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Kenneth H. Schatten

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PREDICTION OF THE CORONAL STRUCTURE FOR THE SOLAR ECLIPSE OF SEPTEMBER 22, 1968*

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Technical Report

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Prediction of the Coronal Structure for the Solar Eclipse of September 22, 1968

Kenneth H. Schatten
Space Sciences Laboratory
University of California
Berkeley, California

A method of determining the large-scale structure of the coronal and interplanetary magnetic fields has recently been described by Schatten *et al*[1]. The model originated as an attempt to explain the observed large-scale structure of the interplanetary magnetic field. The model has been partially validated by successful comparisons of the observed interplanetary magnetic field with a field computed from photospheric observations according to this formalism. Further evidence for support of the model has been established by Schatten[2] by comparisons of the computed coronal magnetic structure with coronal green line (λ 5303) emission. The model has been further investigated by comparisons with the coronal structures revealed in eclipse photographs, and this process has suggested the possibility to make a prediction of the coronal structures to be expected at the solar eclipse of September 22, 1968.

The model consists of a "source surface", which in first approximation is a sphere concentric with the sun. Between the photosphere and this sphere a potential solution to Maxwell's equation is assumed to govern the large-scale magnetic field. Near the source surface, 0.6 solar radii above the photosphere, the transverse magnetic energy density is superseded by the plasma energy density and thus this solution becomes invalid. The magnetic field above this region is "stretched" by the radial expansion of the coronal plasma. It is this coronal plasma that develops into the solar wind, transporting the imbedded source surface magnetic field with it. Currents on the source surface are computed to approximate this effect. These currents and those necessary to represent the observed photospheric magnetic fields (Zeeman effect) comprise the sources of the magnetic field in this potential solution.

The magnetic field is assumed to structure the coronal plasma in the region between the source surface and the photosphere. This results in magnetic loops or closed regions within the inner corona, predominantly above small regions of opposing photospheric magnetic field polarity. Unipolar Magnetic Regions, observed in the photosphere, result in open field line configurations within the corona. The model calculates the effect of this structuring in the potential solution. It has proved successful in describing the transition from small scale features observed in the photosphere to the much larger scale features observed in interplanetary space, and in comparisons with coronal green line intensities.

A further evaluation of the model can be made using the coronal structure revealed in eclipse photographs. Figure 1a shows a photograph of the November 12, 1966 eclipse obtained by S. Smith of NASA-Ames Research Center using a radial transmission filter with a 3.3 second exposure time. The radial transmission filter compensates for the large variation in brightness present in the corona. This allows a single photograph to exhibit structure throughout a large portion of the corona.

Three large prominences near the solar limbs are indicated by the letters P. Above these prominences are helmet streamers. A coronal condensation is indicated by the letter C in this figure. The ray structure above the condensation is sometimes referred to as a coronal fan. Some polar plumes are visible in the polar regions of the photograph. The general appearance of the photograph is that of an inactive corona.

The corona is an optically thin, three-dimensional object and thus to describe its appearance, one must project all of its features into the plane of the sky. Figure 1b is a composite drawing made from many computer plots of the coronal magnetic field structure on November 12, 1966. It was made without prior reference to a coronal photograph from this eclipse. Figure 2 shows a typical computer plot of a cross-section of the magnetic field in the inner corona projected into the plane of the sky. The arrows indicate the direction of the magnetic field and the spacing between the arrows is inversely proportional to field strength. Figure 1b was drawn from about 10 such plots.

Closed loop structures in Figure 1b appear on the east limb of the drawing in the same region where coronal arches are seen in the photograph. In the north-east quadrant, open field lines correspond to open coronal rays. In the south-west quadrant, the helmet streamer appears to be in agreement with the drawing. The coronal condensation and fan just northward of the equator on the west limb correspond to diverging field lines seen in the drawing. Magnetic loops northward of this feature also agree with coronal arches. General features appear to be quite similar between Figures 1a and 1b. It should be kept in mind that coronal photographs show the appearance of the corona rather than the structure. The structure present can only be ascertained by examining the photograph very carefully. Isophotes, lines of equal intensity, should not be identified with structure, but rather with large-scale density variations.

Figure 3 is a prediction made on September 20 of the structure of the September 22, 1968 eclipse of the sun (which will be total over the U.S.S.R. and a small portion of western China). Observations of the photospheric magnetic field were unavailable during most of the month preceding the time of this prediction due to malfunctioning of the Mount Wilson Observatory magnetograph guiding system. Thus good magnetic observations for the limbs of the sun on September 22 were unavailable. Utilizing magnetograms available from the previous solar rotation, and spectroheliograms of the calcium K2 line and the Hα line, estimates of the photospheric field strengths and directions at the time of the eclipse could be made. The coronal structure in Figure 3 appears more complex than structure evident in the November 12, 1966 eclipse due to the greater solar activity at the present time.

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References

1. Schatten, K. H., Wilcox, J. M. and Ness, N. F., Solar Physics (in press, 1968).

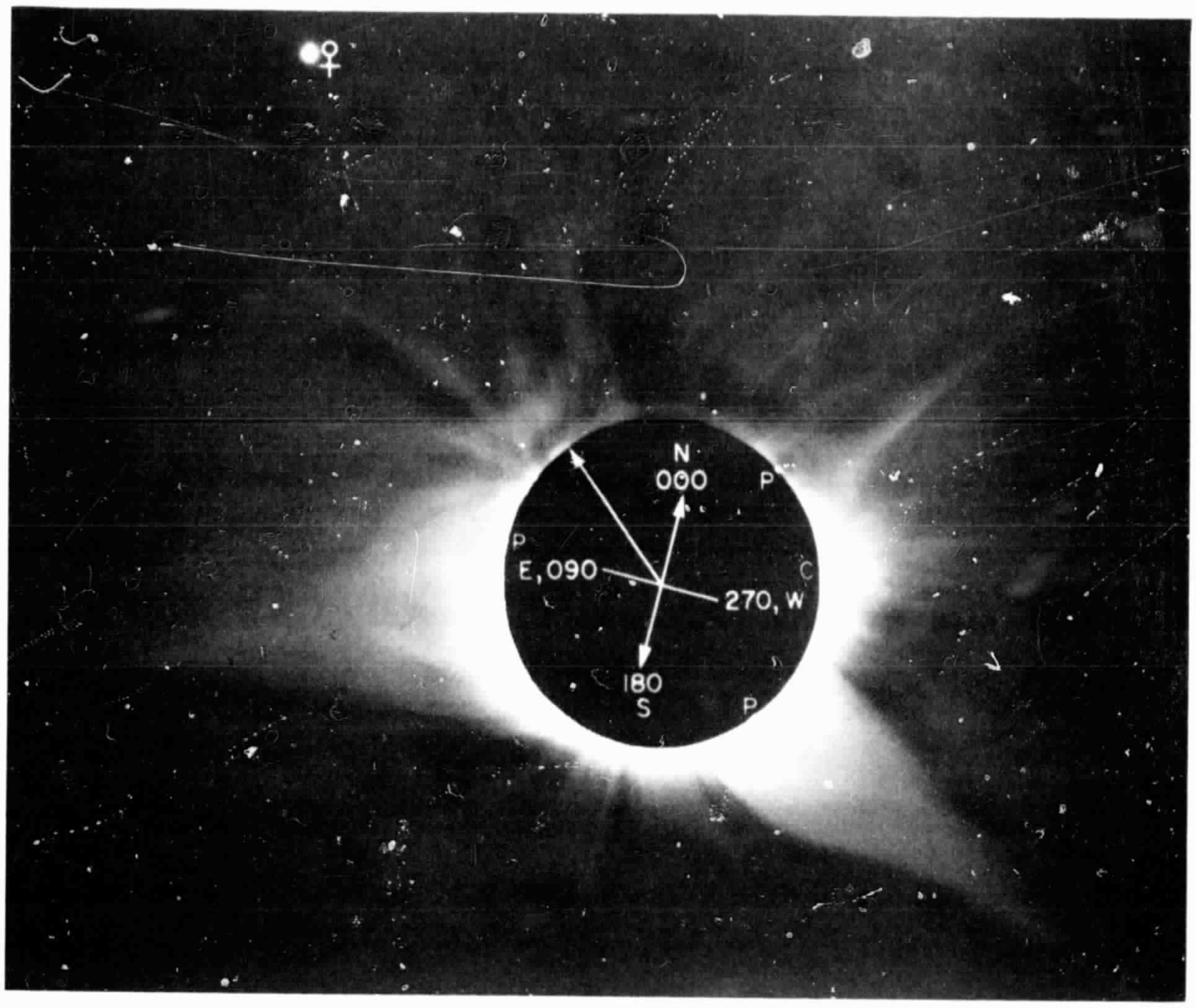
2. Schatten, K. H., Ph.D. Thesis, Department of Physics, University of California, Berkeley (1968).

Figure Captions

Figure 1a. Photograph of the corona of November 12, 1966 by S. Smith, NASA-Ames Research Center. b. (bottom) Drawing of the magnetic structure of the corona according to the formalism outlined.

Figure 2. Magnetic field structure in one cross-section of the corona computed from the photosphere to the source surface and projected into the plane of the sky.

Figure 3. Prediction of the coronal structure for the September 22, 1968 solar eclipse.



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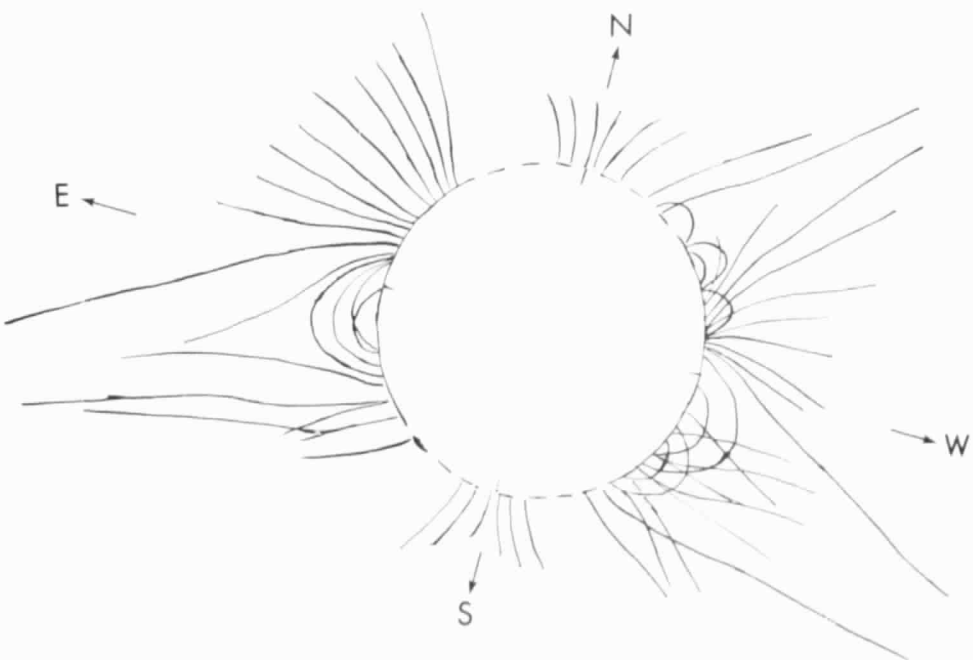

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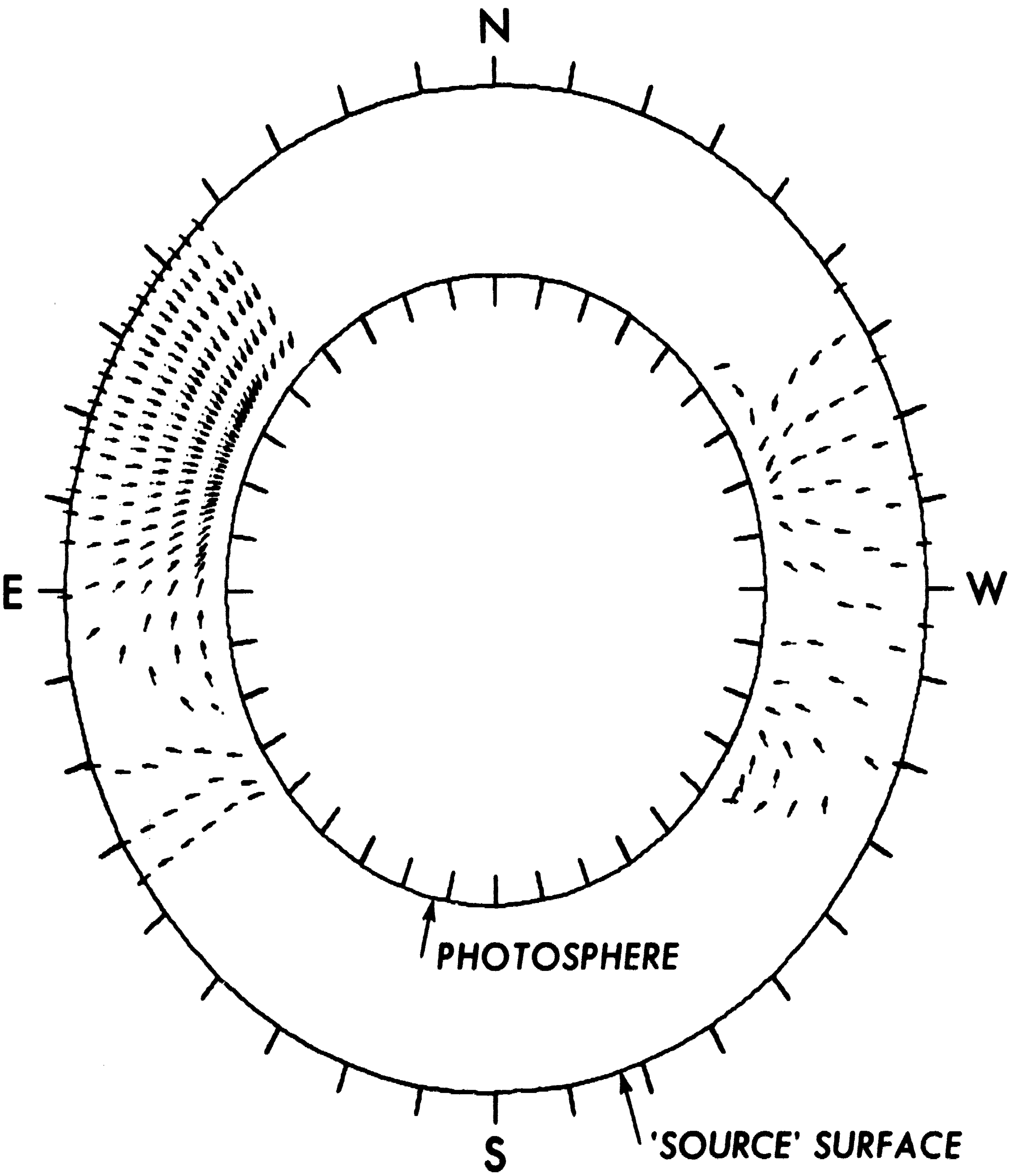

Figure 2

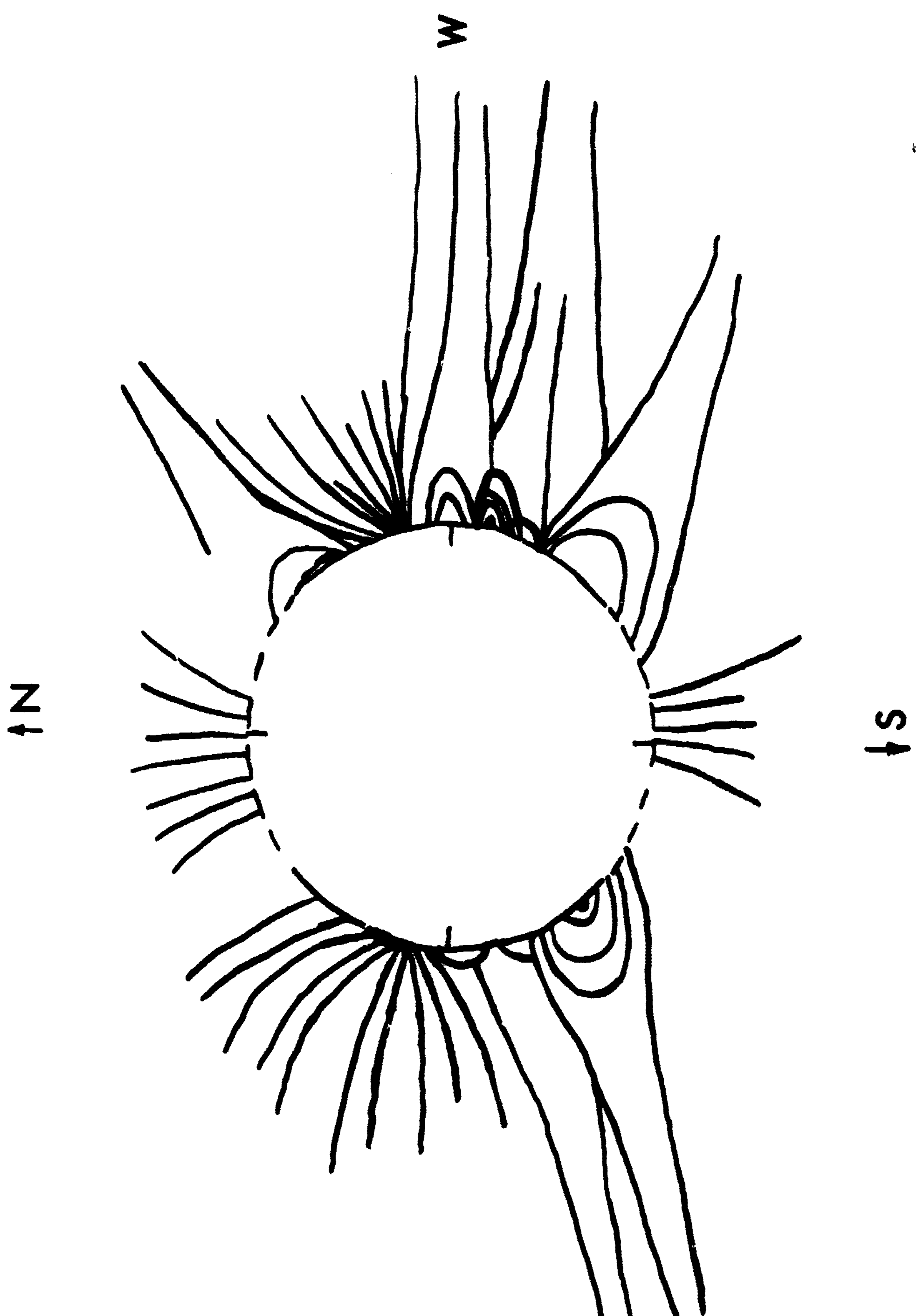

Figure 3

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13. ABSTRACT

The coronal structure for the solar eclipse of September 22, 1968 has been predicted utilizing a recent model for large-scale structure within the inner corona. Supporting evidence for the model has come from comparisons with interplanetary magnetic field observations, coronal green line emission and comparisons of coronal structures evident in previous eclipses. (U)

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