COSMIC STATIC

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Introduction

From the time of Jansky on to the present, various investigators have hung out simple antennas tuned to decameter wavelengths and measured the apparent temperature of the radiation resistance. In all cases it has been found to be very high. Obviously, such antennas are immersed in an intense radiation field. As Jansky pointed out, these fields are of celestial origin. Since the field strengths decrease rapidly with wavelength, it is apparent that previous studies conducted at meter and decimeter wavelengths are merely studies of the tail of the phenomenon. Much interesting information should be forthcoming if high resolution studies were conducted at decameter wavelengths.

Measurements of position in optical astronomy often involve the timing of an object as it passes by a group of cross hairs. This can be done with high precision. If a similar scheme could be devised for radio astronomy, considerable advances would be made. To form the cross hairs a type of interference pattern is necessary. It must have a sharp beginning and a sharp ending so that only a few hairs will be present. The sharp beginning can be supplied by a Lloyds mirror technique as developed in Australia. The sharp ending must be provided by some other natural obstacle which breaks up the pattern after a few lobes have been formed.

These considerations indicated apertures on the order of many thousands of feet would be required. No man made devices seemed possible. However the earth is large and perhaps some natural geographic features could be put to work.

Hawaii

A search was made of possible locations. The most feasible seemed to be Haleakala volcano on the island of Maui in the Hawaiian Archipelage. This volcano is dormant as no flows have occurred since about 1750. The first slide shows Haleakala taken from a plane approximately 35 miles to the southwest on a flight from Hilo, Hawaii to Honolulu, Oahu. The clouds are at 5000 feet. The tops of the cinder cones on the summit are nearly a mile above the clouds as the highest point is 10,020 feet above mean sea level. The second slide shows Haleakala from the southwest taken during a clear day at a distance of 15 miles on a flight from Kahului, Maui to Kailua, Hawaii. This very steep side of the mountain is a desert similar to the southwestern states of continental america.

Interferometer

The third slide shows the geometry of the situation on an enlarged vertical scale. As the source rises out of the sea in the east the sea reflection point advances toward the observer over the horizon at time T_1 with a velocity of about 1000mph. In a short time it has advanced to point T_2 which is the middle of the lobe pattern. Slightly later at time T_3 the reflected wavefront falls upon the rocks and is cut off by the edge of the crater. Thus the lobe structure ends and one is ready to study another source. The general effect is looking at an interference pattern thru a narrow slit. Only a few lobes can be seen and these form the desired cross hairs.

Optical determination of declination is secured by observations of angles from the poles or by observing the azimuth of rising and setting. The accuracy of these angles depends upon the primary resolving power of the instrument and its calibration. Since the primary resolving power of any feasible instrument in radio astronomy will always be poor, some way to circumvent the above must be found. Fortunately, a second set of cross hairs is available in the form of setting observations. The distance between the first and second set of cross hairs is a simple and rapid function of declination. The fourth slide shows this relationship. It should be noticed that the curve has appreciable slope at zero declination. Thus the accuracy of measurement does not vanish as it does in the case of the Michelson type interferometer or lobe counting techniques. Actually, this situation is merely the old business of requiring two independent sets of data to secure two independent sets of answers. Here the data are in the form of rising and setting observations and the answers consist of Right Ascension and Declination of the source.

Slit

The fifth slide is a fotograph to the east from Kole Kole, which is a cinder cone atop the southwest rift of Haleakala. One edge of the slit is formed by the straight horizon line approximately 140 miles away. The other edge of the slit is formed by the jagged far edge of the crater. As can be seen, the slit is only a couple of degrees wide most of the way. The crater is about 7 miles long. To the west the topography is different as Haleakala slopes directly to the sea. The bottom of the slit is formed by the mountains of West Maui and those on the islands of Molokai, Lanai and Kahoolawe. The Koolau range on Oahu sticks up slightly above the horizon and thus narrows the slit a bit for a few degrees of azimuth. To the north and particularly to the south Haleakala drops rapidly and at one place in the latter direction nearly 20 degrees of water produces a very wide slit. To the southeast about 25 degrees of azimuth are obstructed by the island of Hawaii; altho some results may be possible using reflections from the Alenuihaha channel which is about 50 miles wide.

Results

The sixth slide shows a sample record taken at a frequency of 19.6 megacycles of the rising of the Cygnus source. Marks in the margin are at second intervals with the 59th second omitted. The sharp beginning and ending of the trace are apparent.

Because the earth is a ball a phenomenon known as divergence is encountered. When a beam of parallel rays falls upon a curved surface the reflected beam will be spread out in a divergent angle. This weakens the intensity of the ray reflected from the sea so that it cannot properly reinforce or cancel the direct ray from the sky. Thus the first couple of lobes of the interference pattern are incompletely formed. As the angle at the sea increased from grazing incidence the divergence decreases rapidly and the pattern improves. These effects can be seen in the trace shown. The fur on the trace is mostly terrestrial atmospherics coming in via the ionosphere from the Indies. Later in the night as the MUF decreases the atmospherics disappear and the recorder draws nice smooth traces. Local atmospherics are practically unknown.

Troposphere

Both rays travel thru the troposphere with the reflected ray going to its very bottom. Thus a study was made of refractive bending in the lower atmosphere. The seventh slide shows the results for 100 representative winter days computed directly from individual radiosonde data. The bending shown is for a ray travelling thru the entire atmosphere and arriving at sea level at grazing incidence.

Nearly all the variation and especially that represented by the extreme values is encountered in the first few hundred feet of altitude. The large values are caused by conditions where the surface temperature and humidity are both high and both decrease rapidly with altitude. The small values are causedby conditions where the surface temperature and humidity are both rather low and then increase rapidly with altitude.

The variations caused by changes in temperature alone are quite small because this function enters only as the absolute temperature in the computation of index of refraction. Much more important are the changes in absolute humidity as this enters in a direct way and may vary from zero to a third of the temperature term. It is of course influenced by the temperature.

The most important part of the bending is at low altitude because the ray is travelling at a small angle to the discontinuities in the atmosphere. Above 1500 meters where the trade wind inversion is the ray is making a much larger angle with the discontinuities. Furthermore the absolute humidity is never high at these altitudes. Thus the trade wind inversion can scarcely be detected.

The data used for these computations was taken from Pearl Harbor, Oahu between 5 and 6 am. The conditions for the first few hundred feet of altitude were undoubtedly greatly influenced by the associated land mass and air currents from the Koolau and Waianae ranges of mountains. Thus the scatter in bending is probably much greater than that encountered on the open sea. Recently a ship has been installed about 500 miles east and north of Maui. Negotiations are under way to secure radiosonde data taken at this ship. Analysis of such data should provide a much more reliable guide to actual refractive bending on the open sea.

As the angle of incidence at the sea increases the scatter in the bending drops rapidly. When the angle is 1.42 degrees the mean bending is 55% and the scatter covering half the observations is 21% of the values shown on the slide. For these reasons, the data shown is considerably on the pessimistic side of that encountered in practice. Analysis of 100 representative summer days provided nearly the same results. This is to be expected as the demarkation of seasons in Hawaii is vague.

Ionosphere

The role of the ionosphere in this investigation is uncertain. At these very small angles of arrival the Cosmic Static wavefront passes thru the ionosphere some 2000 miles from Maui. Thus ionosphere soundings taken at Kihei are not indicative of actual conditions encountered. A few simple extrapolations show that to get any results the value of critical frequency must be less than a fourth and preferably a seventh of the operating frequency. Such values are in line with the findings of the Australians during their moon echo experiments.

At these ratios the effect of the ionosphere seems to be one of introducing a variable absorption instead of a variable bending. This is deduced from the fact that over a short run of days, the Cygnus source progressed along the expected four minutes of time per day quite accurately but was of marked variability in intensity. Some days it was barely perceptable; others it was clear and strong. Apparently there is still considerable to be learned about the top half of the F layer.

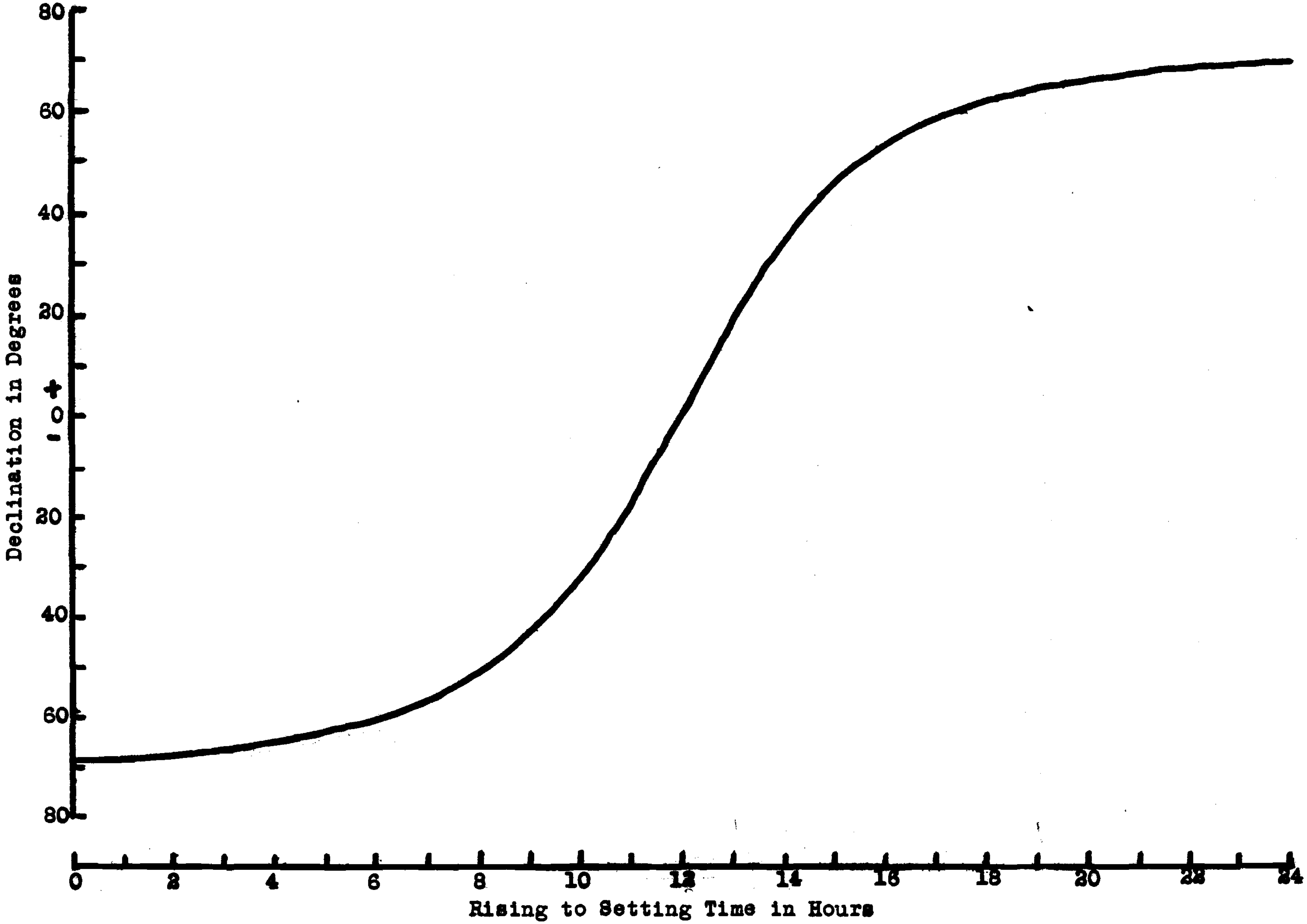
The rapid fluctuations of celestial sources found in England and Australia have not been encountered on Maui. If they exist at all, they are weak and rare. Such might be expected because of the low geomagnetic latitude of the archipelago. Perhaps at a wavelength of 15 meters the blobs in the ionosphere are too small to cause appreciable fluctuations. When sufficient data on Cosmic Static has accumulated, it is expected to attempt correlations with simultaneous ionospheric soundings taken to the east and to the west.

Other Sources

Only a small amount of data is presently available. However quite a number of other sources have been encountered but not identified. A few are markedly stronger than the Cygnus source.

As explained above the slit widens out to the north so the lobe structure becomes extended. Thus some of these sources overlap and confusion results. Part of this difficulty is due to the very low primary resolution in azimuth of the present antenna.

The eighth slide shows Kole Kole hill taken from the east. The clouds are at 8000 feet and West Maui may be seen as a small bump under the clouds about 25 miles away. The ninth slide shows the installation in more detail with the movable framework in the background. This framework is presently 30 feet high, 60 feet long and turns on a track 82 feet in diameter. The antenna it supports is temporary and consists of two, 3 element Yagis spaced 0.7 wavelength colinearly. During the coming summer it is expected to complete the framework similar to the model shown on the tenth slide. Then it will be possible to install four, 5 element Yagis spaced colinearly about 1.1 wavelength. With improved resolution in azimuth it should be possible to untangle the multiple sources found at high declination.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Declination in Degrees
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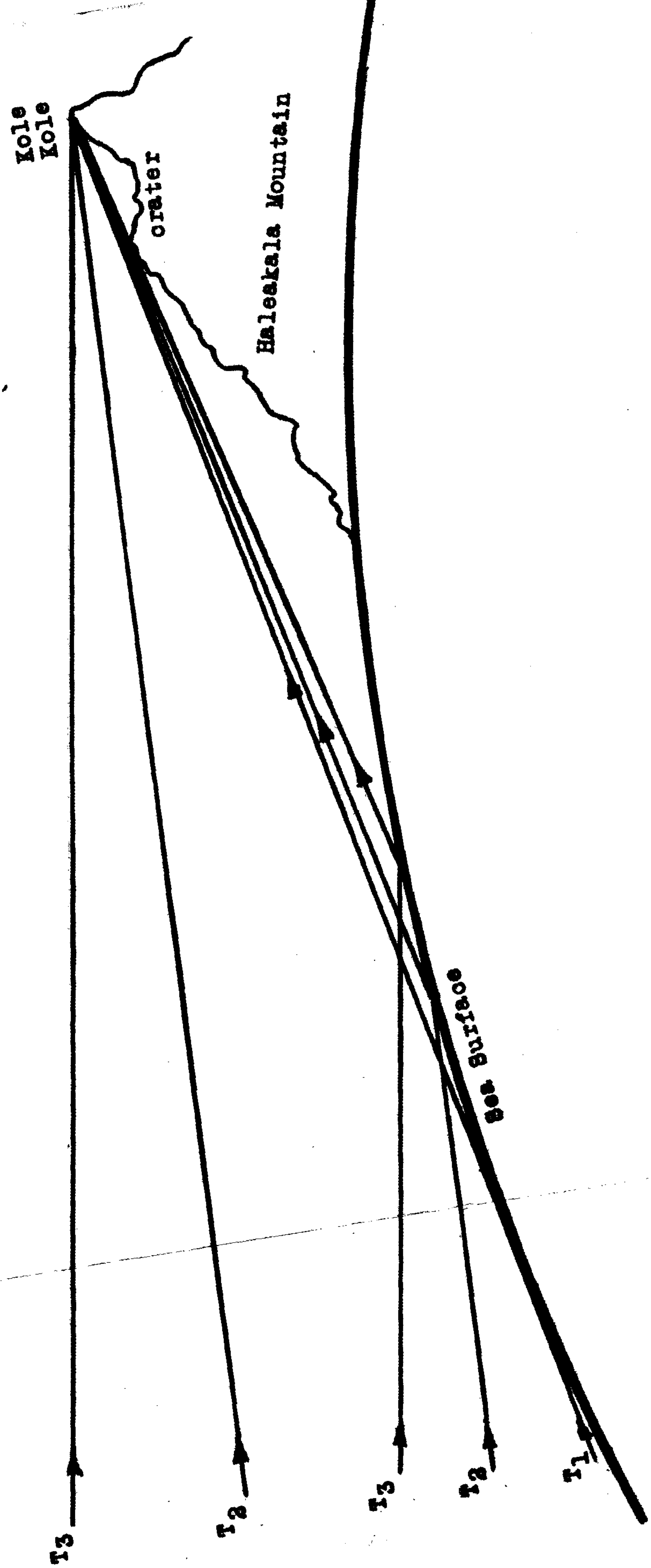
Kole Kole
crater
Haleakala Mountain
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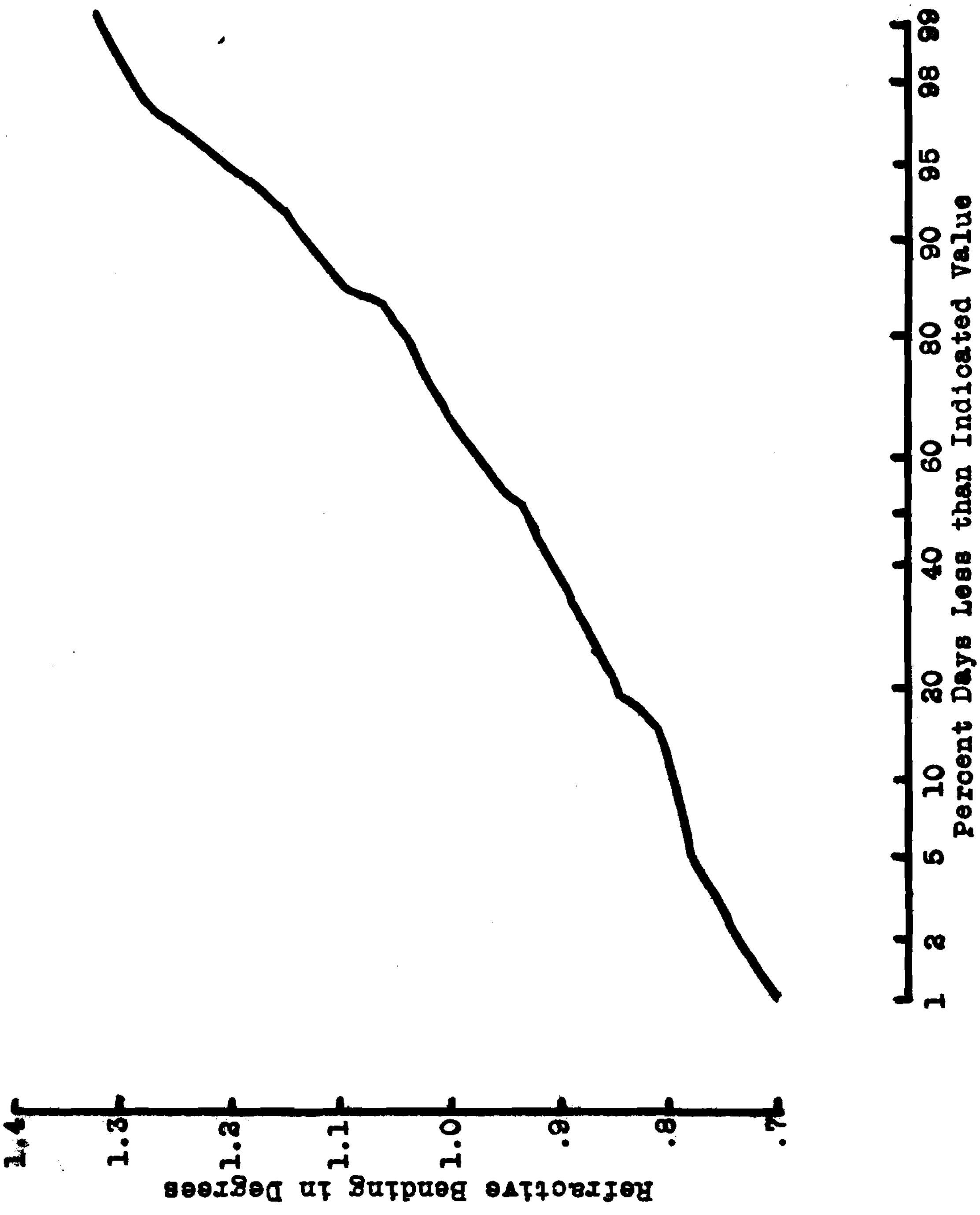
Percent Days Less than Indicated Value
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Refractive Bending in Degrees
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