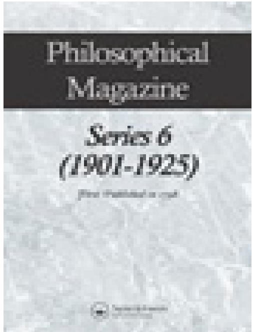

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XXIV. Note on the theory of the greenhouse

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XXIV. *Note on the Theory of the Greenhouse.* *By* Professor R. W. Wood *.

THERE appears to be a widespread belief that the comparatively high temperature produced within a closed space covered with glass, and exposed to solar radiation, results from a transformation of wave-length, that is, that the heat waves from the sun, which are able to penetrate the glass, fall upon the walls of the enclosure and raise its temperature: the heat energy is re-emitted by the walls in the form of much longer waves, which are unable to penetrate the glass, the greenhouse acting as a radiation trap.

I have always felt some doubt as to whether this action played any very large part in the elevation of temperature. It appeared much more probable that the part played by the glass was the prevention of the escape of the warm air heated by the ground within the enclosure. If we open the doors of a greenhouse on a cold and windy day, the trapping of radiation appears to lose much of its efficacy. As a matter of fact I am of the opinion that a greenhouse made of a glass transparent to waves of every possible length would show a temperature nearly, if not quite, as high as that observed in a glass house. The transparent screen allows the solar radiation to warm the ground, and the ground in turn warms the air, but only the limited amount within the enclosure. In the "open," the ground is continually brought into contact with cold air by convection currents.

To test the matter I constructed two enclosures of dead black cardboard, one covered with a glass plate, the other with a plate of rock-salt of equal thickness. The bulb of a thermometer was inserted in each enclosure and the whole packed in cotton, with the exception of the transparent plates which were exposed. When exposed to sunlight the temperature rose gradually to 65° C., the enclosure covered with the salt plate keeping a little ahead of the other, owing to the fact that it transmitted the longer waves from the sun, which were stopped by the glass. In order to eliminate this action the sunlight was first passed through a glass plate.

There was now scarcely a difference of one degree between the temperatures of the two enclosures. The maximum temperature reached was about 55° C. From what we know about the distribution of energy in the spectrum of the radiation emitted by a body at 55°, it is clear that the rock-salt plate is capable of transmitting practically all of it, while the glass plate stops it entirely. This shows us that

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the loss of temperature of the ground by radiation is very small in comparison to the loss by convection, in other words that we gain very little from the circumstance that the radiation is trapped.

Is it therefore necessary to pay much attention to trapped radiation in deducing the temperature of a planet as affected by its atmosphere? The solar rays penetrate the atmosphere, warm the ground which in turn warms the atmosphere by contact and by convection currents. The heat received is thus stored up in the atmosphere, remaining there on account of the very low radiating power of a gas. It seems to me very doubtful if the atmosphere is warmed to any great extent by absorbing the radiation from the ground, even under the most favourable conditions.

I do not pretend to have gone very deeply into the matter, and publish this note merely to draw attention to the fact that trapped radiation appears to play but a very small part in the actual cases with which we are familiar.

XXV. *Molecular Diameters.* *By* WILLIAM SUTHERLAND *.

GREATER absolute precision and better mutual consistency were introduced into the measurement of molecular diameters by the kinetic theory of gases, when Jeans applied electrical data to give the number of molecules of a gas in a cm.^{3} under normal conditions (Phil. Mag. [6] viii. 1904, p. 692). But in his calculations he took no account of the effect of cohesional forces in the viscosities, conductivities, diffusivities, and collisional virials of gases which he used in the calculation of molecular diameters. Now in "The Viscosity of Gases and Molecular Force" (Phil. Mag. [5] xxxvi. 1893, p. 507) it was shown that if $2a$ is the diameter of a molecule, and C a parameter proportional to the mutual potential energy of two molecules in contact, T denoting absolute temperature, the molecules behave as if devoid of attractive force, but enlarged so that $(2a)^2$ is replaced by $(2a^2)^2(1+C/T)$. Thus the temperature law of the viscosity of a natural gas is $\eta \propto T^{\frac{1}{2}}/(1+C/T)$, instead of the law $\eta \propto T^{\frac{1}{2}}$ which holds for the ideal perfect gas. On this account the quantities given by Jeans as the diameters of molecules $2a$, are in reality $2a(1+C/T)^{\frac{1}{2}}$. By means of the values of C and with T=273 it is easy to obtain the true values of $2a$. In the Landolt-Börnstein-Meyerhoffer *Tabellen* values of C for many of the gases in the list of Jeans are

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