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ORBITER HEAT FLUX COMPUTER PROGRAM

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Abstract

A two-phased contract is currently underway to develop 1) a set of parametric curves of absorbed heat flux for specific geometries, and 2) a generalized computer program whose output is absorbed heat flux on the surfaces of a planet orbiting spacecraft. The absorbed heat fluxes include the effects of blockage by and reflections from adjacent spacecraft surfaces, assuming all surfaces to be diffuse.

The final computer program will calculate fluxes on any of ten arbitrarily positioned plane surfaces, with any surface properties, planetary radiation characteristics, solar intensity, and orbital parameters. Outputs will be heat fluxes versus time, geometrical configuration factors, and radiant flux interchange factors.

This effort started roughly in May of 1963 when JPL was in the midst of its Voyager Studies. Thermal Control was actively involved in that study, seeking to provide guidelines for basic vehicle configuration. The transit problem was felt to be fairly well understood, and effort was directed at determining the peculiarities involved in making a deep space probe into an orbiter.

At this point, it might be worth while to mention some of the constraints to the Voyager as they apply to the thermal design. JPL spacecraft are typically fairly regular polygons with the electronics connected to the flat faces of this polygon, which then constitutes what is called the spacecraft bus. This, plus the fact that cylinders can be represented by flat surfaces, allowed us to restrict the study to flat surfaces. Mission requirements of importance were dual planet capability (Venus or Mars), solar panel or RTG power source, landing capsule, and a scientific payload which would want to scan the planet. Obviously a solar panel power source required sun orientation for the solar panels and probably the spacecraft bus, while an RTG would allow planet orientation. Therefore, both situations had to be evaluated.

Our first estimation was that the added heat fluxes near a planet would be critical, especially in the case of Venus. This conclusion was reinforced by some preliminary numbers extracted from Reference 1.

A survey of the literature (Reference 2) indicated that no published effort had been expended in the direction of accounting for shading of orbiter radiator surfaces by portions of the vehicle. It was felt that this might be a reasonable way to eliminate some unwanted heat fluxes. Alternatively, this approach might allow adding some heat flux during periods of spacecraft quiescence. These heat fluxes, in order to be successfully used, must include the energy reflected from the adjacent surfaces. To provide the capability to more readily evaluate these effects, a contract was let to generate a computer program which would provide the required heat flux information. The required flux information will consist of the following fluxes: solar, planet albedo, and planetary infrared, including blockage by and reflections from adjacent spacecraft surfaces. Secondary information output will be incident solar, planet albedo, and planetary infrared fluxes, view factors, and radiant flux interchange factors.

The contract consists of two phases. The first is a parametric study of particular orbiter configurations. The second is to prepare a generalized computer program for generating the required heat fluxes for any configuration of flat surfaces.

In the parametric study, the basic configuration studied consists of two or three adjacent sides of a rectangular box as shown in Fig. 1, surface 1 being the primary radiator surface, surfaces 2 and 3 being secondary surfaces. Fig. 1 also delineates the dimensions used to describe the configuration. This configuration is then considered to be either sun oriented or planet oriented in three particular orbits as shown in Fig. 2. Specific positions considered in each orbit are shown in Fig. 3. For all the above conditions, eight attitudes are considered varying from 100km to 30,000km, a/b and c/b (see Fig. 1) vary from 1/4 to 1 while $\phi = 90°$ and $\lambda = \beta = 90°$, and the surface properties of the primary surface and the secondary surface are fixed.

Several of the other parameters are varied at only one altitude at the sub-solar point in order to indicate the trends of these changes.

This parametric information will be tabulated with bounding values plotted. It is intended that this data will provide preliminary design information for the up-coming planetary orbiters.

The generalized computer program will have as inputs any arbitrary set of orbital parameters, planetary characteristics, solar intensity, number and orientation of radiator surfaces, and a specification of either sun or planet orientation. Using these inputs, the program will generate the required heat flux information as mentioned previously in addition to giving the points of entry and exit from the planet shadow. These heat flux outputs, as well as the radiation interchange factors can then be inserted directly into a temperature computation program to develop a complete temperature profile for the vehicle in orbit.

References

1. ASD Technical Report 61-119, Part 1, December 1961.

2. JPL Literature Search No. 522, April 29, 1963, Thermal Design of Non-Spinning, Planet, or Inertially Oriented Satellites.

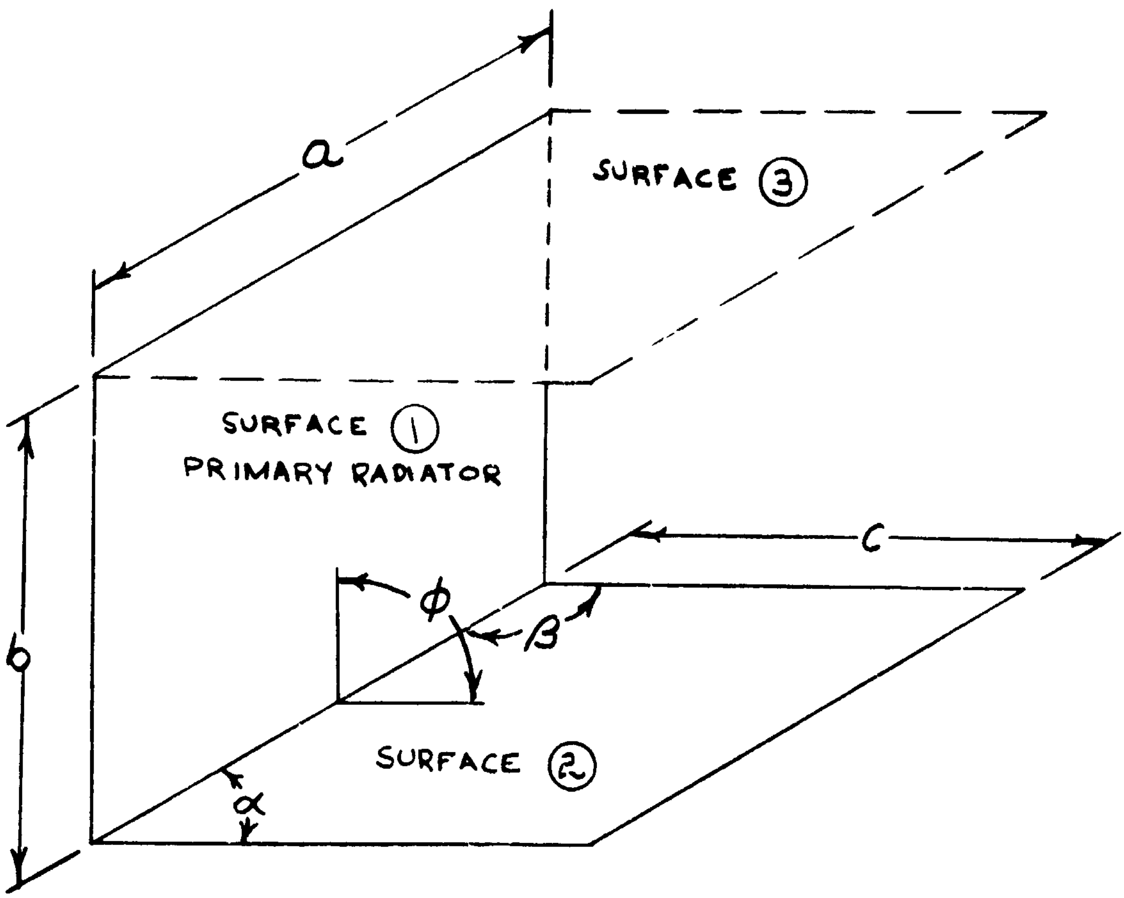


FIGURE 1 ~ CONFIGURATION

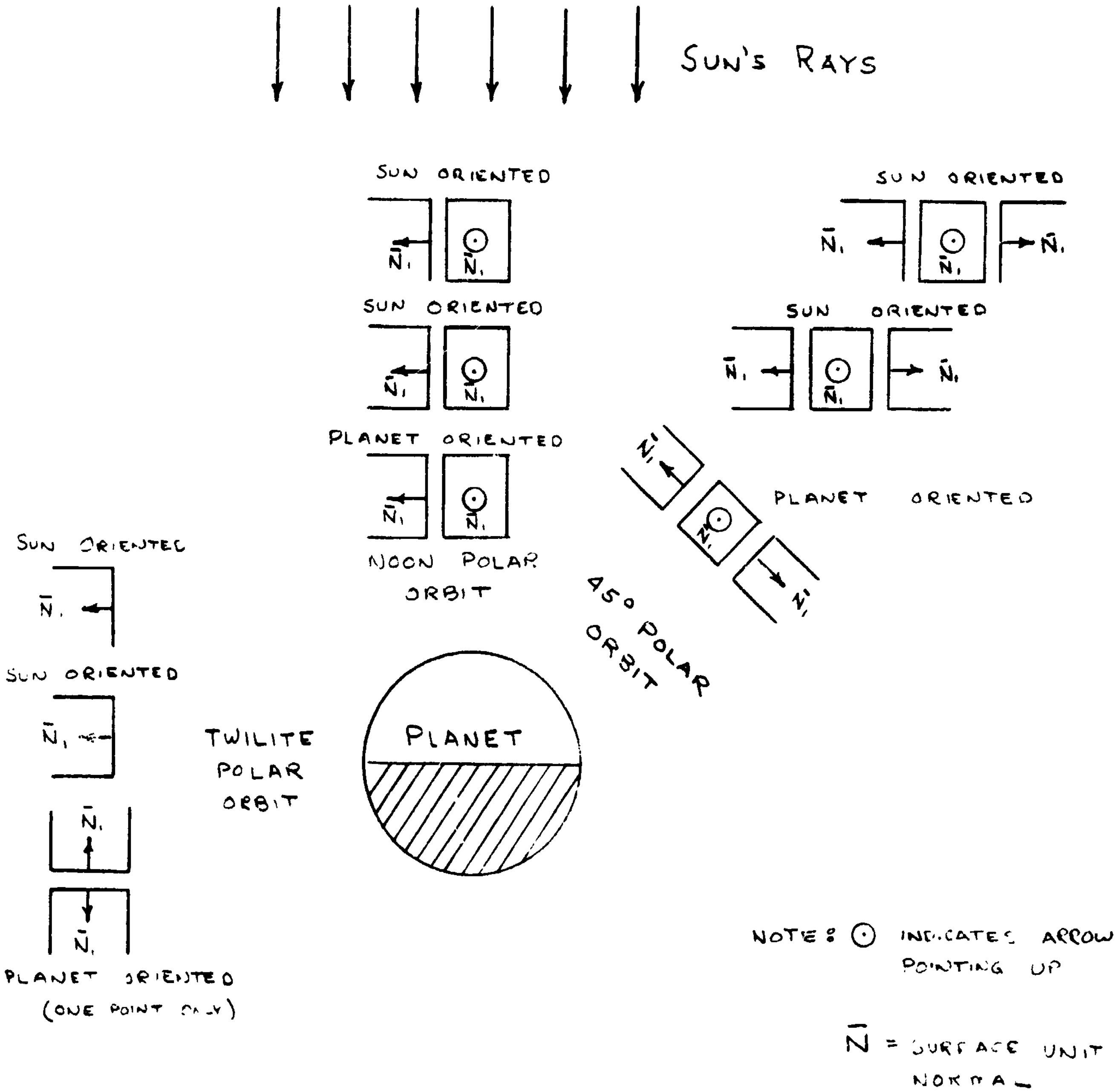
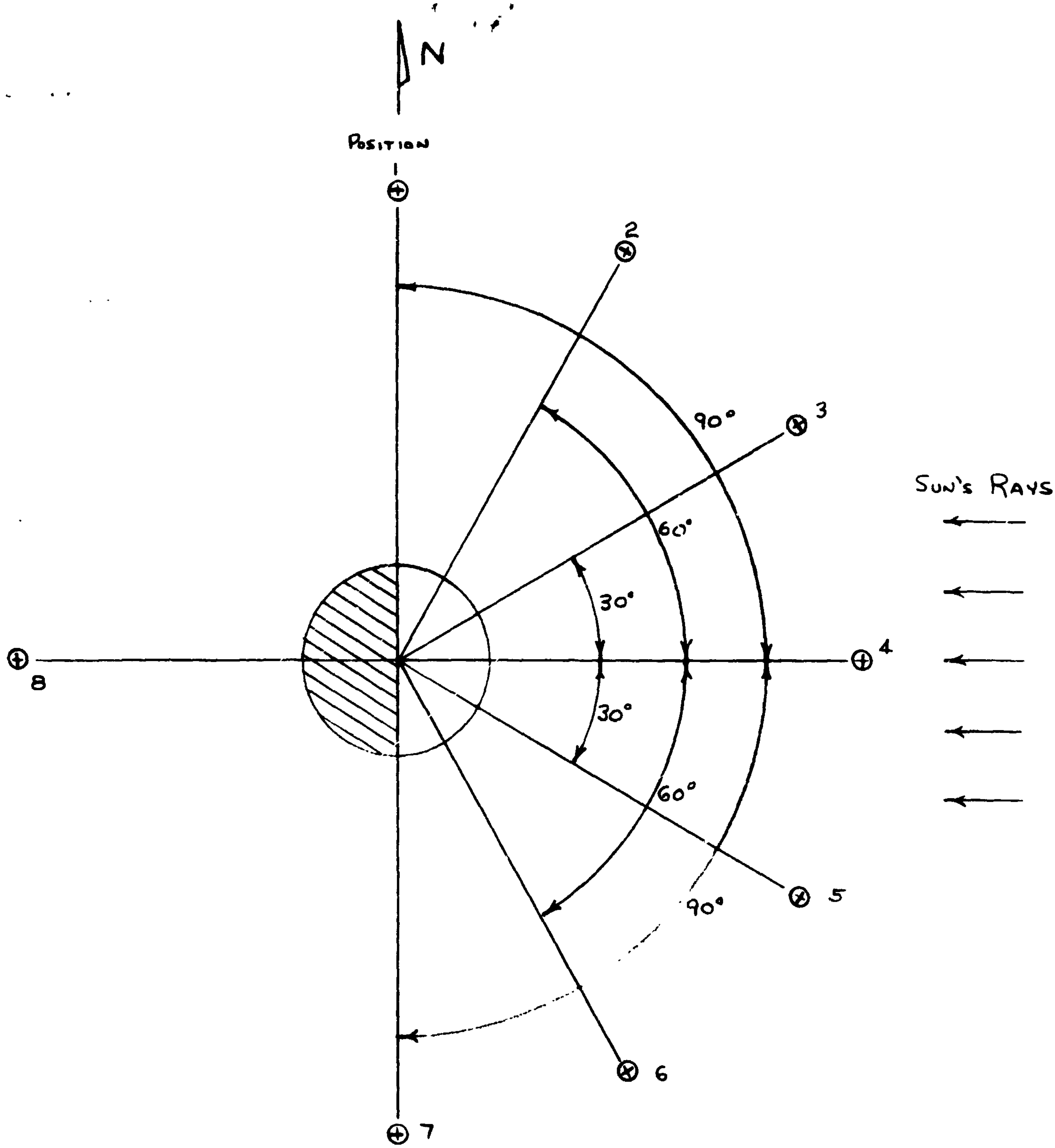


FIGURE 2 ~ ORIENTATIONS



NOTE: THIS SET OF POSITIONS IS ROTATED CLOCKWISE WHEN VIEWED FROM ABOVE THE NORTH POLE FOR THE 45° AND TWILITE ORBITS.

FIGURE 3 ~ POSITIONS