These properties are true for various relations between I and E. The first approximation is $I=c_1E$. The second, introduced by Lorentz, is $I=c_1(E-uB)$, that is, the polarisation is proportional to the moving force on a moving ion. Other forms allowing of undistorted pulse propagation may be proposed. All give special relations between w and u. In Lorentz's case,

$$U_0=\tfrac{1}{2}c_1E_3^2(1-u/w)^2. \qquad (12)$$

To pass to perfect reflection, reduce w to u, its least value. U_0 does not vanish, but has the value given by (10), (11) still, with $w=u$. But the transmitted wave is reduced to a surface film, moving with the glass. The moving force on the glass is now

$$F=2p_1\,(w-u)/(v+u), \qquad (13)$$

and finally, if $u=0$, $F=2p_1$.

Here we come right back to the pressure of radiation. It does measure the force on the glass when at rest, when it reflects perfectly, and it looks as if (13) were merely the form p_1+p_2 a little modified by the motion. But appearances are very deceitful here, for (10) above is the proper formula.

As regards the distribution of F. With an actual transmitted wave consisting of a pulse of uniform intensity all through, F is entirely at the wave front. So, with total reflection, it is just under the surface of the glass. Again, if E_3 varies continuously in the transmitted wave, F is distributed continuously, to the amount $B(\partial I/\partial t)$ per unit volume. What F means in (11) now is the total of this volume force, *i.e.* the integral from the surface up to the wave front, expressed in terms of the momentary surface state.

After a pulse has left the surface there is an equal opposite force at its back, so there is no further loss of energy or moving force on the glass. The obscurities and apparent contradictions arise from the assumption that the ether is quite motionless. If we treat the matter more comprehensively, and seek the forces in a moving ether, with moving polarisable matter in it as well, if this is a complication one way it is a simplification in another, viz. in the ideas concerned. There is harmony produced with the stress theory. To illustrate, $(\partial/\partial t)V\mathbf{DB}$ is the moving force per unit volume when the ether and polarised matter have a common motion, $\mathbf{D}$ and $\mathbf{B}$ being the complete displacement and induction. (The variation of $\mathbf{u}$ is ignored here.) But if we stop the ether, a part of this force becomes inactive. If the matter is unmagnetisable, the only active part is that containing the polarisation current, for that is carried along.

Besides this electromagnetic force, there is also a force due to a pressure of amount U_0. But it does not alter the reckoning of the moving force on the glass, because the pressure acts equally and oppositely at the front and back of a pulse.

Some other illustrations of the curious action between electromagnetic radiation and matter can be given. For example, two oppositely moving plane pulses inside moving glass. Say $E_1=\mu w_1H_1$ one way with the glass, and $E_2=-\mu w_2H_2$ against the glass. If $H_1=-H_2$, work is done upon the glass when they cross, ceasing the moment they coincide, so that the energy of the momentary electric field is less than the wave-energy. On separating, the loss is restored. If, on the other hand, $E_1=-E_2$, work is done by the glass on the waves when uniting, so that the momentary magnetic energy, together with the polarisation energy, is greater than the wave energy. In this second case, too, it is noteworthy that the solitary waves are of unequal energy, whereas they are equal in the first case. But details must be omitted, as this communication is perhaps already too long.

OLIVER HEAVISIDE.

February 21.

Secondary Röntgen Radiation.

IN a paper read before the Royal Society on February 16, I described experiments demonstrating the partial polarisation of Röntgen radiation proceeding from an X-ray bulb, and at the same time verifying the theory previously given of the emission of secondary X-rays from gases and light solids subject to Röntgen radiation.

Later experiments have shown that beams of X-radiation may be produced exhibiting a greater amount of polarisation than there was evidence of in the original experiments. This discovery has proved useful in the investigation of secondary radiation proceeding from solids.

It has been found that while the intensity of secondary radiation from light substances varies considerably in different directions owing to the partial polarisation of the primary radiation, the amount of this variation diminishes with an increase in the atomic weight of the radiator, and ultimately is inappreciable. The radiations from air, carbon, paper, aluminium, and sulphur vary in intensity in different directions by a considerable amount. From calcium the variation is much less, while from iron, copper, zinc, and lead it is inappreciable. This must be connected with the fact that the radiation from light substances differs in character only very slightly from the primary, while the heavier substances emit radiations differing more from the primary producing them. The radiation from the heavier metals was found not to consist of an easily absorbed radiation superposed on a radiation such as proceeds from light substances, and of intensity given by the law found for that from light substances, but is as a completely transformed radiation. This is strong evidence that the freedom of motion of the electrons which permits what may be called a simple scattering in substances of lower atomic weight is interfered with in the heavier atoms, for we find from them a more absorbable radiation *in place of, not simply superposed on,* a more purely scattered radiation.

With this change in character, the polarisation effect disappears. No special absorption of the radiation proceeding from a substance by plates of the same substance has been observed.

A considerable variation in the penetrating power of the primary radiation incident on heavy substances is accompanied by a smaller change in that of the secondary (measured by change of absorbability).

Radiation from compounds appears to be merely a mixture of the radiations which proceed from the separate elements in the compound, both the absorbability and polarisation effects being what would be given by such mixtures. Atomic weight, not molecular weight or density, thus seems to govern the character of the radiation produced by a given primary.

These results may be accounted for by considering the electrons constituting the atoms as the radiators. In light atoms the electrons are far enough apart, and have sufficient freedom to move almost entirely independently of one another, under the influence of the primary pulses, consequently to emit a secondary radiation similar to the primary, but the intensity of which depends on the direction of propagation with regard to that of electric displacement in the primary beam. In heavier atoms considerable inter-electronic forces are probably brought into play by small displacements, and the resultant acceleration of motion of an electron is then not in the direction of electric displacement of the primary beam, and evidence of polarisation of that beam vanishes. Also there ceases to be a simple connection between the time for which the electron is accelerated and that of passage of the primary pulse.

In atoms of greater weight we would expect appreciable inter-electronic forces to be called into play sooner, and to attain a much greater intensity than in lighter atoms.

The precise connection between the atomic weight of the radiator and the absorbability of the radiation is being investigated.

CHARLES G. BARKLA.

University of Liverpool, March 1.

Dates of Publication of Scientific Books.

I HAVE just bought a copy of "A Treatise on Slate and Slate Quarrying, Scientific, Practical, and Commercial," by D. C. Davies, F.G.S., fourth edition, dated 1899 (Crosby Lockwood and Son).

To my astonishment, I find no statistics of later date in it than 1876, *e.g.* p. 33, statistics of 1872 and 1873, p. 58, list of quarries in 1873, p. 59, production in 1876, p. 64, production last year (1876), p. 170, prices of slates in London last year (1876).

As the Home Office publishes annually a general report and statistics of mines and quarries, and also a list of mines and quarries, there is no excuse for the book being so out of date in its statistics.

B. HOBSON.

The Owens College, Manchester, February 21.