The March Eclipse from Santa Maria Tonameca

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ATMOSPHERIC PHYSICS

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A group consisting of Dr. Herman Haupt, Dr. Maria Firneis and Engineer Gerhard Klement of the University Observatory of Vienna, Austria along with the author collaborated in an experiment to measure the brightness and polarization of the corona during the March 7, 1970 total eclipse of the sun.

Our observing site was near the edge of the small friendly village of Santa Maria Tonameca in the state of Oaxaca, Mexico. Tonameca is located 20 miles inland from the Pacific Coast and northwest of the city of Pochutla near where the center of the path of totality passed, (Sky and Telescope, July, 1969). Its elevation is just above sea level and it is located on the narrow plateau near the coast which has very clear skies at this season of the year. In fact on the morning of the eclipse not even a single cloud was visible in the clear blue sky as final preparations were made for the eclipse. These conditions prevailed, allowing us a remarkable view of the corona.

The equipment used was constructed at the University of Minnesota under the direction of Dr. E. P. Ney and has been used in three previous eclipses to measure the brightness and polarization of the corona. It consists of two one meter focal length telescopes which raster scan the corona measuring its brightness and polarization in the near infrared and visible regions of the spectrum. Two 19 cm focal length telescopes were also used to measure the brightness and polarization of the sky around the corona. With the data from these four telescopes, the absolute surface brightness, percent polarization and the direction of polarization as a function of position in the corona can be determined in each of the spectral regions.

Between second and third contact we were successful in making six raster scans in each spectral region. This data, after many hours of analysis, should provide a detailed knowledge of the polarization and brightness of the corona.

A fifth telescope consisting of a 65 cm focal length f-5 objective mounted in a baffled lens barrel imaged the corona onto a 35 mm movie camera. This camera, loaded with improved type Extended Range film (XR-film),was started some seconds before second contact and photographed the corona at 8 frames per second during totality. The photographs and data accompanying this article are from just two of the 1600 odd frames of this movie.

XR-film is a three emulsion layer panchromatic film. Each of the emulsion layers has a different sensitivity and when the film is processed as color negative film the most sensitive layer appears as cyan, the intermediate sensitivity layer appears as magenta and the least sensitive layer appears as yellow. The sensitivities of these layers permit a brightness range of over a million to be recorded.

The camera and optical system used was such that the background sky and outer corona were properly exposed in the magenta layer while the limb of the sun just before second contact, was well exposed in the yellow emulsion layer. The exposure in the cyan layer is well suited for study of the inner corona.

Sensitometry wedges were placed on the ends of the film using the same exposure time used to take the coronal movies. These wedges allow one to determine the relative surface brightness of the corona by densitometering the negatives and comparing the measured densities with the densities of the sensitometry wedges for which the relative surface brightnesses are known. The three layers can be separated by densitometering the negative through colored filters. A blue filter is used to separate the yellow layer, a red filter is used for the cyan layer and a green filter enables one to study the magenta layer of the film.

The isodensity recordings accompanying this article were made with a Joyce-Loebl microdensitometer equipped with an Isodensity Recorder. This equipment enables a negative to be scanned and contours of constant density to be plotted automatically. Densitometry that would take months using more conventional techniques can be done with this instrument in an afternoon.

The isodensity recordings can be used to determine relative surface brightness in the corona since the edges of the isodensity contours are lines of constant brightness or isophotes. This can be accomplished by using the density vs. log of the surface brightness or gamma curve relation for each of the emulsion layers, which was determined from the sensitometry wedges, along with a single plot of density as a function of position on a line across the image of the corona on the negative.

It is interesting to note that the plot of density as a function of position across the frame, made through a green filter of the magenta layer of the film, suggests that there are two components to the corona. One observes that the density decreases with almost constant steep slope from the solar limb until about two solar radii from the sun's center and then decreases less rapidly until the edge of the frame again with almost constant slope. The light producing the rapid fall off near the sun is interpreted by the author as being primarily due to light from the K-corona while the light producing the shallow gradient beyond 2 solar radii as due to the light of the F-corona. This is particularly evident since the gamma curve for the magenta layer is to first approximation linear in the range used for this exposure.

The K-corona is due to Thompson scattering of the solar light from electrons near the sun in the solar atmosphere whereas the F-corona is produced by the small angle scattering from the zodiacal dust particles between the sun and the earth.

The success of our expedition is in large part due to the help and cooperation of Mr. Edwin Rudisuhle of Mexico City who helped us with our planning and logistics and who accompanied us at the camp site. Special thanks should be extended to Mr. Carlos Hernandez and his helpers who transported the ton of equipment needed for the measurement over rough and dangerous roads without damage.

Support for the University of Minnesota portion of this experiment was furnished by the Office of Naval Research under Contract No. N00014-67-A-0113-0004.

Figures

Figure 1. This photograph was printed from an early frame of the movie which was taken about 3-1/2 seconds before second contact. This, like the other photograph of the corona accompanying this article, was printed on Panolure paper and color separation filters were used to take advantage of the Extended Range film to produce this remarkable photograph of the diamond ring. One notes the presence of the two prominences close together near the bottom of the photograph at the base of the large streamer and the single prominence on the right hand side.

Figure 2. This photograph was printed from a frame of the eclipse movie which was exposed near mid-totality. One notes the presence of the structure of the corona which can also be seen in the isodensity tracings.

Figure 3. Isodensity recording of a frame exposed near mid-totality that was scanned through green filter showing the high speed magenta layer of film. One observes the inflections in the isophotes produced by the streamers that were present in the corona. These can be clearly seen all the way to the edge of the frame.

Figure 4. Isodensity recording of the same frame as the above, but made through a red filter showing the density contours of the intermediate sensitivity cyan layer. One notes the remarkable structure that is seen in the inner corona particularly near the prominences and at the base of the streamers. Many small streamers can be seen.

Figure 5. Plot of density in the high sensitivity magenta layer as a function of position along the long direction of the rectangular frame on a line through the sun's center. The units along the bottom axis are in solar radii. The recording across the graph at about .35 density units is the background density in this layer. It is observed that the intensity of the lunar disk is well above background, but less than the intensity at the extreme edges of the frame. This plot suggests the presence of both the K and F coronas as is discussed in the text.

Figure 6. Plot of density in the intermediate sensitivity cyan layer as a function of position along the long direction of the rectangular frame on a line through the sun's center.

Figure 7. Relations between relative surface brightness and density which was determined from the sensitometry wedges for the cyan and magenta layers.

Figure 8. Relative surface brightness as a function of distance from the sun's center in solar radii. This data was derived, using the calibrations discussed in this article, from the density traces through the sun's center along the long direction of the frame. The righthand side was used which is observed to be brighter near the limb than the lefthand side. One observes a change of slope in this curve just beyond two solar radii from the sun's center which is interpreted by the author to show the separation of the K and F corona.

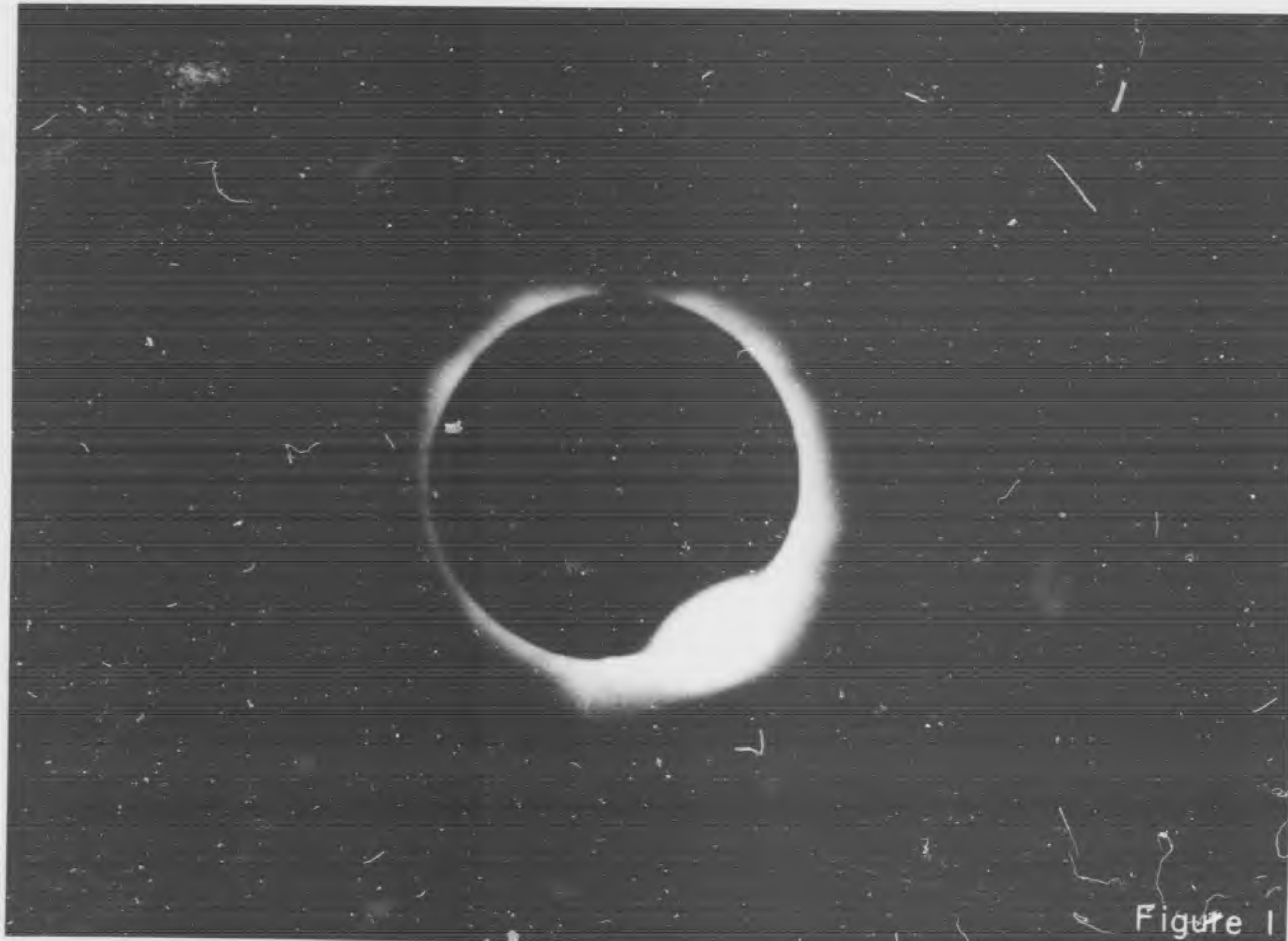

Figure 1

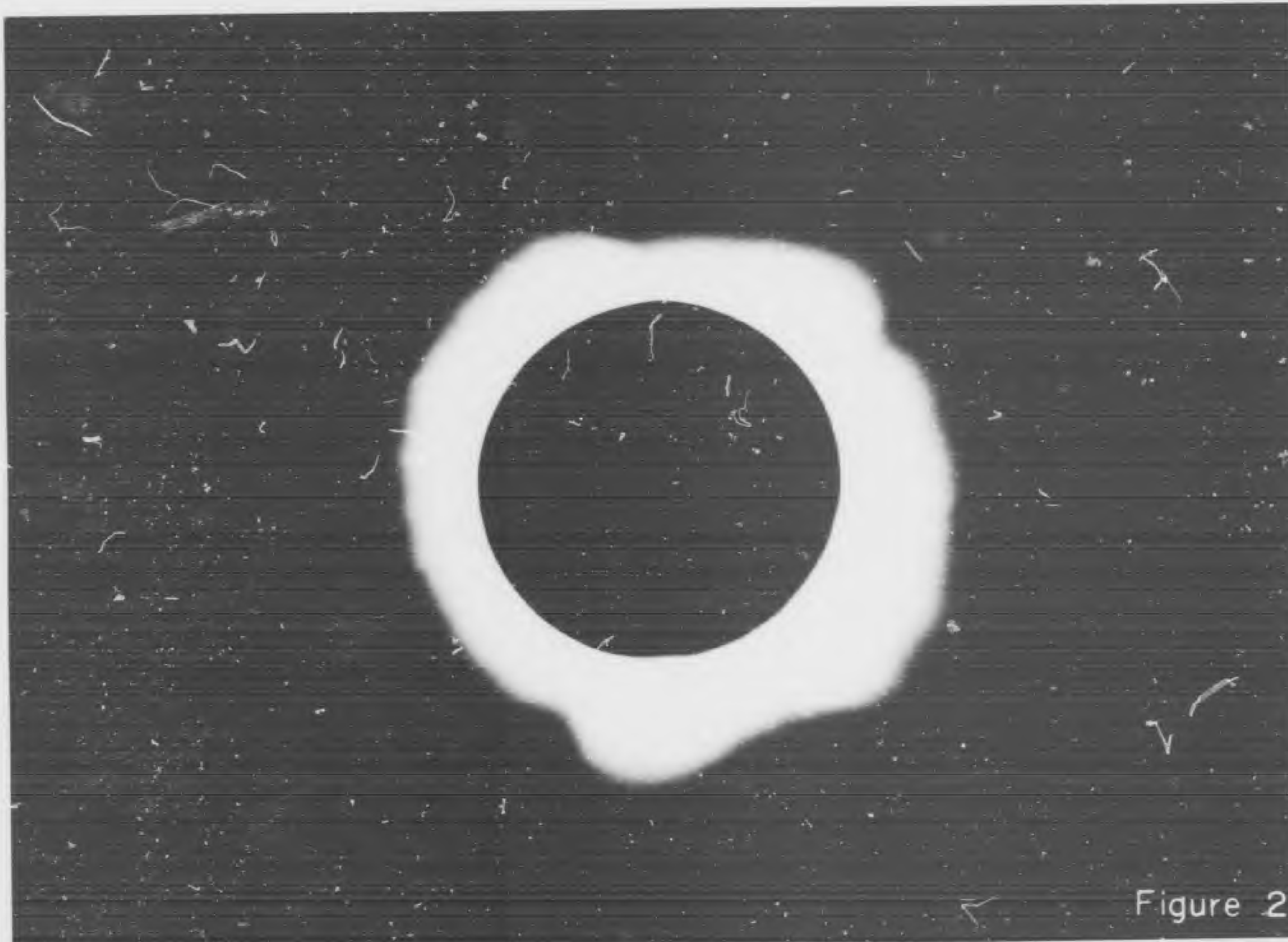
Figure 2

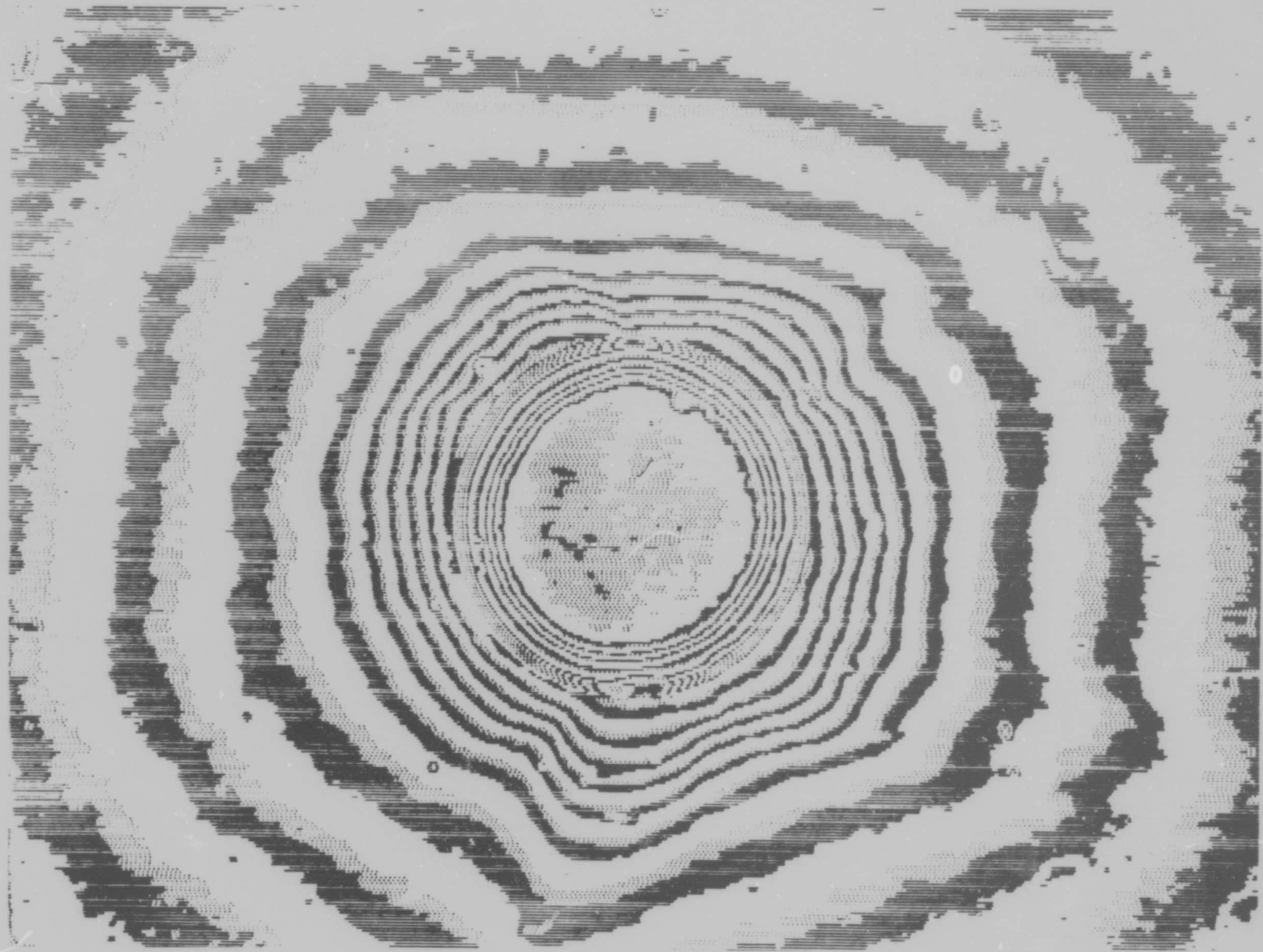

Figure 3

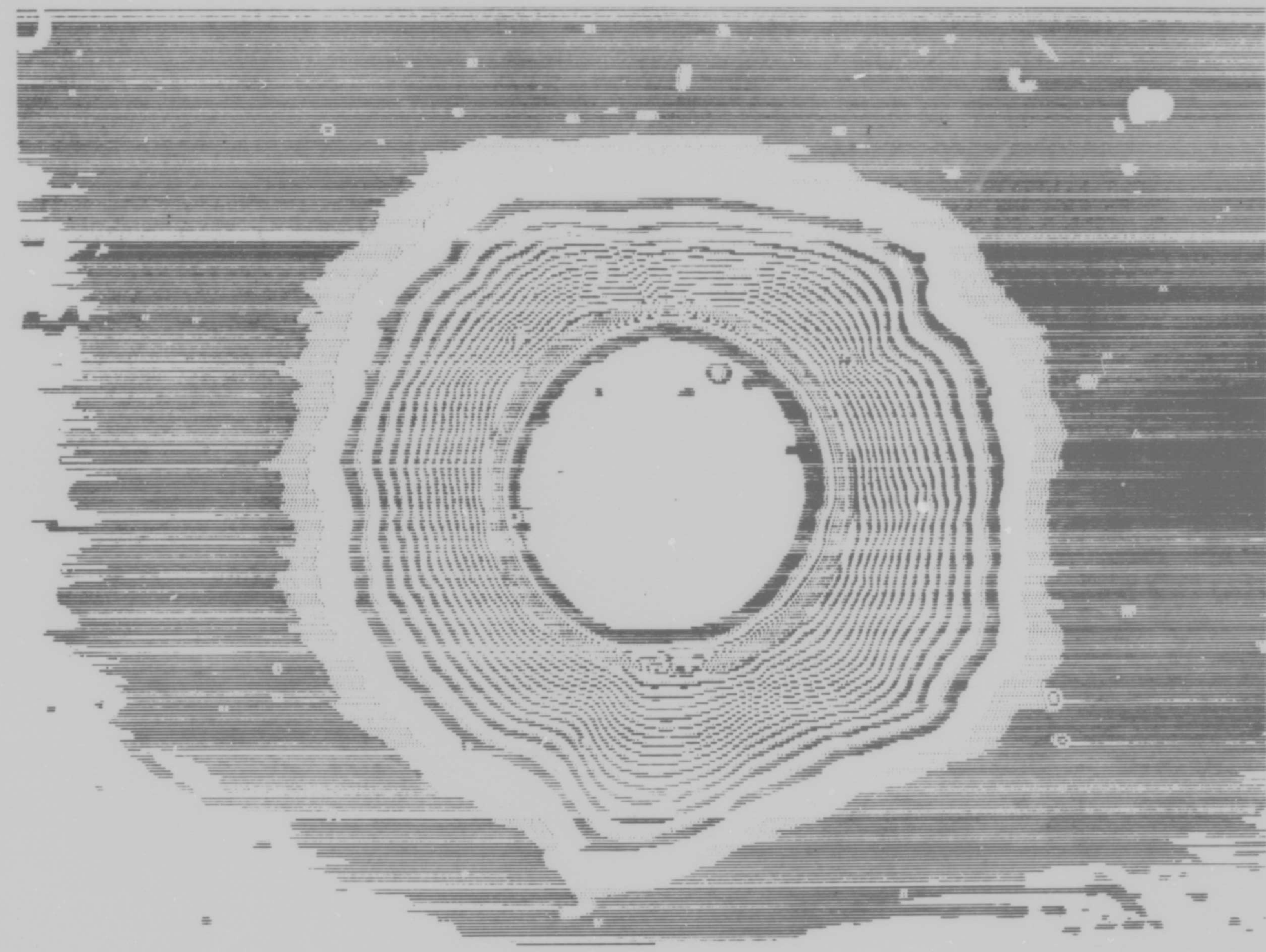

Figure 4

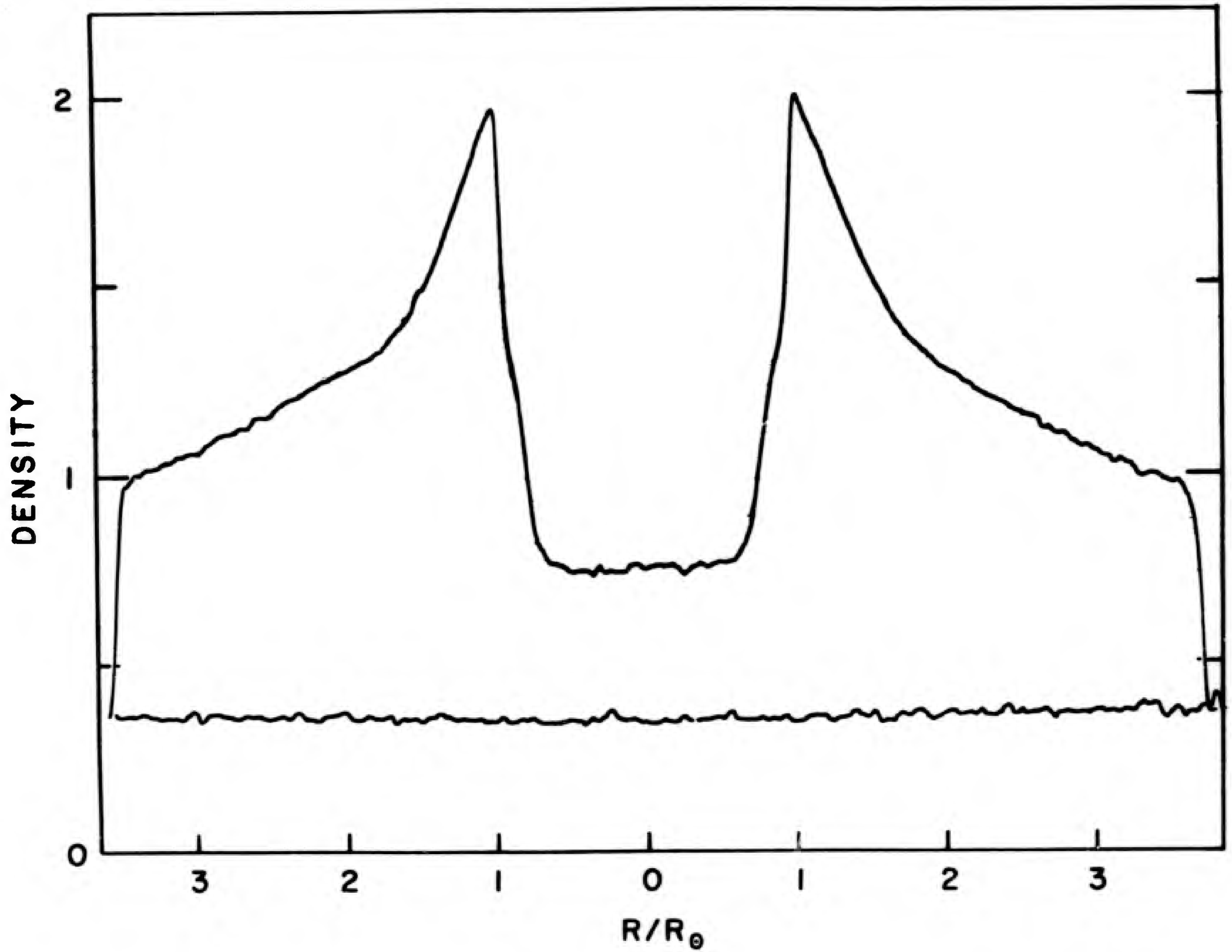

Figure 5

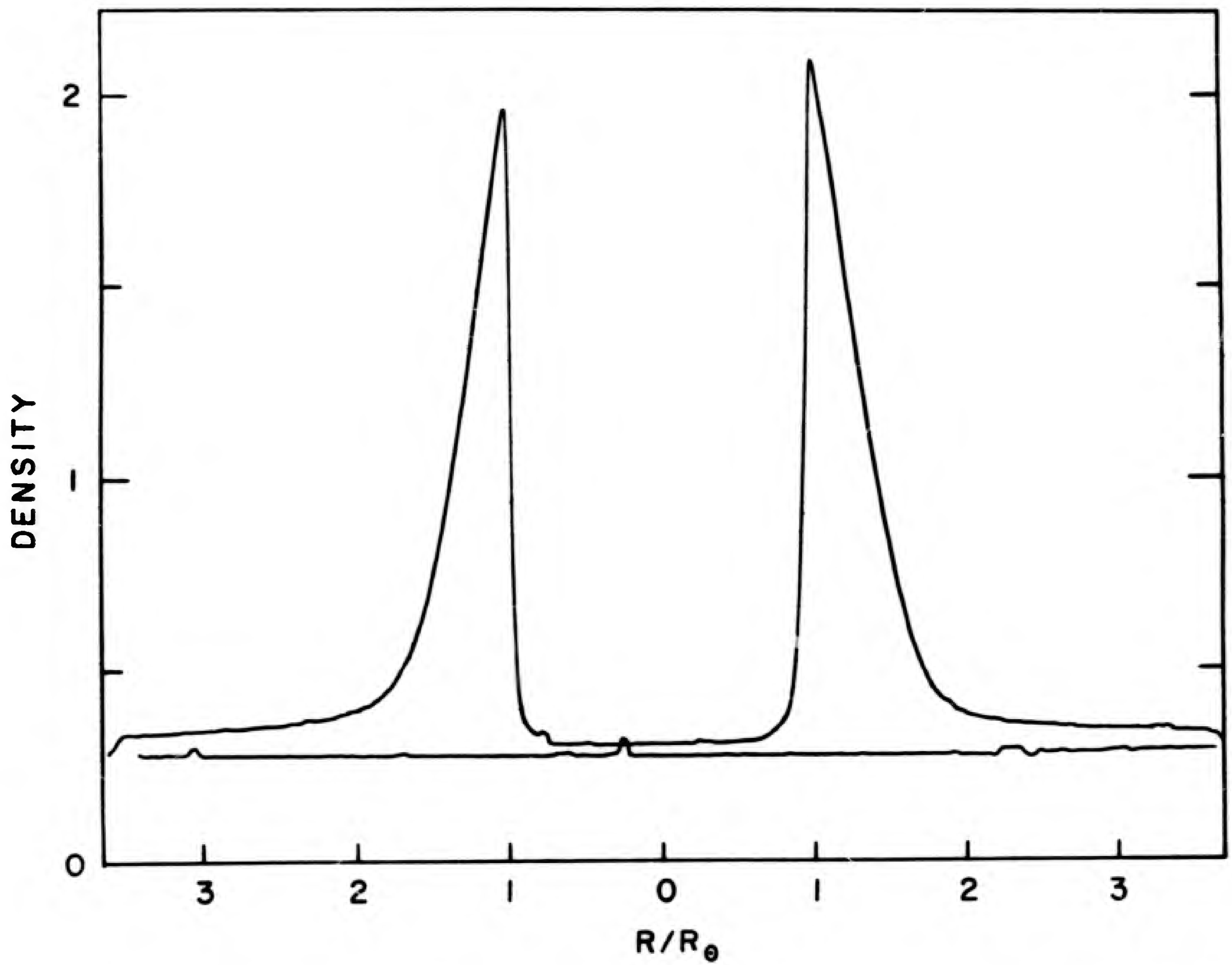

Figure 6

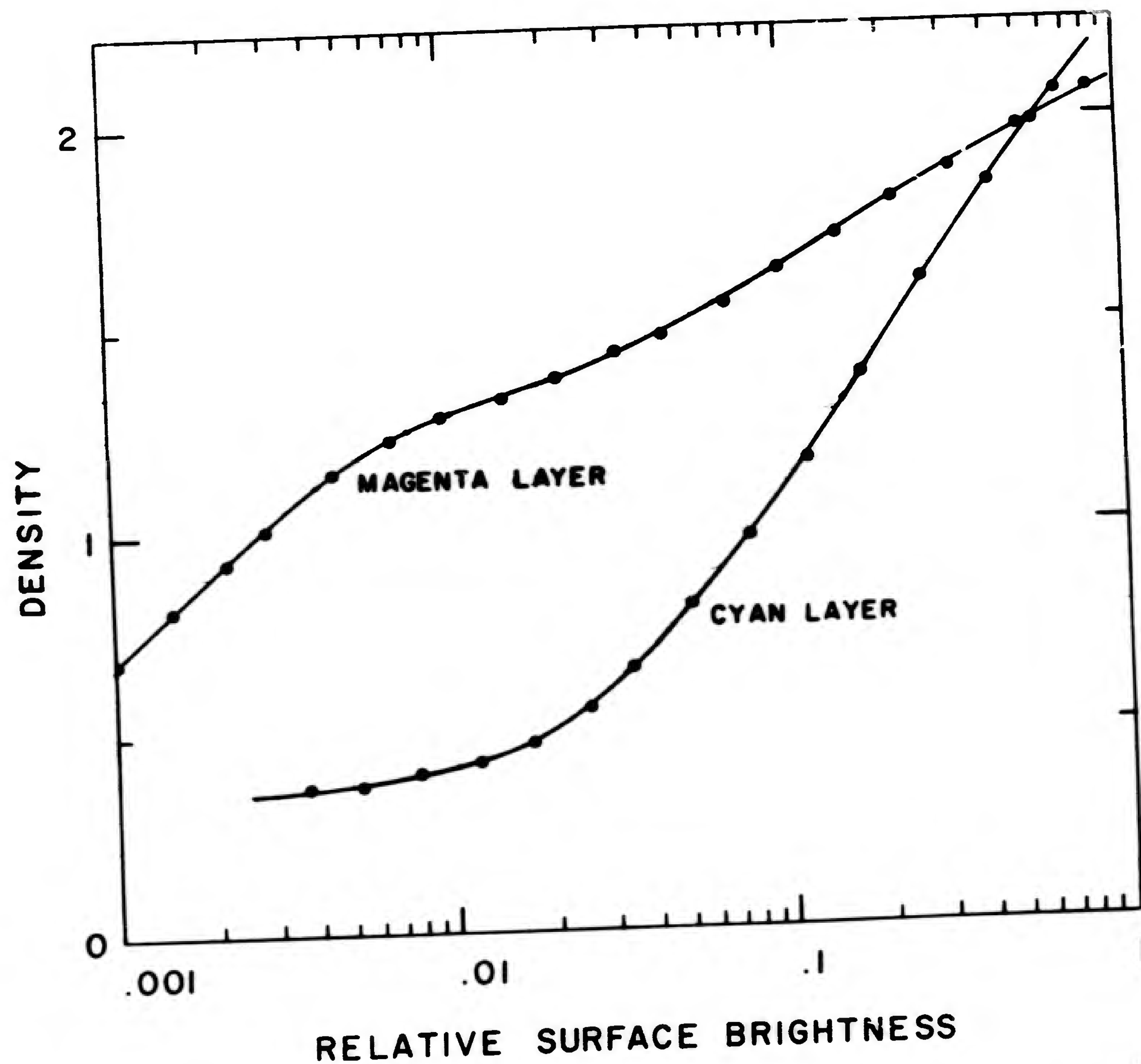
2
1
0
DENSITY
MAGENTA LAYER
CYAN LAYER
.001
.01
.1
1
RELATIVE SURFACE BRIGHTNESS

Figure 7

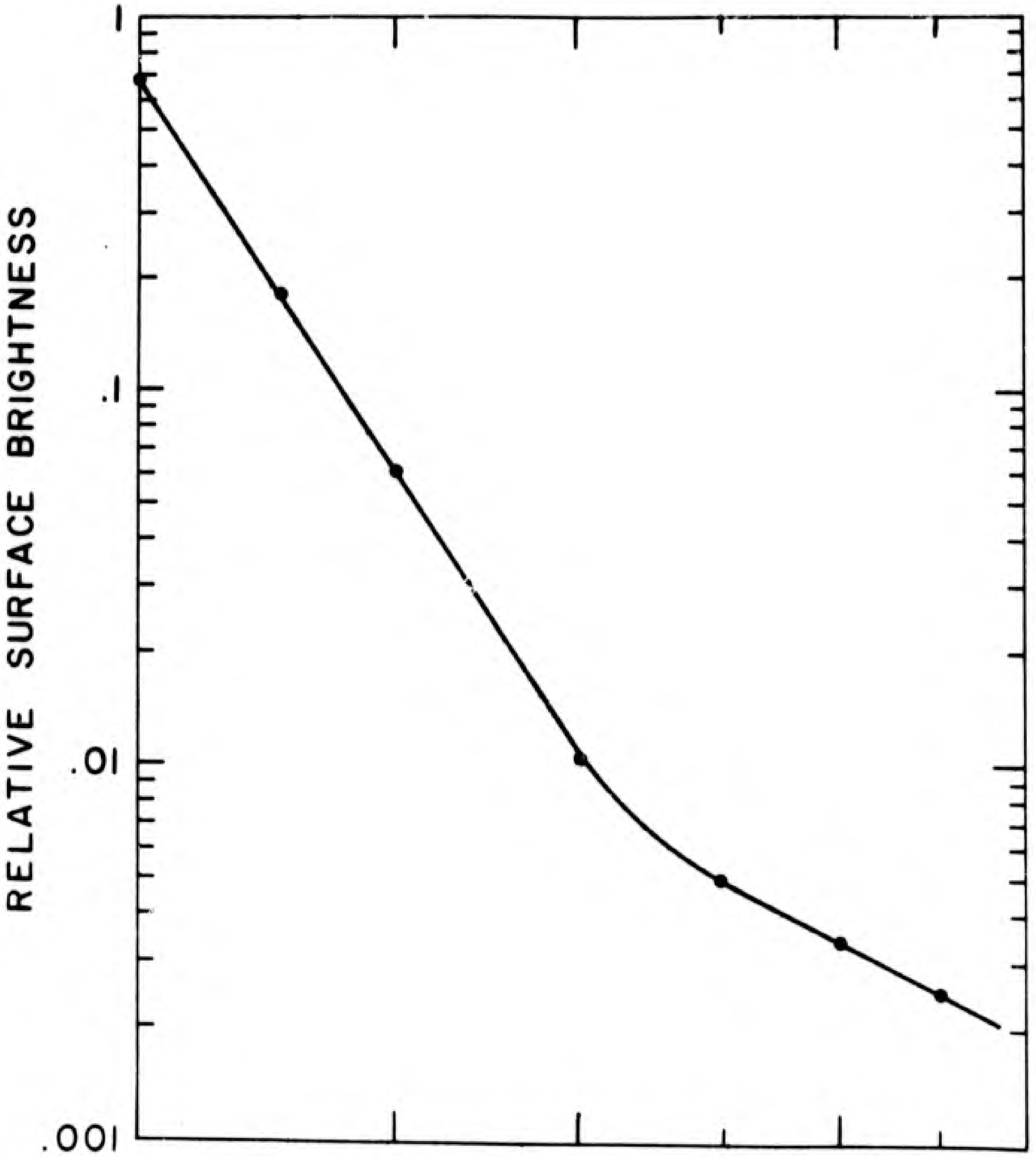

Figure 8