uate the differential coefficients appearing in the equations of condition. For example:

$$\frac{\partial \theta}{\partial e} = \left\{ \frac{57.3 \sin v (2 + e \cos v)}{1 - e^2} \right\} \{1 - \sin^2 i \cos^2(\theta - \Omega)\} = \alpha \cdot \beta,$$

where v is the true anomaly. Although $\partial \theta / \partial e$ is a function of four parameters, namely, e , v , i , and $(\theta - \Omega)$, it is possible to *tabulate* two functions, α and β , whose product gives $\partial \theta / \partial e$. α is a function of only e and M (the true anomaly) and β is a function of only i and $(\theta - \Omega)$. e , M , i , and $(\theta - \Omega)$ are known at each point so that the evaluation of a single value of $\partial \theta / \partial e$ involves two table lookups and one multiplication—a matter of a minute or less.

The other differential coefficients can be treated in somewhat similar fashion. A total of 11 tables suffices and these tables have been calculated with the IBM 650 at the Indiana University Research Computing Center. In a typical case, the use of these tables enables the computer to calculate and check all necessary coefficients in a matter of a very few hours. The tables can also be used to correct the elements one at a time.

Tables of $\partial X / \partial e$, $\partial Y / \partial e$, $\partial X / \partial M$, and $\partial Y / \partial M$ have also been calculated. Such tables are useful in a least-squares solution involving x and y rather than ρ and θ .

Reliability Approach to Astronomical Satellites.

EDWIN D. KARMIOŁ AND JOHN S. YOUTCHEFF, *General Electric Company, Missile and Space Vehicle Department, Philadelphia, Pennsylvania*.—As in all complex systems, astronomical satellite reliability is essential in the attainment of the operational objectives. However, the uniqueness of astronomical observations in space imposes reliability considerations and requirements which are equally unique. In determining the adequacy of the astronomical satellite to meet these requirements satisfactorily, techniques can be employed to predict the system reliability utilizing methods developed in ballistic missile and space vehicle reliability programs. This paper discusses the astronomical satellite operational and environmental problems and the techniques that can be employed to predict the probability of successful system functioning in the operational environment.

A New 21-cm Interpretation of the Spiral Structure and Motions of the Galaxy. F. J. KERR, *CSIRO Radiophysics Laboratory, Sydney, NSW, Australia*.—A detailed comparison has been made between the Leiden and Sydney 21-cm surveys for the two halves of the Galaxy. The first reduction of the observations was done in a homogeneous manner, using the Leiden rotational velocity model for the whole Galaxy. This yielded a quite implausible

spiral structure diagram, and it was necessary to consider alternative models. As a basic criterion, the assumption was made that the structure and motions of the Galaxy are symmetrical on a large scale.

The observations for the southern side lead to somewhat lower apparent rotational velocities than are observed on the northern side. The results on the two sides of the Galaxy can be reconciled by introducing an additional solar motion component of 7 km/sec in a direction outwards from the galactic center, in other words, an outward motion of the young stars which are mainly involved in the determination of the "local center of rest." (This motion is relative to very distant hydrogen, and so the result is not in conflict with optical results on the solar motion relative to nearer objects.) A further anomaly is found in the asymmetrical appearance of the 21-cm relief map of the galactic disk, when based on the earlier model. This result, together with the lack of relative motion between the local stars and local gas, suggests that the gas at the sun's distance from the center is also moving outwards with a velocity of 5–7 km/sec. This motion is presumably related to the rapid outflow of gas which is known to be occurring in the central region.

A new spiral diagram has been derived, taking both rotation and expansion into account; the arms are more continuous and the general pattern has a more reasonable appearance than in earlier interpretations. Some of the implications of the proposed velocity picture will be discussed.

Star Distribution in the Globular Cluster M15.

IVAN KING, *University of Illinois Observatory*.—Star counts and photoelectric surface photometry have been combined to derive the star distribution in the globular cluster M15, from the small central core to the edge of the cluster. Because of its high central concentration, M15 is a severe test for any empirical law. The core has a radius of ten seconds, while cluster stars are easily detectable 15 minutes from the cluster center.

A plot of the logarithm of projected density against $\log r$ shows clearly that no power law will represent the distribution. Instead it appears that the density approaches zero at a finite value of r , exactly as should be expected for a cluster in the tidal field of the Milky Way. From $r=1'$ out to the limit of the observations, the projected density in M15 is closely proportional to $(1/r - 1/r_0)^2$. Extrapolation gives for the tidal limit of M15 $r_0=21'$, a figure which agrees well with the theoretical estimate. The formula also closely represents the densities outside the central cores in Centauri, 47 Tucanae, and M13, provided suitable values are taken for r_0 .

In the neighborhood of the limit, the above formula goes to zero as $(r_0 - r)^2$. This can be shown to