LETTERS TO THE EDITOR.

[The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of NATURE. No notice is taken of anonymous communications.]

The Doppler Effect and Carnot's Principle.

IN my letter of March 19 I endeavoured to show that the latent heat absorbed in the production of unit volume of stationary vibration of a particular frequency in a mixed beam of radiation, is not equal to $4q/c$ (where q is the energy stream per sq. cm. per sec., and c the velocity), as would naturally be supposed, but, in consequence of the Doppler effect at the moving mirror or piston, takes the form $T(dp/dT)$, as required by Carnot's principle, where p is the pressure, or the mechanical work per unit volume, and is equal to $2q/c$ for a directly reflected beam under equilibrium conditions. The latent heat, $T(dp/dT)$, may be represented as the sum ($u+p$) of the intrinsic energy or internal latent heat u and the external work p . As a matter of interpretation, u was identified in my letter with some form of stationary vibration which continued to exist in the medium at the frequency at which it was emitted. Further analysis shows that this is not the case, but that the energy left in the medium conforms exactly to the distribution required by the theory of exchanges. The energy density is $2q/c$ in a directly reflected beam, and is equal to the pressure, but differs from the energy absorbed on emission or evolved on condensation, namely, the latent heat, $T(dp/dT)$, which is the quantity measured experimentally, as previously explained (*Phil. Mag.*, October, 1913, p. 787).

Similarly in the case of full radiation where the energy stream is Q per sq. cm. per sec. in all directions, the energy density is $4Q/c$, and the pressure $4Q/3c$ for each frequency, but the latent heat per unit volume is still $T(dp/dT)$ (in place of $16Q/3c$) on account of the Doppler effect, and the energy stream as measured experimentally is not Q but $\frac{1}{4}T(dQ/dT)$. With a slight change of viewpoint the consideration of the Doppler effect leads to the exact formulæ and numerical relations already detailed in my previous note (*loc. cit.*), which are now seen to be no longer in conflict with the electromagnetic theory as was at first supposed.

H. L. CALLENDAR.

Imperial College of Science, South Kensington,
March 30.

Lead and the Final Product of Thorium.

IT is now practically certain that the final product of the uranium family of radio-elements is isotopic, or chemically identical, with lead. The constancy of the ratio between lead and uranium, Pb/U , in the case of primary rock-forming minerals of the same geological age, and its sympathetic variation in the case of minerals of different ages, go far to establish this important conclusion. The recent discovery that all the final products of radio-active disintegration fall into Group iv. B of the periodic classification has naturally led to the further suggestion that each one is isotopic with lead.

If lead, or one of its isotopic equivalents, is the final product of the thorium series, then the estimates of geological time hitherto based on the lead-uranium ratio stand in need of a ruthless revision.

Fortunately this does not appear to be necessary, for mineralogical evidence clearly indicates that the presence or absence of thorium in a uranium-bearing mineral does not affect the lead content, which can

generally be adequately accounted for by the uranium alone.

It is easy to calculate the relative rates at which uranium and thorium generate their final products, and assuming that the latter are isotopic, to express a given amount of thorium in terms of uranium, and so to arrive at a "total equivalent quantity of uranium," U_0 , which also takes thorium into consideration. If then lead is, chemically speaking, the final product of thorium as well as that of uranium, the ratio Pb/U_0 ought to be constant for minerals of the same age, and ought to vary in sympathy with the ages if these should differ. I have examined a large number of analyses of radio-active minerals from this point of view, and neither of the above criteria is found to hold. In many cases a large percentage of thorium may be present, but unless uranium is also present, lead is nearly always absent. In the few examples where lead and thorium occur alone, the ratio Pb/Th is variable and bears no relation to the geological age of the minerals.

However, more fully to demonstrate the bearing of evidence of this kind on the problem, Mr. R. W. Lawson, of the Radium Institute, Vienna, and myself are at present estimating the thorium content of a series of Norwegian minerals of Devonian age which had already been analysed for lead and uranium (*Proc. Roy. Soc., A*, vol. lxxxv., p. 248, 1911). Other workers are busily engaged on determinations of the atomic weights of the lead from uranium and thorium bearing minerals respectively, and there is therefore some likelihood in the near future of a final settlement of the question whether lead is an end-product of thorium or not.

ARTHUR HOLMES.

Geological Department, Imperial College of
Science, London, March 18.

Thermions and the Origin of Solar and Terrestrial Magnetism.

PREVALENT opinion seems to favour decidedly the hypothesis that the chief part of the magnetism of the earth or sun is due to the rotation of all, or a considerable portion of, the matter of which it is constituted. Theories of the magnetisation of matter by rotation fall into two classes: one (a) assuming that the substance is magnetic but not necessarily charged, the other (b) assuming that the substance is charged but not necessarily magnetic.

(a) If the matter is magnetic, consisting of molecular systems with individual magnetic moments differing from zero, rotation about a given axis will, on the electron theory, produce a torque on each individual system, causing it to contribute a magnetic moment parallel to the axis of rotation, and thus magnetising the whole body, if originally neutral, along this axis.

(b) Gravitation, or electrical forces, acting differentially on the positive and negative constituents of the matter, or differential centrifugal action, or some other cause, may give rise to a volume-density of electrification throughout the mass of a rotating body, in which case magnetisation, or at least a magnetic field, must result from the convection currents thus formed.

The particular kinds of differential action just mentioned have been proposed before, but I have seen no reference to the fact that an essentially steady electric volume-density must long ago have been produced by the emission of negative electrons from the heated matter of which the earth and sun are composed, and the resulting internal electric field. As the emission increases with the temperature, which increases from the surface inward, it is clear that the volume-density must be of the proper size to account for the polarity of solar and terrestrial magnetism.