All glasses except the vitreous silica showed a strong irradiation-independent resonance at $g=4.00\pm 0.20$ and this is presumably due to some paramagnetic impurity.

Measurement of the optical densities of a series of gamma-irradiated samples of lime glass revealed that the paramagnetic resonance amplitude varied linearly with optical density. Likewise, with annealing at 200°C, the signal amplitude decreased proportionately with bleaching. For the gamma-ray excitation, the dependence of spin concentration on total radiation showed a saturation characteristic with an initial efficiency of, roughly, 20 ev per spin created.

Further studies on the processes involved will be published more completely in the near future.

[1] B. Smaller and E. Yasaitis, Rev. Sci. Instr. **24**, 991 (1953).

Visible Light from Localized Surface Charges Moving across a Grating

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IT occurred to one of the authors (EMP) that if an electron passes close to the surface of a metal diffraction grating, moving at right angles to the rulings, the periodic motion of the charge induced on the surface of the grating should give rise to radiation. A simple Huygens construction shows the fundamental wavelength to be $d(\beta^{-1}-\cos\theta)$, in which d is the distance between rulings, β stands for v/c as usual, and θ is the angle between the direction of motion of the electron and the light ray. If $d=1.67$ microns, as in a typical optical grating, and if electrons of energy around 300 kev are used, the light emitted forward should lie in the visible spectrum. As for intensity, if we assume that the surface charge traversing the hills and dales is equivalent to a point charge e oscillating with an amplitude $d/10$, we find that in the forward direction the radiation (in laboratory coordinates) should amount to 40×10^{-12} erg (about ten photons) per sterad per millimeter of electron path. Only if the electron path lies within perhaps $d/2$ of the grating will the surface charge be so well localized. Nevertheless, with a reasonable electron current density over the surface an easily detectable amount of light should be produced. In fact, under the assumed conditions, the total radiation per cm² of grating surface, in milliwatts, should be about four times the electron current density parallel to the surface in amp/cm².

We have tried the experiment, using a small pressure-insulated Van de Graaff generator and electron accelerator tube. A 5-microampere beam, focused electrostatically and magnetically to a diameter of 0.15 mm and diverging less than 0.004 radian, is adjusted by deflection coils to pass over a flat grating,[1] just grazing its surface. The 48-mm long path across the grating, viewed from a forward position 10 or 20 degrees off the beam, appears as a sharp, luminous, colored line on the surface of the grating. The color of the light changes with angle of observation and beam voltage in the manner expected. The light is strongly polarized with the electric vector perpendicular to the grating. The effect of varying d can be investigated by rotating the grating in its own plane (a test suggested by E. H. Land) and here, too, the color changes as predicted.

The spectrum of the light has been recorded at low dispersion by photographing the source through a transmission grating. Light from the electron track is collected by a collimating lens, where an arc-shaped aperture restricts the range of angles θ, passed through the analyzing grating and received by a 35-mm camera ($f=90$ mm) focused for infinity. With this arrangement only one point on the line source is in good focus. Figure 1 shows a sequence of such photographs in which only the electron velocity was varied. Within the accuracy of our still rather crude measurements of wavelength and voltage, the predicted dependence of

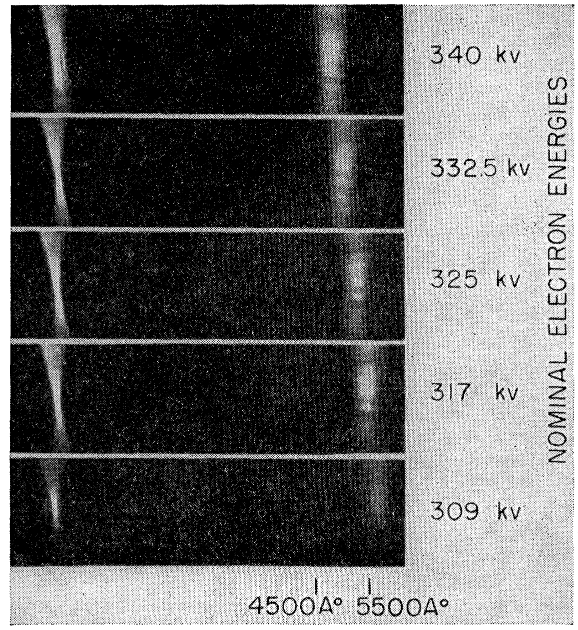

FIG. 1. Spectrogram of the light emitted from the grating surface at $\theta=20°$. Central images are vertically aligned on the left. First-order spectra appear on the right. Light was accepted over an interval of 3.5° in θ; this corresponds to a spread in wavelength of about 350° and accounts for the width of the first-order line. Striations in the first-order line are presumably due to vertical irregularities on the surface of the grating. The exposure time for each spectrum was about 60 seconds, on Linagraph Pan.

wavelength on v, d, and θ is quantitatively confirmed by the spectrograms. On spectrograms taken at $\theta=30°$, radiation of half the fundamental wavelength is detectable. Higher harmonics appear in considerable intensity at 90°, where we find radiation of one-third, one-fourth, and one-fifth the fundamental wavelength.

Although many details remain to be studied, we believe these observations establish the reality of the effect and suggest that it may have interesting applications.

* Recipient of a General Electric Fellowship in Applied Physics for 1952–53.
[1] Obtained from Baird Associates, Cambridge, Massachusetts.

Derivation and Renormalization of the Tamm-Dancoff Equations*,†

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IN this note we show that (1) the derivation of Tamm-Dancoff (T.D.) equations for two nucleons (as well as for meson-nucleon scattering) from the covariant Bethe-Salpeter[1] (B.S.) equation can be simplified to a remarkable degree, and (2) the renormalizations in the T.D. method can be achieved in a covariant manner without having the difficulties presented by the original T.D. method.

We introduce the spinor function $\psi(12)$ by the relation

$$\chi(12)=\int S_{F'a}(11')\beta_a\psi(1'2)d1'+\int S_{F'b}(22')\beta_b\psi(12')d2', \quad (1)$$

where $\chi(12)$ is the B.S. wave function for two nucleons. By using (1) in the B.S. equation we obtain

$$[(\beta\gamma_\mu\partial_\mu+\beta M)_a+(\beta\gamma_\mu\partial_\mu+\beta M)_b]\psi(12) = -\int \mathcal{G}(121'2')\psi(1'2')d1'd2', \quad (2)$$

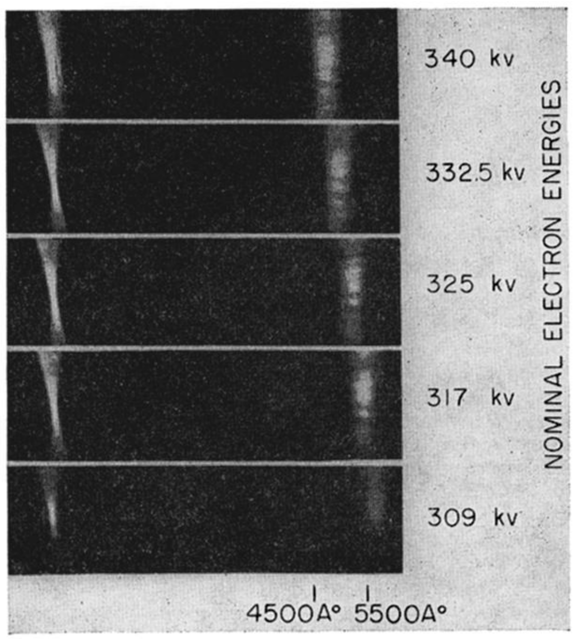

FIG. 1. Spectrogram of the light emitted from the grating surface at $\theta = 20°$. Central images are vertically aligned on the left. First-order spectra appear on the right. Light was accepted over an interval of 3.5° in θ; this corresponds to a spread in wavelength of about 350° and accounts for the width of the first-order line. Striations in the first-order line are presumably due to vertical irregularities on the surface of the grating. The exposure time for each spectrum was about 60 seconds, on Linagraph Pan.