inside the sphere, there is only one position for Q . But if P is inside the cone, there are two. The value of V at P is the same for both, given by (3) reckoned positive always. So the real V at P is double as much.

If the speed varies, the values of u will usually be not the same in the two positions, so the two partial V 's must be separately reckoned. But the speed and path may vary in such a way that there are more than two positions of Q which are the centres of waves which all arrive at P at the same moment.

When there are any number of electrons moving about in given paths, the following will give a broad idea of the nature of the problem. To find V at a fixed point P at the moment t . Let at that moment a spherical surface expand from P at speed v , not forward in time, but backward. In expanding from radius 0 to ∞ , it will cross the electrons one after another. Take note of the times of passage, t_1, t_2 , &c. (less than t), of the charges and their velocities. Then

$$V = \sum \frac{Q}{4\pi R \{1 - (u/v) \cos \theta\}}, \quad (4)$$

where $R_n = v(t - t_n)$, and θ_n is the angle at Q_n between $\mathbf{R}_n$ and $\mathbf{u}_n$. Similarly as regards the vector potential.

When u is allowed to exceed v , the effect is to increase the number of crossings of electrons. An electron crossed twice counts as two electrons.

The value of i_n is $\{1 - (u/v) \cos \theta_n\}^{-1}$. The vector $\mathbf{u}_n$ is the real velocity of Q_n at the moment t_n . Its apparent velocity, as viewed from P at the moment t , is $\mathbf{u}_n t_n$ or $-\mathbf{R}_n$. It has no necessary resemblance to the real velocity, and may be positive or negative. The dot here signifies differentiation to t at P .

Talking of potentials, I am tempted to add a few words about their King, the Pan-potential. In equation (1) above, let q be not $d/d(vt)$, but any sort of complex time differentiator, for example, if $p = d/dt$,

$$q^2 = (k + cp)(g + \mu p),$$

which is the special form for electromagnetic waves in a conductor. Then (2) is still the solution for a point source, and in general

$$V = \sum \frac{e^{-qr} f}{4\pi r} = \text{pan } f \quad (5)$$

is the pan potential due to the distributed source f . It is not the complete solution, because e^{qr} has not been counted; but that is not wanted when there is no barrier to reflect.

For instance, if $\mathbf{C}$ is impressed electric current, in a conductor, the characteristic of $\mathbf{H}$, magnetic force, is

$$(\nabla^2 - q^2)\mathbf{H} = -\text{curl } \mathbf{C}. \quad (6)$$

It follows by the above that

$$\mathbf{H} = \text{pan curl } \mathbf{C}, \quad (7)$$

that is, the magnetic force is the pan-potential of the curl of the impressed current. The operations pan and curl are interchangeable, so

$$\mathbf{H} = \text{curl pan } \mathbf{C}, \quad (8)$$

i.e.,

$$\mathbf{H} = \text{curl } \mathbf{A}, \quad \text{if} \quad \mathbf{A} = \text{pan } \mathbf{C}.$$

(Similarly $\nabla \text{pan} = \text{pan } \nabla$, and $\text{div pan} = \text{pan div}$.)

I worked out this problem for a fixed point source of impressed current some time ago ("Elec. Pa.," vol. ii. p. 432) without reference to the pan-potential. The operational solution there given, equation (258), represents either (7) or (8). The algebrisation was also done. There is no advantage in using the $\mathbf{A}$ function in this particular case; it is, in fact, more difficult to find $\mathbf{A}$ first and then derive $\mathbf{H}$ than to obtain $\mathbf{H}$ without $\mathbf{A}$. Similarly as regards $\mathbf{E}$, the electric force. The second circuital law derives it from the $\mathbf{H}$ equation, so that it is not required to introduce Φ to supplement $\mathbf{A}$.

If the point-source is in motion, the pan-potential requires Dopplerisation as well as the ordinary potential. But this does not require explicit representation for continuously distributed sources. For example, the electromagnetic circuital equations

$$\text{curl } (\mathbf{H} - \mathbf{h}) = \mathbf{u} \text{ div } \mathbf{C} + (k + cp)\mathbf{E}, \quad (9)$$

$$\text{curl } (\mathbf{E} - \mathbf{e}) = \mathbf{w} \text{ div } \mu \mathbf{H} + (g + \mu p)\mathbf{H}, \quad (10)$$

where $\mathbf{u}, \mathbf{w}, \mathbf{e}, \mathbf{h}$ are functions of position and time, have the solutions

$$\mathbf{E} - \mathbf{e} = \text{pan } \mathbf{X}, \quad \mathbf{H} - \mathbf{h} = \text{pan } \mathbf{Y}. \quad (11)$$

To prove this, and determine the nature of $\mathbf{X}$ and $\mathbf{Y}$, it suffices to put the characteristics of $\mathbf{E} - \mathbf{e}$ and $\mathbf{H} - \mathbf{h}$ in the form

(1), q^2 having the more general later meaning. Now (9) and (10) lead to

$$(q^2 - \nabla^2)(\mathbf{E} - \mathbf{e}) = -\nabla \rho - \text{curl } \mathbf{G} - (g + \mu p)\mathbf{C}, \quad (12)$$

$$(q^2 - \nabla^2)(\mathbf{H} - \mathbf{h}) = -\nabla \sigma + \text{curl } \mathbf{C} - (k + cp)\mathbf{G}, \quad (13)$$

where

$$\rho = \text{div } (\mathbf{E} - \mathbf{e}), \quad \sigma = \text{div } (\mathbf{H} - \mathbf{h}), \quad (14)$$

$$\mathbf{C} = \mathbf{u} \text{ div } \mathbf{C} + (k + cp)\mathbf{e}, \quad (15)$$

$$\mathbf{G} = \mathbf{w} \text{ div } \mu \mathbf{H} + (g + \mu p)\mathbf{h}. \quad (16)$$

So $\mathbf{X}$ and $\mathbf{Y}$ are the right members of (12) and (13) as defined. $\mathbf{C}$ is the impressed electric current, $\mathbf{G}$ the impressed magnetic current. It will be seen that no separate determination of scalar potentials is required, because they are already included in $\mathbf{X}$ and $\mathbf{Y}$.

OLIVER HEAVISIDE.

Recent Dust Storms in Australia.

ON November 11, 12 and 13, 1902, New South Wales and Victoria experienced severe dust storms, apparently caused by a mild cyclone travelling from the west, as the dust reached here yesterday morning, the wind at the time being very light. The atmosphere was so loaded with fine dust that the sun looked dim and objects less than a mile away were quite indistinct; and all furniture, even with doors and windows closed, became coated with a fine grey deposit.

Reports from vessels coming along the coast say that the sea had a peculiar leaden colour; and a remarkable appearance was seen in Sydney Harbour yesterday morning. Crossing the harbour from the north to the south side, immediately on getting in sight of the sun the wavelets between the steamer and the sun showed streaks of brilliant light metallic blue colour. This was intensified when the boat entered the still glassy water of Sydney Cove, when the back of each ripple caused by the steamer on the sunny side showed a sheet of the same colour and that most brilliantly. The water where undisturbed was covered by a slight scum, which might either be settled dust or a layer of mineral oil, but appeared more like the former. The colour had not the iridescent appearance caused by oil, as it was a uniform pale blue and only showed on the back of the wavelets.

It seemed to me that this was an exaggerated example of the blue colour of water caused by finely-divided mineral matter seen in glacier waters and those of the hot lakes of New Zealand, where the water has silica in suspension.

WILL. A. DIXON.

97 Pitt Street, Sydney, November 14, 1902.

ABOUT half-past four o'clock on the afternoon of November 12, I noticed that the sky to the north and north-east, from the horizon half-way to the zenith, had assumed an extraordinary chocolate-brown tint, due to clouds of that colour which were moving towards us from the north-west. Under these clouds, and moving from the north-east, were ashy-grey patches of stratus, streaked with fantastic dark lines resembling bows and boomerangs. A few drops of rain which fell about five o'clock were charged with brown, earthy matter, and at six o'clock a paper which was held in the rain became spotted all over with brown blotches.

This fact, and the colour of the clouds, led me to the conclusion that a tornado had taken place in the interior of Australia, whirling the fine dust high into the upper regions of the atmosphere, in which position it was carried over the Straits and then descended with the rain.

At 6.20 p.m. the solid matter was still descending, but in less quantity; at 6.30 there was a marked diminution; and by ten minutes to seven the rain was all but free from it.

While the six o'clock shower was descending, one heard the remark on all sides that "it was raining mud"; those who were unfortunate enough to have their week's washing hanging out at the time were doomed to a second day at the wash-tub.

This remarkable occurrence recalls the events of Black Thursday, 1851, when Victoria was swept by tremendous bush-fires; leaves and portions of charred ferns were carried up to great heights by the currents of heated air, wafted across Bass' Straits and deposited upon our shores; the sky was so darkened by huge volumes of smoke that, although in the height of summer, lamps had to be lit early in the afternoon.

West Devonport, Tasmania,

H. STUART DOVE.

November 14, 1902.