The second storm began on March 29 at 16h., and was dying down when the record was taken off the instruments at 10h. on March 30. The range in declination was $127'$ and in horizontal force again more than 750γ , being beyond the limits of registration, but apparently to a less extent than in the previous storm.

This second storm could easily be attributed to the influence of the large sunspot which crossed the central meridian on March 26.3, but it is difficult to assign this spot as the cause of the earlier storm, as in this case, allowing for time of transmission, any emanation from this area would have had to be emitted at a very great angle to the solar radius, which is not easily accounted for.

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Relativity of Time

IN Prof. H. Dingle's article on "The Relativity of Time"¹ and the correspondence that has followed, it is taken for granted that, while the Fitzgerald contraction can be detected experimentally, the slowing up of a moving clock cannot. Prof. J. W. Campbell², while disagreeing with Prof. Dingle on other points, is in agreement on this point. This, if it were true, would indicate a surprising lack of symmetry between time and space; but the following considerations show that there is in fact no such lack of symmetry.

The Lorentz transformation relates the space and time measures adopted by two observers in relative motion on the assumption that the observers use *independent* and *indistinguishable* experimental procedures and apparatus. If a stationary observer determines the time by measuring the rest-mass of sand flowing through an hour-glass at rest at the origin, then the moving observer must be assumed to determine the time as the *rest-mass* of sand flowing through an hour-glass, indistinguishable from that used by the stationary observer, and moving with the moving observer's origin.

The slowing down of a moving clock is deduced from the Lorentz transformation on the supposition that the readings of the moving clock could be used by an observer moving with it so as to satisfy the above requirements: in other words, the clock could be used by an observer moving with it without his knowing that it was moving. The predicted slowing down does not, therefore, apply to the moving clock suggested by Prof. Dingle in which the mass of sand flowing through an hour-glass is measured in the *stationary* co-ordinate system; for, if the observer moving with the clock does not know that it is moving, he cannot recognize the stationary co-ordinate system in which the mass is to be measured.

Now consider a uniformly moving clock *A* that satisfies these conditions, and let *B* be a stationary clock that is indistinguishable from *A*. Suppose that the positions of the clocks coincide when the reading of *A* is t_0 . Let light signals be sent out from *A* when its readings are $t_0 - t_1$ and $t_0 + t_1$, and let these signals reach *B* when its (that is *B*'s) readings are t_2 and t_3 . The slowing up of the moving clock is demonstrated by the inequality $2t_1 < t_3 - t_2$. This

experiment is closely analogous with that suggested by Prof. Dingle to detect the Fitzgerald contraction.

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¹ NATURE, 144, 888 (1939).
² NATURE, 145, 426 (1940).

I THINK Dr. Powell's letter is based on a misunderstanding. I did not say that it was impossible to detect experimentally the slowing-down of a moving clock. My point was that whatever slowing-down was detected would not necessarily be in the Fitzgerald ratio unless the clock was an 'ideal' one, and that we could not check the relativity requirement with regard to time measurement by experimenting on actual clocks, because if they did not confirm it, the proper deduction would be simply that they were not ideal. The "lack of symmetry between time and space" thus implied is not at all "surprising". It exists because we can make an 'ideal' measuring rod but not an 'ideal' clock. You cannot, in fact, define the standard unit of length without implying the existence of the measuring instrument—the material bar. The unit of time, on the other hand, cannot be embodied in a material instrument. The best we have, the rotating earth, itself needs slight correction, and experiments on relatively moving earths are, to say the least, difficult. (Incidentally, I wonder if Dr. Powell and Prof. Campbell have considered the case of relatively moving sundials?)

Much confusion is introduced into the subject by multiplying observers. The special theory of relativity can be completely deduced by re-defining length as $l\sqrt{1-v^2/c^2}$ instead of l (where l is the length of a body measured by a relatively stationary rod and v is whatever velocity the body may have in the arbitrary co-ordinate system chosen), and following out the logical implications of the change in all other measurements. This can be done by a single observer, who can choose two co-ordinate systems and compare them. Suppose he has two measuring instruments (say clocks), *A* and *B*, one moving with velocity v relatively to the other. He can choose which he pleases to be at rest. If he chooses *A*, then *B* is running slow: if he chooses *B*, then *A* is running slow. That is how much "objective reality" there is in the slowing-down. If he makes an experiment to see which is "really" running slow, he must make some calculations from his observations to get his result, and the formulæ he must use will depend on his choice of co-ordinate system. They are such that he will always find the "moving" clock, whichever it is, to be running slow, when corrected to the "ideal".

This way of looking at the matter should dispose of the question, which every correspondent has raised, about the measurement of the "moving" mass of sand by the "stationary" observer. A single observer, given the definition of mass (a definition which is not satisfied by "rest-mass", for that is not conserved), has to measure the mass of a body according to that definition, whether it is moving or stationary with respect to himself. If he has to move with it every time, then the mass of a moving body has no meaning, for the whole point of the relativity theory is that there is no absolute, but there is relative, motion. Further, all observers, however they are moving relatively to each other, will obtain the same measurements of similar bodies at rest with respect to