

SPECTROSCOPIC MEASUREMENT OF THE DIURNAL VARIATION OF THE EFFECTIVE OZONOSPHERE TEMPERATURE

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THERE appears to be so far no experimental determination of the diurnal variation of the temperature of the ozonosphere. As a considerable amount of solar energy is absorbed by this layer in the ultra-violet region of the spectrum it should be expected to undergo a diurnal variation in temperature.

This problem has been theoretically examined by a few workers, but their results vary considerably, as accurate data on the vertical distribution of ozone and the spectral energy distribution of the sun in the ultra-violet region were not available to them. For example, Penndorf¹ has calculated the diurnal range of ozonosphere temperature as 0.3°C ., while Gowan² gives a value of 30°C ., and London³ 4.5°C . for the 45-50 km. region. Recently, however, Johnson⁴ utilising the direct measurements of the above quantities made with V-2 and Aerobee rockets at White Sands Proving Grounds, New Mexico, has calculated the range to be of the order of $5-6^{\circ}\text{C}$. for a height of 48 km.

The experimental determination of ozonosphere temperatures made with rockets are yet too few to enable one to estimate the diurnal variation of the temperature of the ozonosphere. A. Adel⁵ has made spectroscopic measurements of ozonosphere temperatures using the 9.6μ ozone band, but as his measurements require the presence of either the sun or the moon, it is not always possible to make a complete series of readings to get an idea of the diurnal variation. The present writer has developed a method similar to Adel's, by which measurements can be made both day and night so long as a clear patch of sky near the horizon is available.

The method essentially consists in comparing the emission of the thermocouple detector in an infra-red spectroscope at 9.6μ , with the emission of the atmospheric ozone layer at the same wavelength, which is the centre of the strong rotation-vibration band ν_2 of ozone. Since the temperature of the detector in the spectroscope is kept constant and is known, the temperature of the ozone layer can be obtained from a simple graphical solution using a series of Planck's curves.

The spectroscope, which is a Beckman model IR-2 with KBr-prism, modified for use with external radiation sources (Momin⁶) is

directed through front-aluminised reflectors to the clear sky as close to the horizon as possible, and the wavelength is set in the 9μ region in which the atmosphere is almost completely transparent. On account of this transparency of the atmosphere the thermocouple is radiating out to space, which may be taken to be at the absolute zero, and thus undergoing cooling at a rate determined by its temperature according to Planck's Law. This cooling appears as a negative e.m.f. in the thermocouple circuit which can be measured by reversing the phase of the mechanical synchronous rectifier of the IR-2 Spectroscope, in relation to its beam modulation. Now the wavelength range between 9μ and 10.5μ is scanned with readings being taken at intervals of 0.1μ . A plot of these deflections against wavelength gives a curve which is the envelope of the Planck curve for the radiating thermocouple, superimposed on which is the emission band of the atmospheric ozone with its centre at 9.6μ . Since the emission of ozone is in the opposite direction, it appears as a decrease in the emission of the thermocouple as shown in Fig. 1. The relative value of

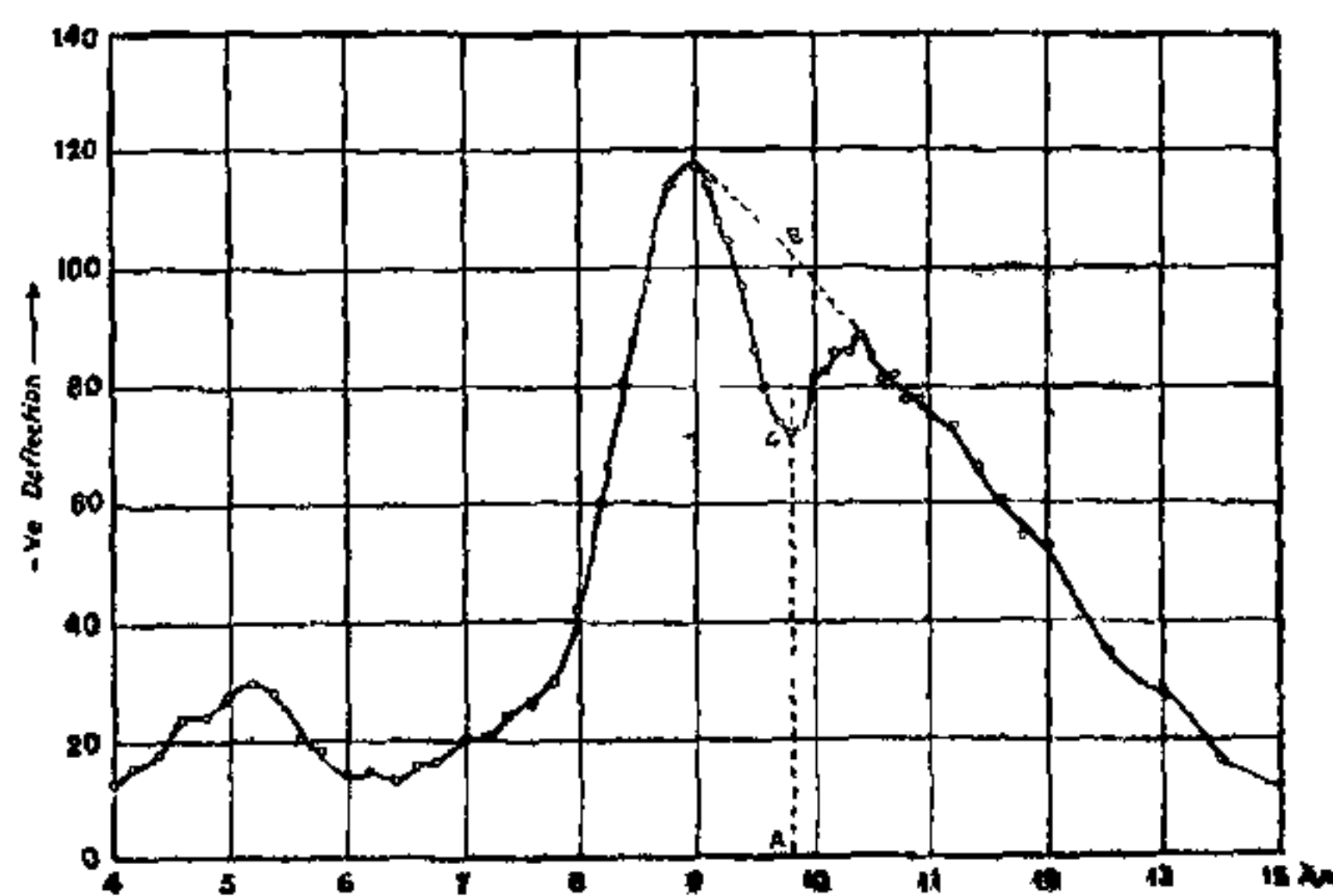


FIG. 1.

$J\lambda - 9.6\mu$ for the thermocouple is given by AB and the $J\lambda - 9.6\mu$ for ozone layer by BC. Since we know the temperature of the thermocouple, which is kept constant by means of a thermostat, the corresponding equivalent black body temperature of the ozone layer for giving emission equal to BC can be obtained from black body emission curves based on Planck's Law. One measurement of the ozone temperature takes only a few minutes.

The thermocouple being at constant temperature, a fixed value for AB is assumed and thus the effect of any background radiation due to water vapour or dust is eliminated in the estimation of the diurnal variation of ozonosphere temperature.

The two main assumptions in this method are:

- (i) that the ozone layer is emitting like a black body;
- (ii) that any diurnal variation in the quantity of ozone does not affect the readings.

Since we are using a portion of the sky about 10° above the horizon, the ozone mass involved is approximately 5 times that in a vertical direction and with the normal amount of ozone at Poona which is about 0.16 to 0.18 cm. (at N.T.P.), we should obtain absorption almost approaching saturation at the centre of the band. This is verified experimentally by the fact that very close to the horizon our records show absorptions of the order of 92 to 95 per cent. This means that in assuming the ozone layer as a complete absorber at the centre of the band, we are underestimating its emission by only a small percentage, but, for determining the diurnal range of temperature, which is our main purpose, the error involved is negligible. The fluctuations in the amount of ozone also have very little effect on the ozone emission as the absorption at the centre of the band is almost fully saturated.

Using this method, measurements have been made on some clear days at Poona (Lat. $18^\circ 30' N$, Long. $73^\circ 51' E$, Alt. 1,800' above sea-level) during May, October and November 1953. Fig. 2 gives a typical curve for November, from which we can see that the range of the equivalent black body temperature comes out

as about $15^\circ C$. The readings for May and October also give a range of the same order although in May the ozonosphere temperature appears to be slightly higher, thus indicating the possibility of a seasonal variation. It must

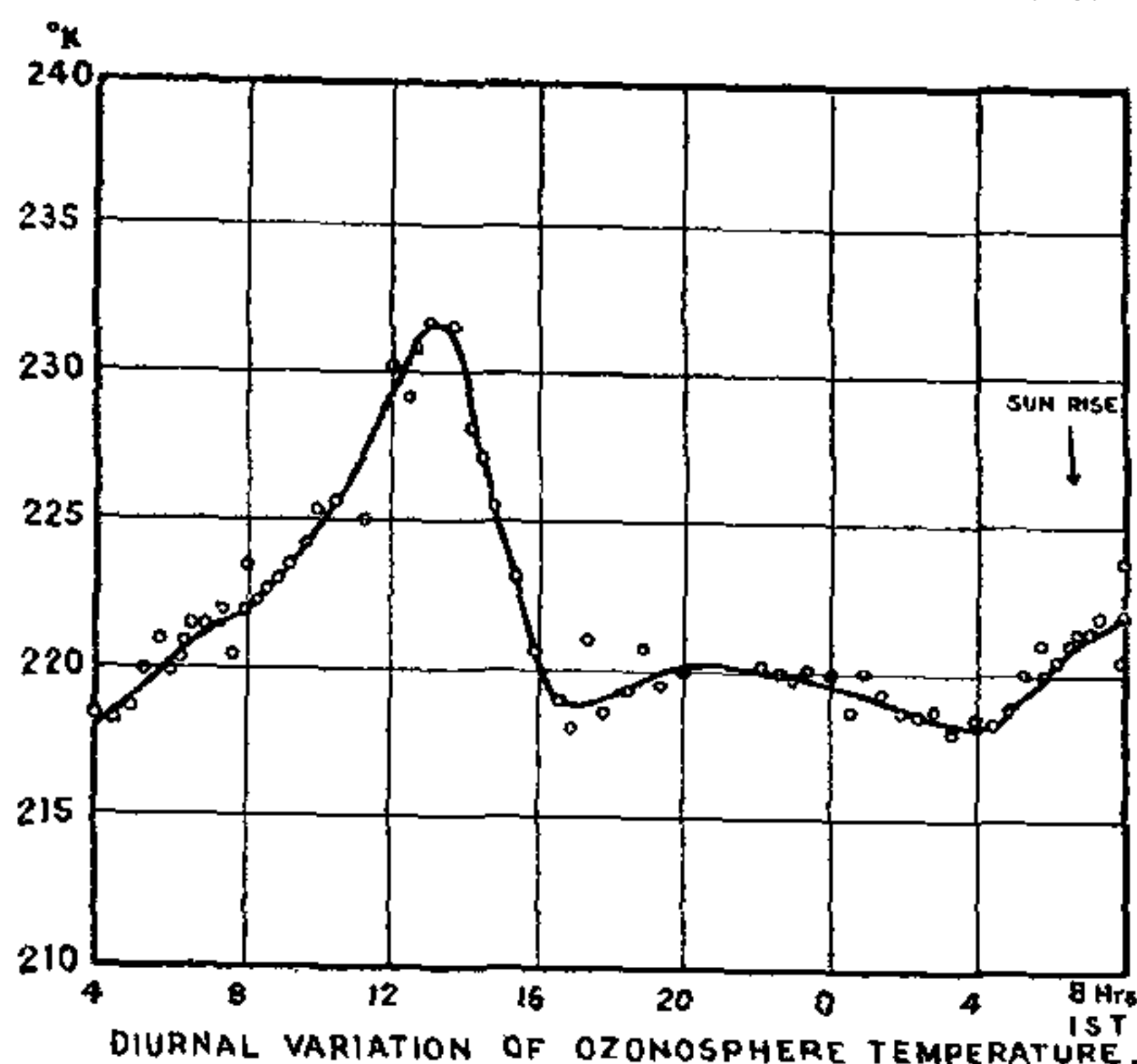


FIG. 2.

be pointed out, however, that the above results are preliminary and we need a much longer series of data for more definite conclusions.

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1. Penndorf, R., *Beiträge zum Ozonproblem*, Veröff. Geophys. Inst. Leipzig, 2nd Series, 1936, 8, 181.
2. Gowan, E. H., *Proc. Roy. Soc.*, 1947, 190A, 219; 1947, 190, 227.
3. London, J., *Bull. Amer. Met. Soc.*, 1951, 32, 399.
4. Johnson, F. S., *Ibid.*, 1953, 34, 3, 106.
5. Adel, A., *Astrophys. J.*, 105, 406.
6. Momin, A. U., *Jour. Sci. Ind. Res.*, 1952, 11B, No. 7, 307.

NUCLEAR ENGINEERING CONGRESS

AN International Nuclear Engineering Congress will be held at the University of Michigan in Ann Arbor, June 20-25, 1954. This is the first public meeting of its size devoted entirely to the peacetime uses of the atom. Over a hundred papers and addresses have been scheduled to be presented during the six-day meeting, twelve of which are from authors in Canada, England, Belgium, France, Norway, Italy, Spain and India. The technical programme consists of some ninety papers on the following subjects: materials of construction for reactors, reactor technology, research and

educational reactors, reactor fuel refining and preparation, nuclear power reactors, processing of irradiated materials and applications and uses of radioactive products. In addition to the above there will also be a symposium on 'Education in the Nuclear Field' and an 'Atoms for Peace' exposition featuring radiation, reactor models and instruments. Educational displays will also be held in the galleries of the Rackham Building at the University concurrent with the Congress. Further particulars can be had from Prof Robert R. White, University of Michigan, Ann Arbor, Michigan (U.S.A.).