is purely electrolytic, we should expect the alkalinity to be neutralised by the acid radicle ions driven into solution from the glass. The initial current was 8·5 micro-amperes, rising at the end of fifteen minutes to 13 micro-amperes. By this time the solution in contact with the thinner parts of the bulb was a deep pink. The current was then reversed, the initial value being now 16 micro-amperes. After six minutes the solution in contact with the glass was very nearly, if not quite, colourless. If the current in the glass were electrolytic, there can be little doubt that sodium ions would have been driven into solution, thus maintaining the pink colour. The large changes in the conduction current with time and reversal of direction are probably attributable to alteration and polarisation effects in the glass. The thin parts of the bulb carrying most of the current probably represented an area of only 2 or 3 sq. cm., so that the current density was comparatively large, and the potential gradient probably between 1 and 2 megavolts per cm. The evidence of the colour changes, which were repeated several times, is strongly in favour of the view that under such gradients and at air temperature the conduction current is largely, if not entirely, of a non-electrolytic nature.

HORACE H. POOLE.

Royal Dublin Society, June 20.

The Displacement of Spectral Lines by a Gravitational Field.

ACCORDING to the theory of relativity the paths of moving particles or light pulses are geodesics in a four-dimensional Riemann space defined by the metric

$$ds^2 = g_{\mu\nu} dx_\mu dx_\nu.$$

The resulting abstract kinematics is brought into relationship with the facts of experience by the identification of the Gaussian co-ordinates x with the observer's space-time co-ordinates in a Newtonian-Euclidean system. Since the spaces are Euclidean, and since the velocity of light is the same for each observer, it follows that the systems of two different observers are similar, but not necessarily on the same scale.

Consider the field of a single gravitating centre. The metric is given by

$$ds^2 = -\gamma^{-1}dr^2 - r^2[d\theta^2 + \sin^2\theta d\phi^2] + \gamma dt^2.$$

Taking the unit of ds as the fundamental unit, and measuring radial and transverse lengths and times at two different points of the Riemann space, we see that throughout the space the local scale is constant for transverse lengths, varies as $\gamma^{\frac{1}{2}}$ for radial lengths and as $\gamma^{-\frac{1}{2}}$ for times. Since the separated space-time systems of different observers are to be similar, it is clear that their scales cannot be obtained by carrying over the scales of the Riemann space at the observers' world-points. Assume that the observer's time-scale bears to the time-scale at his world-point in the Riemann space the ratio $1 : f(r)$. The scales of the Euclidean systems of two different observers then vary inversely as $\gamma^{\frac{1}{2}}f(r)$.

This variation of scale has no effect on the mercury problem or on the deflection of a beam, but it is of fundamental importance in the third crucial phenomenon, the displacement of the spectral lines.

The usual argument shows that

$$\gamma^{\frac{1}{2}}{}_{S} dt_S = \gamma^{\frac{1}{2}}{}_{E} dt_E,$$

where dt_S, dt_E are measured in the units of the Riemann space. If we transfer to the Euclidean spaces of local observers, the equation becomes

$$\gamma^{\frac{1}{2}}{}_{S} f_S dt_S = \gamma^{\frac{1}{2}}{}_{E} f_E dt_E.$$

Eddington's argument on p. 129 of "Space, Time, and Gravitation" shows that the time-period *as measured in the units of any one observer* is transmitted by the radiation. Hence dt_S can be compared with dt_E by observation. The measurement of the displacement of the spectral lines determines the function f.

No displacement is to be expected if $f = \gamma^{-\frac{1}{2}}$. In this case, if dt is a time-interval in the Riemann space, $\gamma^{\frac{1}{2}}dt$ is the corresponding observer's interval, and $\gamma^{\frac{1}{2}}dt$ or ds is propagated by the radiation as suggested in my letter of March 10.

H. J. PRIESTLEY.

University of Queensland, Brisbane, May 11.

The Measurement of Single and Successive Short Time-Intervals.

THE following modification of the well-known method of determining small time-intervals by the discharge of an electrical condenser does not appear to be generally used, judging from some inquiries I have had. Though the modification possibly has been published somewhere—the man who can claim originality in these days is fortunate—this letter may be a help to some other workers.

The well-known method to which I refer consists in so arranging the circuit with a condenser and ballistic galvanometer that the former is charged or discharged during the interval. The potential of the condenser is measured before and as soon after the interval as possible by the galvanometer, and the duration of the interval is proportional to the difference of the logarithms of these quantities.

The modification I first used during 1915 in connection with the measurement of the velocity of detonation of explosives consists in connecting one side of the condenser to the string of a Laby string electrometer. The displacement of the string is proportional to the potential of the condenser, so that during an experiment the string falls from one position to another, and the logarithm of the ratio of these displacements from the zero position is proportional to the time. The accuracy of the method can be increased by using a moving plate and photographing the string's position; it can be increased up to the limit imposed by the accuracy within which the condenser capacity and discharging resistance are known by measuring the displacements on the plate with a microscope.

The advantages of this method as compared with the ballistic method are: (*a*) the procedure and circuit are much simplified, (*b*) small leakage is of no importance or embarrassment, (*c*) the whole process being self-recording, the result is available for measurement at any time, and, further, the inertia of the string or its natural period of vibration does not affect the result.

Its disadvantage in common with the ballistic method is the disturbing influence of the inductance of the circuit upon the rate of flow. It may be possible in some applications to calculate this, or to allow for it by calibration.

If a bicycle ball suspended by a long thin wire be allowed to impinge against, and rebound from, the vertical face of an anvil until it comes to rest, the resulting record with its gradually diminishing steps, corresponding to the several durations of contact, affords a pretty example of the application of this method to the measurement of rapidly successive short time-intervals.

ALAN POLLARD.

The Imperial College of Science and Technology, South Kensington, S.W.7, June 14.