would have realised that our greatest investigators rarely "work in splendid isolation," but that only a man who has proved his capacity as an investigator can lead and co-ordinate research. It is certain that British scientific men will not submit to control and direction from the practical man; thus a definite breach is opened between science and an important branch of industry.

It has not been sufficiently clearly realised that scientific and industrial research is passing out of the control of the recognised scientific and technical societies and institutions and of the universities into the hands of the Department of Scientific and Industrial Research, and, in accordance with Government policy, the secretary of this Department is an administrator without practical knowledge of science, industry, or research. The associations which are formed under the ægis of the Department are governed by councils upon which organised science is unrepresented, but to which the Department may nominate scientific men. To the council of the Glass Research Association the Department has nominated two scientific representatives, one of whom is in India. On the executive committee science is not represented; and when this appointment was discussed between that body and the secretary of the Department, the scientific aspects of the case can have received no consideration. As the Department controls funds for research which are vastly greater than those at the disposal of the Royal Society and all the other societies and universities put together, the outlook for science is a poor one unless scientific men are prepared to take united action with the view of securing a proper share in the control of research.

MORRIS W. TRAVERS.

The Predicted Shift of the Fraunhofer Lines.

MAY I submit the following two propositions for the consideration of relativists?

(1) An occurrence takes place at a point S. Light-signals are dispatched from S at the beginning of the occurrence to two observers A and A′, and signals are again dispatched at the conclusion of the occurrence. By means of these A and A′ measure the time of the occurrence to be dt and dt' respectively. Then

$$\sqrt{g_{44}}.dt = \sqrt{g'_{44}}.dt',$$

where g_{44} and g'_{44} are the values of Einstein's 44 potential at A and A′.

(2) An occurrence takes place at S, and is measured by an observer there to take the time dt. Another occurrence takes place at S′, and is measured by an observer there to take time dt'. By means of light-signals dispatched from S and S′ at the beginning and conclusion of each occurrence, an observer A measures the times of each occurrence to be equal. Then

$$\sqrt{g_{44}}.dt = \sqrt{g'_{44}}.dt',$$

where g_{44} and g'_{44} are the values of Einstein's 44 potential at S and S′.

Prop. (1) seems to be a correct inference from Einstein's theory, and prop. (2) is deduced by applying (1) to the occurrence at S as measured by S and A, and then to the occurrence at S′ as measured by S′ and A.

If these propositions are sound, how does the Einstein theory predict the displacement of the solar lines? For it seems to me that the criterion for "similarity" of two radiating mechanisms in different parts of a gravitational field is that the invariant space-time elements corresponding to one oscillation of each should be equal. For two mechanisms at rest in the field this condition reduces to $\sqrt{g_{44}}.dt = \sqrt{g'_{44}}.dt'$.

JAMES RICE.

University of Liverpool.

EINSTEIN'S prediction of a shift of the Fraunhofer lines to the red can be analysed into two assertions:—(1) That the period of vibration of an atom at rest on the sun differs from that of a similar terrestrial atom; and (2) that this difference is preserved unchanged by the light-waves travelling from the solar atom to the earth, so that it is revealed by a comparison made in a terrestrial laboratory. It is the second assertion that is challenged by Mr. Rice; and, so far as I can make out, the same objection was at the root of the criticisms formerly made by Sir Joseph Larmor. Since criticism centres entirely round the second assertion, I will deal with it solely. I may state, however, that although I regard the first assertion as highly probable, I do not regard it as proved with complete rigour; and had the criticism been directed against this, I should have been much less willing to take sides in the controversy.

The interval ds between two events is a quantity having an absolute significance independent of co-ordinate systems; and when the two events take place at the same place, $ds = \sqrt{g_{44}}.dt$. Mr. Rice's first proposition states that if we have two light-pulses travelling from the sun to the earth, the interval ds between their passages through any point is the same all the way along the track. The statement has a certain appearance of plausibility, but I cannot see any definite argument in favour of it. Space-time round the sun is non-Euclidean; the geodesics have, accordingly, defined but rather complicated tracks, and there need be no constancy of interval between points on neighbouring geodesics. The rule deduced from Einstein's theory for comparing the passage of two light-pulses at the points A and A′ respectively is not $ds = ds'$, but $dt = dt'$, *provided the co-ordinates used are such that the velocity of light does not change with* t.

If we found that the velocity of light changed secularly, we should at once condemn our time-reckoning as non-uniform; accordingly, the proviso is satisfied in practice. With the co-ordinates most commonly adopted the velocity of light is $1-2m/r$, which depends on the position r, but not on the time t. Then if t_1 and t_2 are the times of the two pulses at r, t'_1, t'_2 the times at r', since the mean velocity of the first pulse $(t'_1-t_1)/(r'-r)$ has to be the same as the mean velocity $(t'_2-t_2)/(r'-r)$ of the second pulse, over the same course but at a later time, it follows at once that $t'_2-t'_1$ is equal to t_2-t_1, which proves the statement made. The time between the two light-pulses is preserved unchanged on the journey from the sun to the earth.

In his letter (NATURE, January 22, p. 530) Sir Joseph Larmor describes this condition, that the velocity of light (or the formula for ds) shall not contain the time explicitly, as "a reasonable assumption." I cannot see that any assumption is involved; nor can I agree that it is of "an absolute type." The well-known expression

$$ds^2 = -(1-2m/r)^{-1}dr^2 - r^2d\theta^2 - r^2\sin^2\theta d\phi^2 + (1-2m/r)dt^2 \quad . \quad . \quad . \quad (A)$$

is, in the first place, simply a particular integral of Einstein's differential law of gravitation. It can be shown that it is an appropriate solution for the case of an isolated particle. But there is a fourfold infinity of other solutions applicable to the same case; so there can be nothing absolute about this solution, or about the co-ordinates r, θ, ϕ, t which it defines. It is, in fact, often more convenient to write $r = r' + m$,