Range (ft.)	300–500	500–700	700–900	900–1,100	1,100–1,200
Gravimeter density	2·23 ± 0·08	2·23 ± 0·08	2·14 ± 0·15	2·65 ± 0·15	2·15 ± 0·20
Chippings density (wet)	2·40	2·37	2·25	2·50	2·25
(dry)	2·25	2·17	1·97	2·33	2·0

should not be drawn, however, as the effect of assuming a linear drift of the 'zero' frequency is to indicate a lower density than would be obtained if the alternative drift curve were adopted.

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Electromagnetic Momentum and Newton's Third Law

THE following simple relations[1] between electromagnetic momentum, Poynting's vector of energy flow, and mass–energy equivalence do not appear to have received general recognition in connexion with the validity of Newton's Third Law when applied to electromagnetic forces.

If the dielectric medium is free space, so that there is no matter present to take reactive forces, we suppose that the energy represented by the Poynting vector, $\vec{\varepsilon} \times \mathbf{H}$ (rationalized M.K.S. units), moves with the velocity of light and also has mass of amount m per unit volume of the field. Suppose also that its momentum per unit volume is $\mathbf{D} \times \mathbf{B}$ (where $\mathbf{D} = \varkappa_0 \vec{\varepsilon}$, $\mathbf{B} = \mu_0 \mathbf{H}$, $\varkappa_0 \mu_0 = 1/c^2$), and consider a unit area of surface normal to the direction of energy flow. Then if the rate at which energy passes through this surface is $|\vec{\varepsilon} \times \mathbf{H}|$, it follows that the amount of *moving* energy per unit volume of the field is $W = |\vec{\varepsilon} \times \mathbf{H}|/c$. Its momentum is mc, so if this is to be equal to $|\mathbf{D} \times \mathbf{B}|$, we must have:

$$m = \frac{|\mathbf{D} \times \mathbf{B}|}{c} = \frac{|\vec{\varepsilon} \times \mathbf{H}|}{c^3} = \frac{W}{c^2},$$

which is the mass–energy relation.

Whenever the total 'ponderomotive' force on an electromagnetic system is not zero, it is equal to the volume integral of $-\frac{\partial}{\partial t}(\mathbf{D} \times \mathbf{B})$ taken over the whole of the dielectric in which $\mathbf{D}$ and $\mathbf{B}$ exist. It is therefore balanced by the volume integral of $\frac{\partial}{\partial t}(\mathbf{D} \times \mathbf{B})$, the time-rate of change of the total electromagnetic momentum. The interpretation is clearly that this represents the rate of change of ordinary mass-momentum of the energy which is moving about in the changing field, and that the 'equal and opposite' reaction to the unbalanced ponderomotive force is borne by the energy photons.

Newton's Third Law is thus reinstated if the mass of the field energy is taken into account. The theorem applies both to radiating and to non-radiating systems. A simple example of the latter is to be found in the case of a charged particle moving with uniform velocity through a constant-current toroidal coil.

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[1] See, for example, Lorentz, H. A., "Lectures on Theoretical Physics", 241 and 249 (English trans., Macmillan, 1931), in the chapter on "The Inertia of Energy".

Screw Dislocations in Pyrite

IN the course of an investigation into the surface structure of a wide range of mineral crystals, the results of which were reported to the Mineralogical Society in March 1951, a number of screw dislocations were observed on the cube faces of one crystal of pyrite, FeS_2. Fig. 1 shows a single screw dislocation; while Fig. 2 exhibits a pair of screw dislocations of opposite sense, which ultimately form an almost closed step-line. The crystal was photographed using a metallurgical microscope, with bright-field illumination, and the surfaces were not silvered. Under these conditions, the very high visibility of the steps forming the main spiral patterns indicates that the layers are multimolecular. This point is further substantiated by the presence of some much thinner layers between the main steps. Examples of screw dislocations with a Burgers vector greater than unity, often considerably greater, have already been reported for cadmium iodide[1], silicon carbide[2], and muscovite[3].

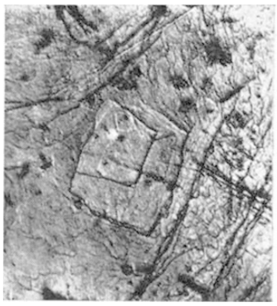

Fig. 1 (× 35)

Fig. 2 (× 35)

The incompleteness of the spiral patterns in Fig. 2 appears to be due to the separation of the thickest layers into several thinner ones in some places.

Note added in proof. A paper on the surface structure of crystals is to be published in the *Mineralogical Magazine*.

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