with the help of a 19-cm. camera and filtered X-rays were used. The cell edges were determined by the extrapolation technique due to Sinclair and Taylor⁵. Extrapolation to absolute zero was carried out by the technique described by Fischmeister⁴. The resultant curves are shown in Fig. 1. Unlike the curves for ionic crystals obtained by Fischmeister⁴ for metallic crystals, these are non-linear. Further work is being carried out to find the nature of these curves for other metals and alloys.

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Interaction Energy of Electric Charges in a Very Thin Tube

IN classical electrostatics, we have the problem of the mutual interaction of two electric charges in a one-dimensional linear space, or—a similar problem—the self-energy of a one-dimensional continuous distribution of charge. Treatment of these problems thus far has given the well-known result that the energy of both these interactions is infinite.

It has been assumed *a priori* that the potential due to the interaction for two points and corresponding to the above distribution is of the type

$\frac{1}{|z_1 - z_2|}$, where z_1 and z_2 are the co-ordinates of points on the line. Integrating along both variables we obtain a quantity tending logarithmically to infinity.

We may, however, approach this problem in another way, which seems to have a stronger physical justification: we calculate the interaction energy of charges in a cylinder of finite cross-section, and then we pass over to the limit for the cylinder radius tending to zero. This gives us a finite value for the interaction energy of two electrons in an ideally thin tube (filament) of length L , namely, $\frac{e^2}{L}$; the self-energy

of a one-dimensional charge distribution with a constant density ρ along the length L is $\frac{1}{2}\rho^2 L$. This is possible because of the non-uniform convergence of the interaction integral.

The calculations were conducted in the following non-trivial manner: we represent the interaction potential by a Green function of the three-dimensional Laplace-Poisson equation, where the function satisfies the relation¹

$$\nabla^2 G = -\delta(\mathbf{r} - \mathbf{r}')$$

here ∇^2 and δ are in cylindrical co-ordinates, and the components δ were expanded into Fourier and Bessel integrals.

With such a potential, we next calculate the interaction integrals in a form corresponding to the Coulomb and exchange integrals constructed from eigenfunctions which are solutions of the Schrödinger equation for particles moving freely in a cylindrical

box of length L and radius R . In this way we obtain, in the limit, an integral for those parameters of the eigenfunctions which correspond to the interaction energy of the classical problem; finally, we obtain the value of this integral for R tending to zero.

The above problem was studied because of its relation to the interaction of electrons in the free-electron model of conjugated organic molecules, this interaction being of basic importance when that model is used for explaining the structure of the absorption spectra of these compounds.

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Irreversible Processes in Physical Theory

IN two recent communications¹, Prof. K. R. Popper has emphasized the existence of physical processes the irreversibility of which is attributable to the physical impossibility of the initial conditions requisite to the occurrence of their inverses, apart from any relationship to thermodynamic theory. Popper refers to an earlier argument of the same type by Einstein². We believe that his point is a sound one and deserves formulation as a general principle.

We distinguish two types of systems which we call 'closed' and 'open'. In classical mechanics the closed systems have quasi-periodic orbits, whereas the open systems have at least some aperiodic orbits which extend to infinity. In quantum mechanics the closed systems have totally discrete energy spectra, whereas the open systems have continuous spectra³. It is sufficient for present purposes to think of a closed system as one confined in a region of finite volume by an outer wall, whereas an open system has no such outer boundary. The theoretical reversibility of elementary processes in both closed and open systems is guaranteed formally in both classical and quantum mechanics by the equations of motion themselves, provided that the maximum information permitted by the theory is supplied.

But there exists a fundamental distinction between the two kinds of system in the following sense. In open systems there always exists a class of allowed elementary processes the inverses of which are unacceptable on physical grounds by requiring a *deus ex machina* for their production. For example, in an open universe, matter or radiation can travel away indefinitely from the 'finite' region of space, and so be permanently lost. The inverse process would require matter or radiant energy coming from 'infinity', and so would involve a process which is not realizable by physical sources. Einstein's example of an outgoing light wave and Popper's analogous case of a water wave are special finite illustrations of this principle.

Einstein argues further that on the emission theory of electromagnetism, as opposed to the wave theory, the energy imparted to a photon on emission is not scattered over infinite space but remains available for elementary processes of absorption and scattering, and he seems to imply by this that the photon theory allows a type of reversibility which is denied to the wave theory. There is no reason, however, for favouring either form of radiation theory on the grounds of reversibility alone, since both forms of emission pro-