NATIONAL RADIO ASTRONOMY OBSERVATORY
Green Bank, West Virginia

Electronics Division Internal Report No. 23

UNDERGROUND TEMPERATURE VARIATIONS

V. R. Venugopal

October 1963

(Originally submitted January 1963)

NUMBER OF COPIES: 100

UNDERGROUND TEMPERATURE VARIATIONS

V. R. Venugopal

Introduction

In an array of antennas one of the ways of transmitting signals either from a local oscillator to the various antenna locations or from the various antennas to a central point is by means of either coaxial cables or waveguides [1]. An important requirement in such transmissions is phase stability to better than $\lambda/10$. One of the factors contributing to the alteration in the electrical length of the coaxial cable or waveguide is variation in temperature. In the best case the change in the electrical length is 10 ppm per °C [1]. This means that for a distance of 20,000 λ the change in electrical length is $\lambda/5$ per °C. This gives an idea of the order of temperature variations that can be accepted in order to maintain the phase of the signals within a few electrical degrees. The problem, therefore, is to keep the variations in temperature of the cable to a very small fraction of a degree Centigrade. The best way to achieve this seems to be to bury the cables underground.

It is known that periodic changes of the temperature decrease about exponentially with depth underground depending upon the range of temperature at the surface and the thermal diffusivity of soil [2]. The experiment was performed near the Beard house to determine the diurnal variation in temperature at various depths below the surface.

II. The Experimental Set-Up

The set-up comprises a weather-proof thermistor probe in one leg of a Wheatstone bridge (of the YSI Tele-Thermometer) which is followed by an opposition battery, a DC Null Voltmeter and a recorder.

With this set-up a variation in temperature of .02 °C could be recorded.

III. Results

The thermistor probe was placed at various depths ranging from 1 foot to 3 feet 9 inches and the diurnal variations were recorded. Typical records obtained for three depths (-1 foot, 2.5 feet, and 3.75 feet) are reproduced in Figures 1 through

3. The observed diurnal variation of temperature with respect to depth is shown in Figure 5.

The diurnal variations were found to be smooth.

The maximum variations at the three depths are found to be 1 °C at 1 foot, 0.28 °C at 2.5 feet, and 0.05 °C at 3.75 feet.

The values agree fairly well with those obtained at Davis, California (Figure 4) reproduced from reference [3].

Hence, cables buried at a depth of 3.75 feet will have their temperature stable to within a small fraction of a degree Centigrade. This seems to meet the requirements mentioned in [1].

Acknowledgment

Dr. Marc Vinokur's guidance in the course of this experiment is gratefully acknowledged.

References

[1] M. Vinokur and N. J. Keen, Internal Memorandum on "Means of Transmission of Local Oscillator Signal" (December 1962).

[2] B. Gutenberg, "Physics of the Earth's Interior", Ed. 1959, p. 121.

[3] F. A. Brooks, "An Introduction to Physical Meteorology", 1959-60, p. 81.

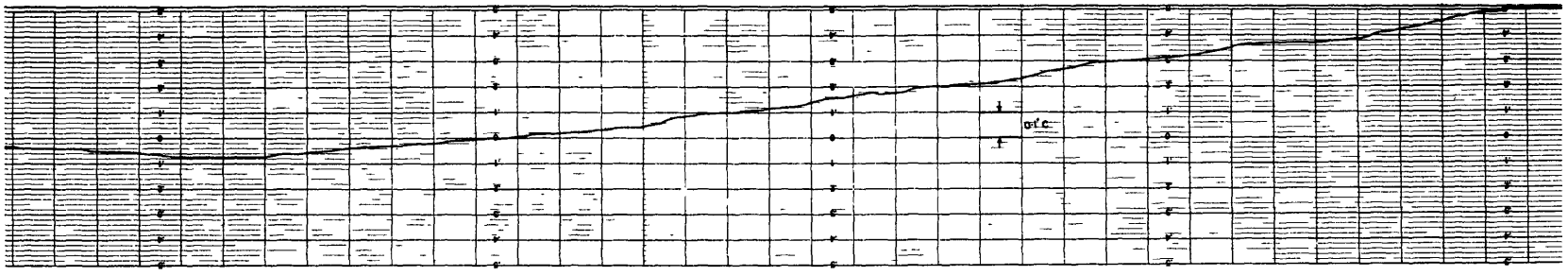

Fig. 1 — Record Of Diurnal Variation Of Temperature
At A Depth Of 1 Foot Below Surface.

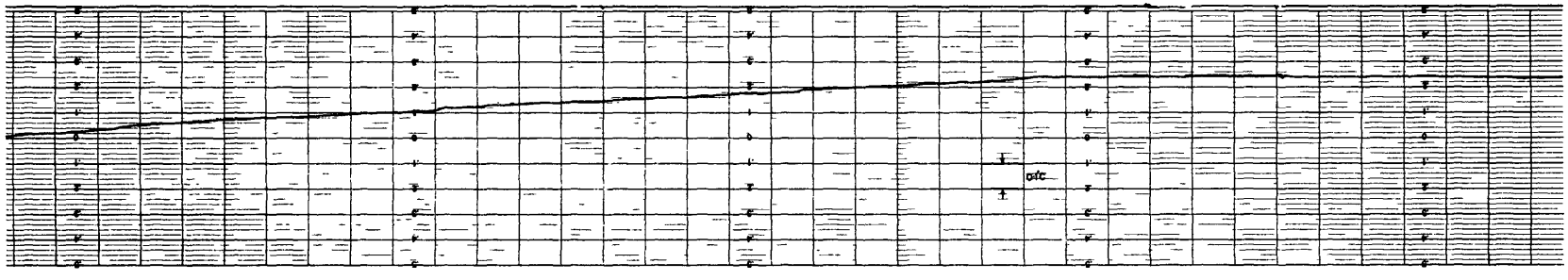

Fig. 2 — Record Of Diurnal Variation Of Temperature
At A Depth Of 2.5 Feet Below Surface.

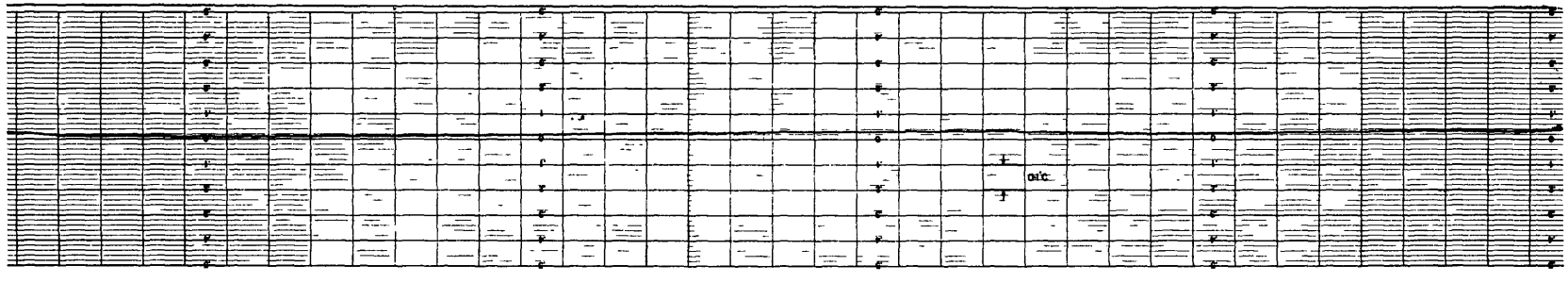

Fig. 3 — Record Of Diurnal Variation Of Temperature
At A Depth Of 3.75 Feet Below Surface.

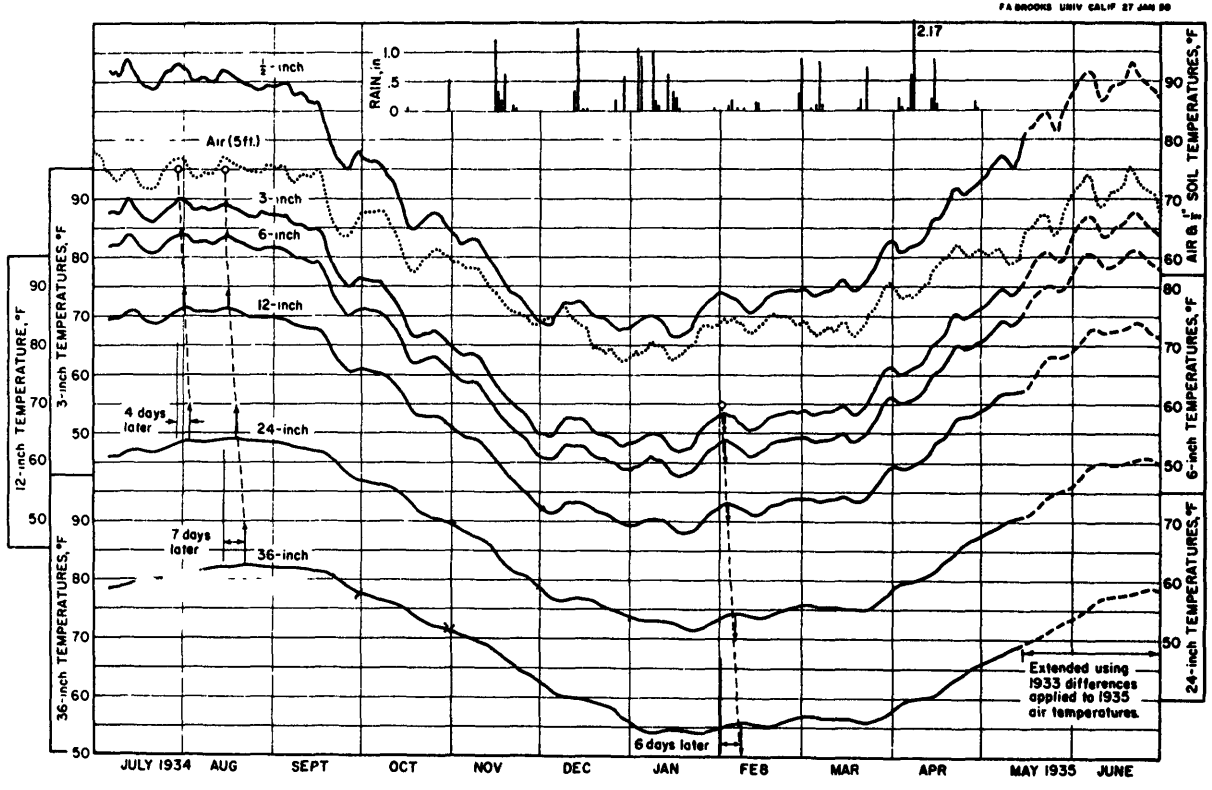

Fig. 4 Ten-day Running Averages of Soil Temperatures to 36-inch Depth at Davis, California.

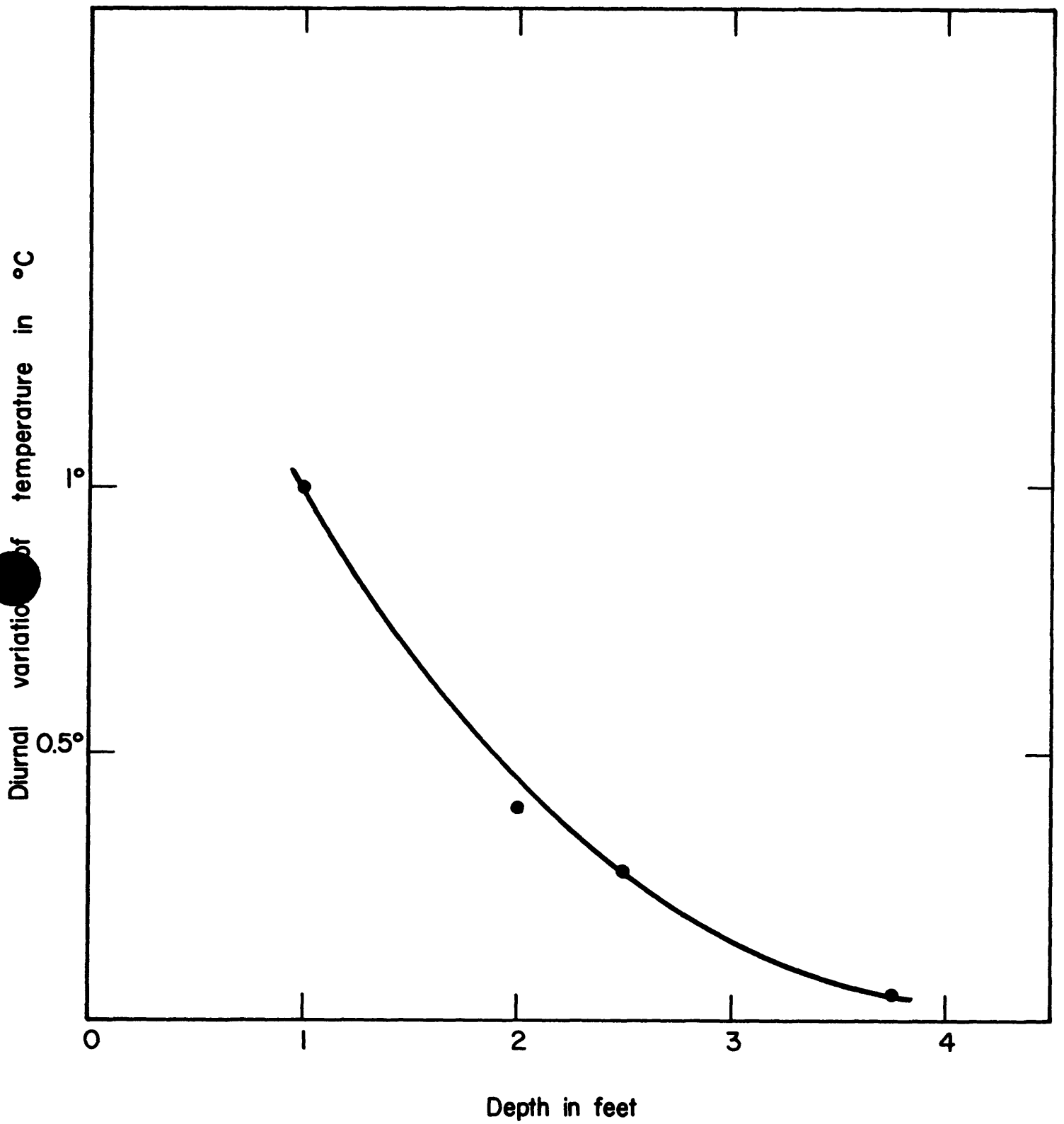

Fig. 5 Diurnal Variation in Temperature with Respect to Depth Underground.