TECHNICAL PAPERS

Radiation Survey of X-Ray Output of an Electron Microscope from Personnel Hazard Viewpoint[1]

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In performing a general radiation survey of the physical plant of the Atomic Energy Project at the University of California at Los Angeles, it was noted that radiation well above background levels existed in the vicinity of the 50-kv electron microscope. Since a portion of the electron beam strikes various metal surfaces in the 'scope, continuous X-rays are generated. It is possible for the operator of the electron microscope to be exposed to this radiation through the various viewing apertures. The presence of this X-radiation from the electron microscope initiated a survey of the instrument for possible hazards.

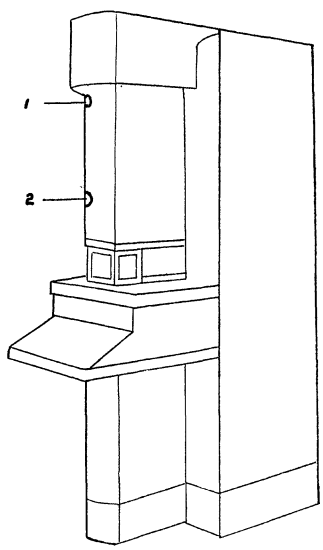

FIG. 1.

A calibrated Keleket dosimeter was placed so that the sensitive volume was in direct contact with the port of the primary viewing screen, (1 in Fig. 1). With the beam current of the electron microscope at 200 μa, the average dosage at this port was approximately 1500 mr/hr. If a person were exposed to this level a full working day, he would receive several hundred times the maximum permissible exposure. The dosage at the intermediate viewing port, (2 in Fig. 1), was 70 mr/hr. At this Atomic Energy Project, the maximum exposure permitted is 50 mr/day.

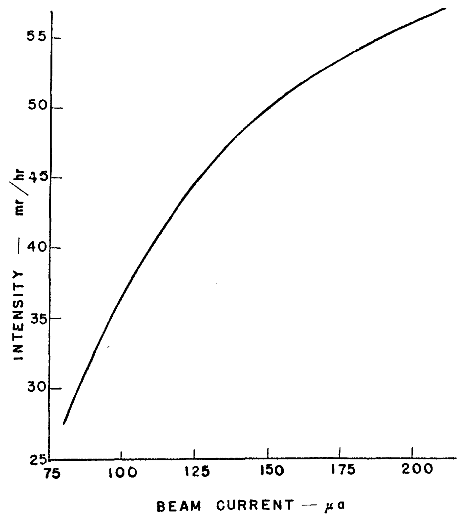

FIG. 2. Dosage vs. beam current at 20 cm.

The intensity of the X-rays was measured as a function of the beam current in the electron microscope. This was done by using a Victoreen Model 356 survey meter placed so that the nylon window of the ionization chamber was 20 cm from the port of the primary viewing screen. The data are shown in Fig. 2. The beam current commonly employed ranges from 100 to 300 μa. At 200 μa, the dosage at 20 cm would be about 56 mr/hr, which is approximately ten times the tolerance rate.

The hardness of the X-ray beam was determined by making a series of measurements with Al filters. Fig. 3 shows the results of these determinations.

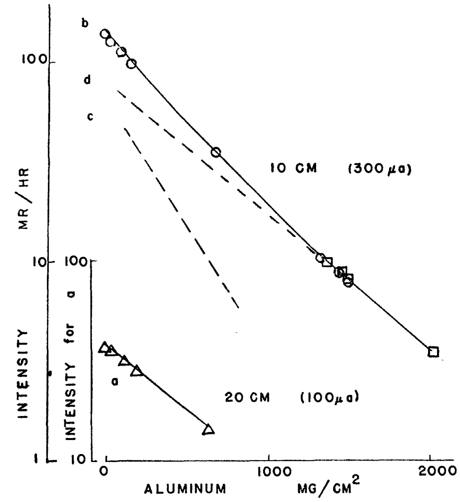

FIG. 3. Attenuation of X-rays from electron microscope.

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Curve (a) is a graph of the X-ray intensity in mr/hr plotted against the thickness of Al filter in mg/cm^2. These data were obtained by using the Model 356 meter. The beam current for this series of measurements was 100 μa, and the distance was 20 cm. This was a convenient set of values to use so that the middle range of the instrument could be employed.

Curve (b) is similar to curve (a) except that a Victoreen Model 247A meter was used. A beam current of 300 μa and a distance of 10 cm were convenient for this instrument. In curve (b) the circles represent the data obtained with the aluminum case of the instrument removed. The squares represent the data obtained with the aluminum case on the instrument. The consistency of these two sets of data indicated that the case was equivalent to 1.34 g/cm^2 of Al filter. In plotting the squares, this equivalent filter weight was added to the actual weights of the filters used.

The range of attenuation in curve (b) is sufficient to show a decrease in the slope of the curve with increasing weight of the Al filter. This change of slope is due to the fact that the softer components of the X-rays are filtered out more quickly than the more penetrating hard components remaining in the X-ray beam. To obtain an approximate estimate of the proportion of soft and hard components, curve (b) was analyzed in the usual way producing curves (c) and (d). Curve (c) represents the more rapidly attenuated soft component, and curve (d) the harder component. Since the X-rays are of the continuous type arising from the bombardment of bronze in the electron microscope by 50-kv electrons, the division of the X-rays into two components, hard and soft, is just a convenient approximation and is an empirical representation of the data.

Mass absorption coefficients, μ_m, computed from the slopes of the curves (a), (c), and (d) are tabulated:

Curve	μ_m *in* cm^2/g	*Distance in cm*
(a)	1.5	20
(c)	2.5	10
(d)	1.5	10

This corresponds to half-value thicknesses of Al of 1.0 and 1.7 mm for the soft and hard components respectively. Apparently the X-rays at 20 cm from the port of the primary viewing screen are qualitatively like the hard component of the beam at 10 cm. Using standard tables for the mass absorption coefficient of Al, this set of values corresponds to a wavelength range of 0.45–0.50 A for the X-rays. This is approximately the wavelength range in which one may expect to find the peak energy for a continuous X-ray spectrum arising from 50-kv electrons (*1*).

A ½-in.-thick plug of lead glass was placed in each viewing port. The dosage at the ports was then reduced to less than 1 mr/hr. The high dosage had been due to the accidental use of ordinary glass instead of lead glass in the assembly of this instrument by the manufacturer.

It is suggested that electron microscopists survey the radiation from the viewing ports to determine whether or not the X-ray intensity exceeds the accepted tolerance dosage.

Reference

1. COMPTON, ARTHUR H. and ALLISON, SAMUEL K. *X-Rays in theory and experiment.* New York City: Van Nostrand, 1935.

Airborne Magnetometer for Measuring the Earth's Magnetic Vector

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An airborne instrument which continuously records geomagnetic information from which all magnetic components may be determined has been developed at the Naval Ordnance Laboratory. The instrument is a modified form of the airborne total field magnetometer developed by the Naval Ordnance Laboratory and Bell Telephone Laboratories during World War II for the location of submerged submarines by the detection of their anomalous fields. Since the war, this submarine detector, with slight changes, has been used for geophysical prospecting.

The basic feature of the new magnetometer is that it now determines the total magnetic field vector instead of only the intensity. This is done by measuring the intensity and the direction of the total magnetic field vector with respect to a set of coordinate axes stabilized with respect to the surface of the earth.

The sensitive measuring element of the magnetometer is a saturable inductor which is excited by a 1000-c current of sufficient amplitude to saturate its permalloy core. A 2000-c voltage is generated by the inductor, the amplitude of which is proportional to the strength of the magnetic field along its axis. The inductor is mounted in a gimbaled arrangement driven by servo motors to maintain its detection axis parallel to the earth's magnetic field. The gimbaled arrangement with its servo motors is called the detector head and is secured to the frame of the aircraft. Potentiometers and their associated electronic circuits measure the amount of angular displacement of the detection element about the two axes of the gimbals in which the detector is carried. By means of these angles the total magnetic field vector can be projected onto a system of coordinate axes fixed with respect to the aircraft.

In order to make use of these data, the orientation of the aircraft with respect to vertical and true north must be determined. A vertical reference is provided by a gyroscope controlled by gravity-actuated devices so as to maintain the spin axis of the rotor of the gyroscope vertical. Potentiometers on the roll and pitch axes of the gyroscope measure the inclination of the aircraft with respect to vertical. These angular measurements are used to refer the magnetic data to a coordinate system stabilized with respect to the surface of the earth.