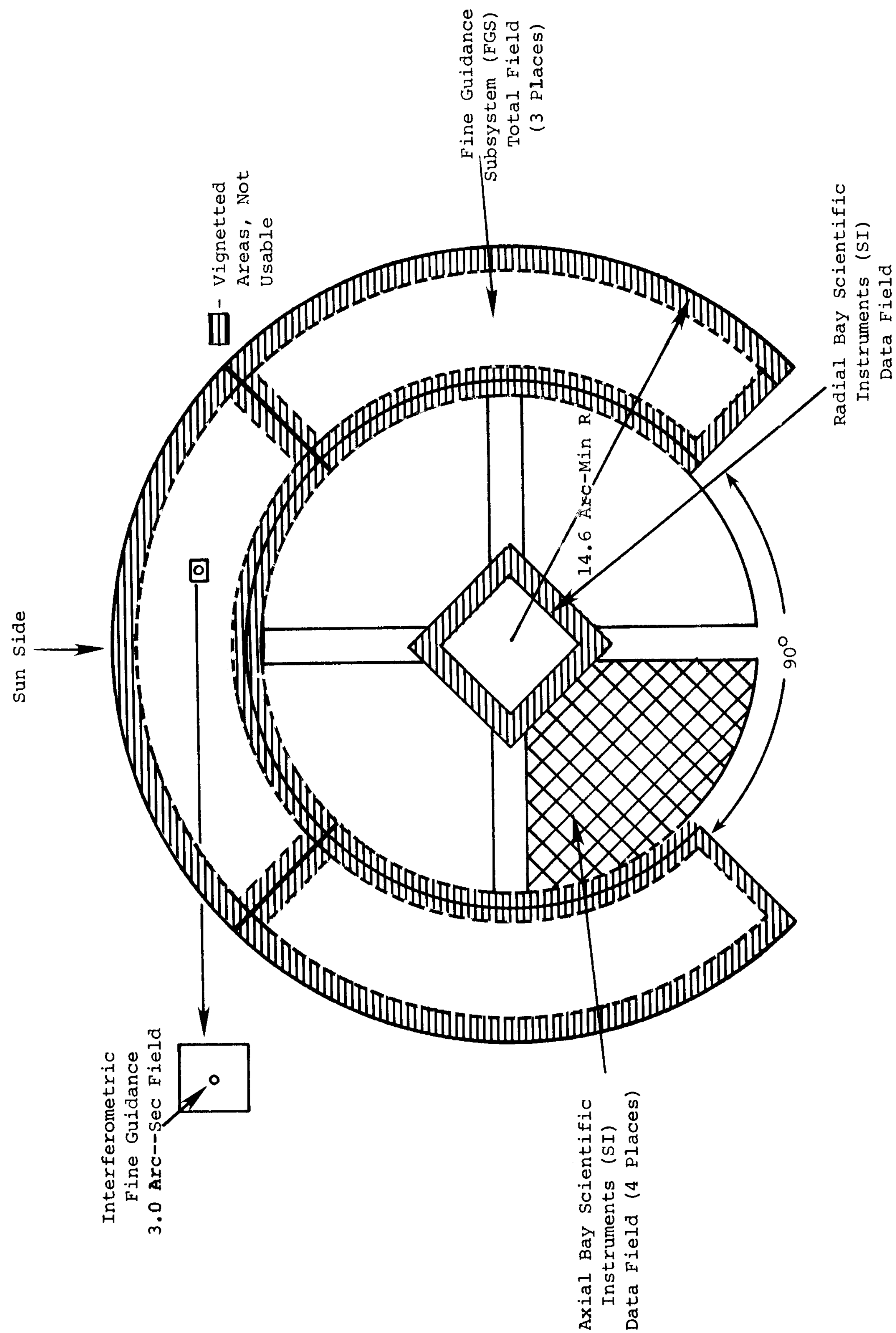

FIGURE 1

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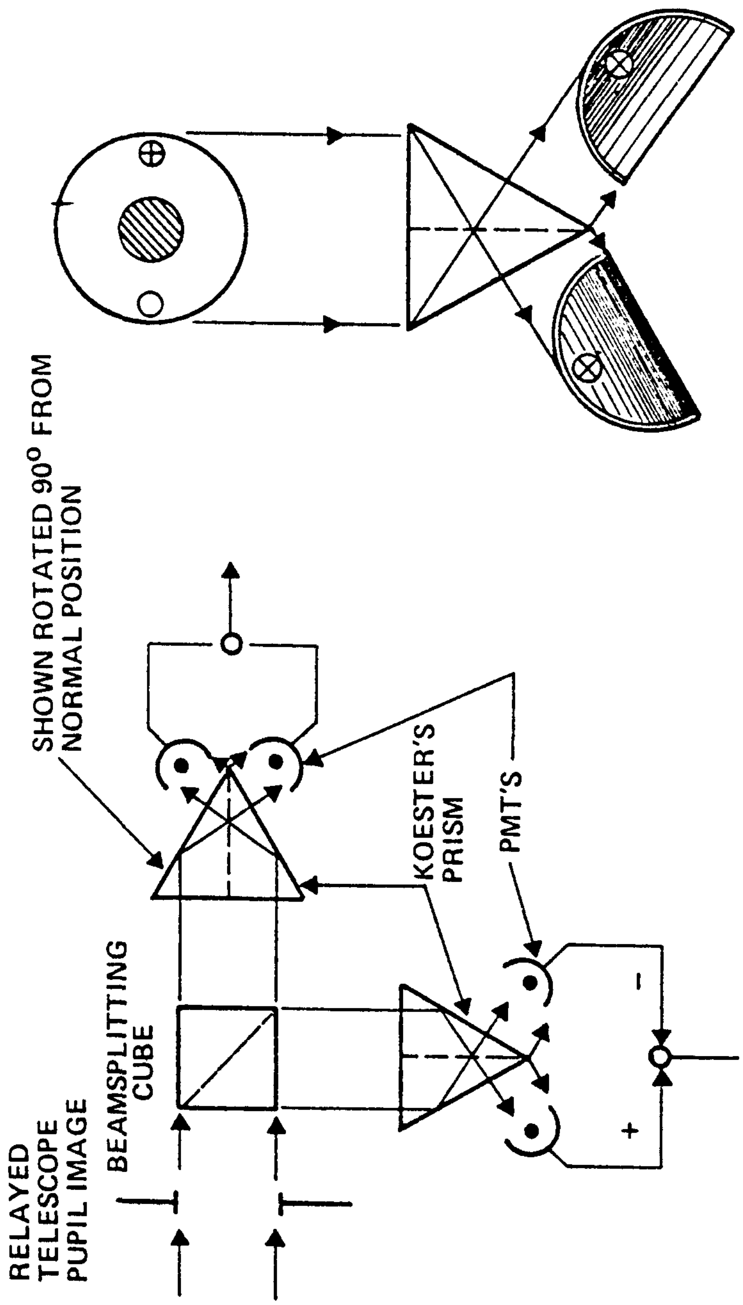

FIGURE 2

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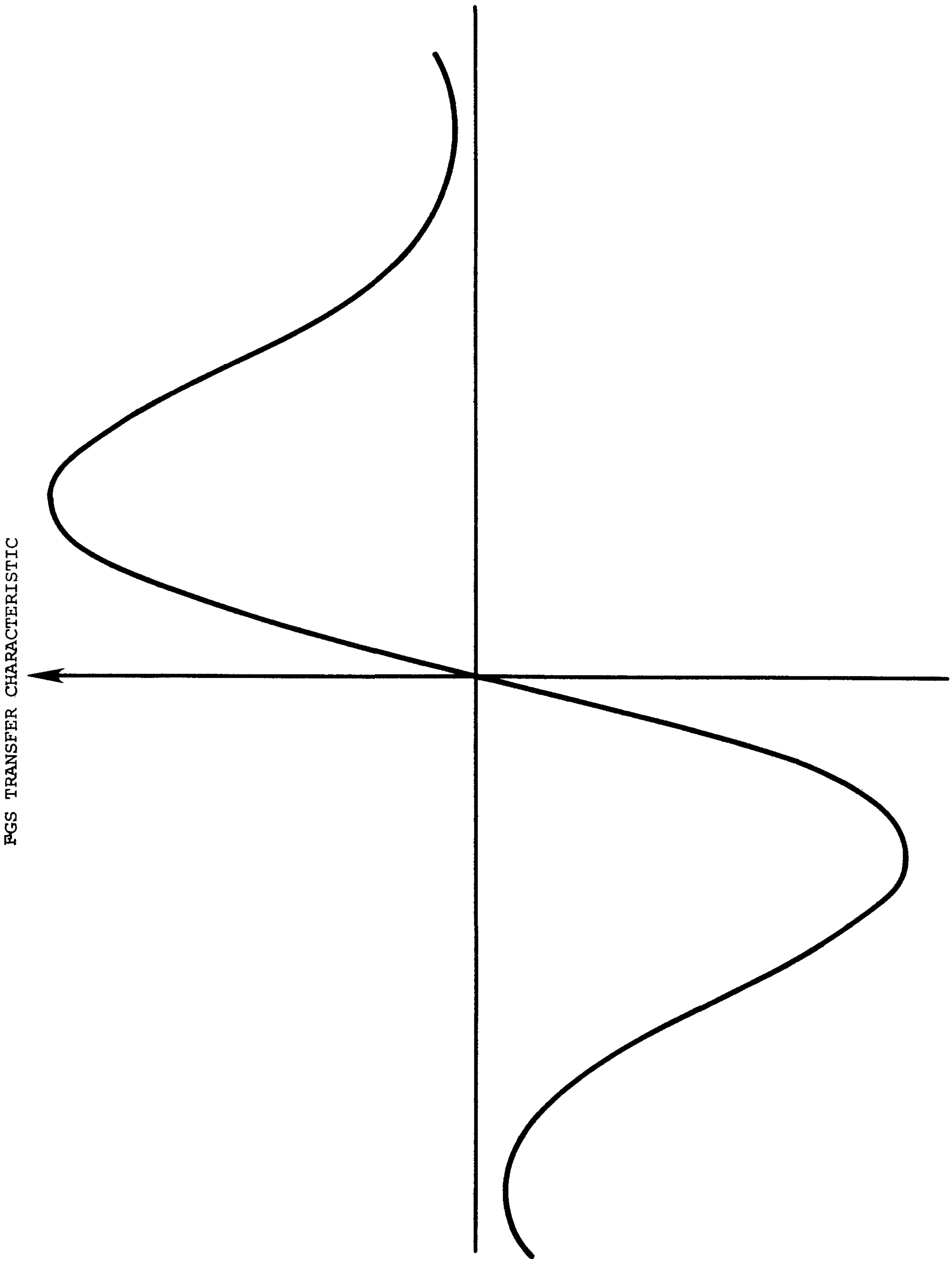

FIGURE 3

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DISCUSSION

POPPER: What are plans for parallaxes of binary stars?

FREDRICK: You cannot do what I would call trivial parallaxes, because this is an expensive instrument, but you can do very special binary systems. We have a list of 25 to 30 spectroscopic systems, a few planetary nebulae, and things like that.

MONET: How faint is the astrometric limit, in contrast to the guiding limit?

FREDRICK: It depends on how long you are willing to integrate, but you can get positions of stars down to 17th visual magnitude. The limit for guiding is a different problem, and that limit is 14.5. Guide stars are all supposed to lie between 10 and 14.5.

WESTERHOUT: Do I understand correctly that distances of objects closer than 0.02 to 0.01 arcsecond can only be observed by comparing scans with models, i.e., do you rely entirely on modeling the transfer function?

FREDRICK: You do not see the individual stars; you see only the transfer function, so that's why you need lots of models, to see the deviations from a single point source.

FRANZ: You will have to deconvolve a sample transfer function, knowing the transfer function of a single star. How that will work in the presence of noise we will see from the experiments.

WESTERHOUT: With the promise of the various groundbased systems being able to use their observations and models down to precisions of perhaps 0.001 arcsecond, what, other than perhaps the faintest objects, can Space Telescope do that cannot be done from the ground, as far as double stars are concerned?

FREDRICK: Primarily you are going to much fainter magnitudes.

HALL: Who decides where the telescope is pointed?

FREDRICK: There are six science teams, and they each get one-sixth of the time. As to who decides just where the telescope is pointed at a given time, the decision is made by some algorithm the Space Telescope Science Institute will make up.

CURRIE: Is the full information on the scan in the third pickle available?

FREDRICK: Yes.

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