before Section G at the Leicester meeting of the British Association, and published with illustrations in *Engineering* for August, 1907, will convey some idea of the ice problem as presented to the users of "white coal" in Canada. In Russia, M. Wladimirop has published several important papers on his studies of the ice conditions on the Neva, in connection with the Waterworks Commission of St. Petersburg. One thing is well established, and that is that the formation of natural ice such as ground-ice, whether in Great Britain, Canada, Russia, France, Germany or elsewhere, conforms to the known laws of nature. Not a single known case of natural ice formation has ever come under my notice which has not its possible duplication in a laboratory experiment. The two differ only in the magnitude of their effects.

H. T. BARNES.

McGill University, Montreal, February 10.

### The Possibility of Life on Mars

MR. DINES's important letter on the "Isothermal Layer of the Atmosphere" has obviously an important bearing on the question of the gases that have been retained or lost by the atmosphere of Mars. If the temperature of our atmosphere ceases to decrease when a height averaging 35,000 feet is reached, and then remains practically constant at an average temperature of $-47°$ C. whatever height be attained, we may expect somewhat similar conditions to prevail in the atmosphere of Mars, and naturally ask what are the temperatures which will allow of the escape of the different gases.

This question can be easily answered by a brief calculation from the data furnished on pp. 113 and 325 of Jeans's "Dynamical Theory of Gases" (1904). We find that at a temperature of $-175°$ C. hydrogen will be "certainly retained," while at $-65°$ C. it will be "certainly lost." The corresponding temperatures for helium will be $-81°$ C. and 136° C., and for water vapour 599° C. and 1583° C. From these figures it results that if the temperature of the isothermal layer of Mars be the same as the temperature of that of our atmosphere, hydrogen will be lost, helium probably retained, and water vapour clearly retained. I should imagine that in the case of Mars the isothermal layer will be much colder, especially as the carbonic acid that is present in the atmosphere of that planet will be concentrated in the lower levels.

Neither Prof. Lowell nor Dr. Russel Wallace appear quite to have realised the importance of the influence of carbonic acid on the atmospheric temperature at the surface of the planet.

It is now a commonplace of geology that a variation in the small percentage of carbonic acid in the earth's atmosphere will have an important effect on the temperature of the latter, though authorities differ as to the numerical amount of the variation required to produce a given change of temperature under given conditions. If the atmosphere contains a relatively large amount of carbonic acid, a correspondingly greater proportion of the heat received will be retained, and the temperature will be higher. Such conditions will be marked by luxuriant vegetation, and at the same time rapid formation of carbonates by the action of water containing carbonic acid on silicates and other minerals. This will eventuate in a period when there is less carbonic acid in the air, and colder conditions will prevail. The growth of vegetation and the decomposition of minerals will be checked and confined to the warmer portions of the earth's surface. The supplies of carbonic acid from intratelluric sources will then gradually add to the amount of carbonic acid in the atmosphere, bringing an increase in temperature with it.[1] There are features in the geological record which lend support to the view that such a cycle of changes has occurred more than once in the earth's history.

If, now, we make the very reasonable assumption that the crust of Mars is composed of the same minerals as those with which we are familiar, and its atmosphere of the same gases as ours, and that accessions of carbonic acid are received from the interior of the planet, we may expect a similar automatic adjustment of the temperature so that it is never too cold for the chemical reactions of carbonic acid in solution to take place, and for vegetation, such as that believed to exist by Prof. Lowell, to maintain itself somewhere on the surface of the planet. The amount of carbonic acid required for the purpose will, of course, be greater than that in our atmosphere, but there is no reason to believe that it would reach an amount which would be injurious to the life of plants or animals, even if such were similar in nature to those on the earth.

Whether Prof. Lowell can be considered to have established his views is a question on which I do not feel called upon to express an opinion, but I confess that the arguments advanced against them do not strike me as convincing. They remind me of those of the engineers who satisfied themselves that a locomotive could not draw a train of trucks on smooth rails, and were not persuaded to the contrary until they saw that it did so.

Imperial Institute, February 28. J. W. EVANS.

[1] I have stated the theory in its simplest terms. There are other circumstances that affect the amount of carbonic acid in the air. Prof Chamberlin believes that the sea plays an important part in absorbing or giving out the gas according to the conditions that prevail.

### A Fundamental Contradiction between the Electrical Theory of Dispersion and the Phenomena of Spectrum-series.

THE electrical theory of dispersion is based on the hypotheses (1) that electric waves are due to motions of electric charges, and waves of light in particular to vibrations of charges inside the atom; and (2) that these vibrations are governed by linear equations. On this basis we obtain the usual dispersion formulæ, *e.g.* that of Drude:—

$$n^2 - 1 = \sum \frac{N_h e^2_h}{\pi m_h} \frac{\lambda^2_h}{1 - \lambda^2_h/\lambda^2},$$

where $n$ is the refractive index for wave-length $\lambda$, $\lambda_h$ one of the free periods of a set of electrons in the atom, $e_h$ the charge, $m_h$ the mass, and $N_h$ the number per c.c. of the electrons of the set, while the summation is for all possible free periods of the atom. In particular, if $\lambda$ be greater than every one of the free wave-lengths of the atom, we get

$$n^2 - 1 > \sum \frac{N_h e^2_h \lambda^2_h}{\pi m_h}.$$

Consider the contribution of all the lines of the well-known Balmer series to the dispersion of hydrogen; for this series

$$\lambda_h = \lambda_\infty \frac{m^2}{m^2 - 4}, \quad m = 3, 4, \ldots \infty,$$

where

$$\lambda_\infty = 3646 \cdot 13 \text{ A.U.}$$

Its contribution exceeds

$$\sum_{m=3}^{m=\infty} \frac{N_h e^2_h \lambda^2_\infty}{\pi m_h} \frac{m^4}{(m^2 - 4)^2}.$$

If the theory is to account for the lines of the series at all, the factor $N_h e^2_h \lambda^2_\infty / \pi m_h$ cannot vanish for any line; let A be its least value. Then the contribution exceeds

$$A \sum_{m=3}^{m=\infty} \frac{m^4}{(m^2 - 4)^2}.$$

The sum is obviously infinite; but all experience shows that for long waves the refractive index of hydrogen is nearly unity, and finite even for *luminous* hydrogen.

The same result follows for any series formula which implies that a series has (1) a tail; (2) an infinite number of lines the wave-length of which exceeds that of the tail, that is, for all known formulæ which agree with measurements either of line or of band series.

Thus we must either reject the usual notion of a series, and with it all the formulæ which represent our experience best, or we must reject the hypothesis that series lines are due to small vibrations of electric charges governed by linear equations, and with it the usual theories of dispersion and absorption, of the Zeeman effect and of magnetic rotation for series lines. G. A. SCHOTT.

Physical Institute, Bonn, February 17.