Point Projector Electron Microscope

Electron images of high magnification and resolution can be obtained by making use of the quasi-rectilinear propagation of the field emission from a minute cathode close to the object being examined. The cathode here takes the form of an etched tungsten or molybdenum point similar to those used by Eyring, Makeown and Millikan[1] for cold emission measurements and by E. W. Muller[2] for the study of the variation of work function with crystalline orientation as well as of adsorption phenomena.

The "point projector microscope" thus constituted is essentially a transmission microscope. Consequently the specimens must be prepared so as to be transparent, wholly or partly, to electrons of the velocity corresponding to the applied voltage. Suitable methods of preparation for this purpose have been indicated by L. Marton[3] and H. Ruska.[4]

The magnification of the device depends on the ratio of the distance from the cathode to the viewing screen (or photographic plate) to the distance from the cathode to the object. The latter can readily be varied externally, permitting a wide range of magnifications.

As this type of microscope involves no electron-optical lens elements, the images obtained are free from the ordinary aberrations. The limit of resolution depends solely on the distribution of initial velocities of the field electrons and on Fresnel diffraction by the object, making it possible to proceed beyond the resolution of the light microscope by some orders of magnitude.

Figure 1, (a), (b) and (c), shows images of a 400-mesh

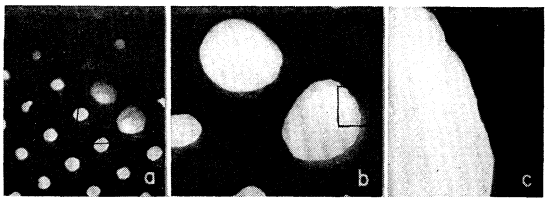

FIG. 1. Electronic projections of 400-mesh copper screen. The area of (c) is marked on (b) and that of (b) is marked on (a).

electroplated copper screen (0.0008 inch thick) magnified electron-optically 200, 600 and 3000 times, respectively, obtained with a sealed-off point projector microscope. While sharp images of the edge of a hole were observed on the luminescent screen with magnifications up to 8000 times, the mechanical steadiness of the image was here inadequate to permit photography with the increased exposures required at the relatively low lens aperture (f: 4.5) available.

A more detailed description of the device and its operation will be published elsewhere.

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Search for Weak Lines in the Molybdenum L Spectrum

Cecil J. Burbank[1] has recently reported the observation of nondiagram lines in the L group of 47 Ag resulting from electron bombardment sufficiently energetic to produce K ionization. The theory of such emission, treated by R. D. Richtmyer[2] is in harmony with Burbank's observations.

An unsuccessful search for similar lines in the spectrum of 42 Mo has just been conducted, with the Burbank apparatus with certain improvements. Since Burbank was greatly troubled by high order reflections of short wave radiation, tending to swamp the weak satellites, we thought it necessary to suppress such radiation and completely succeeded in doing so by interposing a total reflector of magnesium on glass between the silver target and the spectrometer crystal. It was possible to adjust the angle of incidence so that the wave-length region investigated was reflected to the gypsum crystal of the spectrograph almost completely while all radiations capable of higher order reflection were entirely cut off. This technique made possible the use of heavy targets instead of thin layers as used by Burbank.

All of the lines listed by Siegbahn[3] in the region investigated (from $L\gamma_1$ to $L\alpha_2$) were observed and in addition a line, thought to be new, having the wave-length 4979 x.u. was found between β_2 and β_3. Since this line does not disappear when the tube is operated at a potential below the K-excitation voltage it is not a satellite of the type studied by Burbank. The region between β_4 and α_1 was investigated very carefully since the analogy of silver indicated that the strongest satellites of the type sought should appear there. Although exposure conditions appeared at least as favorable as in Burbank's cases none of the expected lines was recorded.

The Auger transitions which result in the double ionization prerequisite to the emission of these satellites are more probable in elements of low atomic number and we had therefore expected the lines to be more intense in the molybdenum than in the silver spectrum. The results indicate that such is not the case.

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Disintegration of N^{14} and N^{15} Produced by Deuteron Bombardment

A mixture of 80 percent N^{14} and 20 percent N^{15} gas has been bombarded with 1.07-Mev deuterons from the Cornell cyclotron. The ranges of the protons and alpha-particles emitted at 90° were measured by means of a shallow ionization chamber and a pulse amplifier. The nitrogen gas at reduced pressure was contained in a target cell of about 1.5 cm² volume. This cell was separated from the cyclotron chamber by a thin aluminum foil. On the side of the cell another aluminum window allows particles emitted in a direction at 90° to the deuteron beam to enter

the range cell. The range cell was 6.86 cm long with a mica foil on the end away from the target cell. The pressure in the range cell could be varied, allowing a change of about 6 cm in the air equivalent of the range cell. The ionization chamber and foil holder were fastened next to the exit window of the range cell. The entire assembly of target cell, range cell, foil holder and ionization chamber were screwed firmly together so that no relative motion of the parts could take place.

The pressure in the range cell could be read to about 1 mm Hg. The set of mica foils used in this experiment were all from one sheet and the stopping power in mg/cm²/cm of air was measured for two thin foils. The air equivalents of the thicker foils were obtained using the value 1.42_5 mg/cm²/cm air for 5-Mev alpha-particles. The value 1.07 Mev for the energy of the deuterons was computed from the physical constants of the cyclotron. A high bias was used on the counting Thyratron of the amplifier and a correction made for the bias and depth of the ionization chamber using the specific ionization curves for alpha-particles[1] and protons.[2]

Two proton groups have been measured by Cockcroft and Lewis[3] from the $N^{14}(dp)N^{15}$ reaction. These proton groups were measured in the present work and, in addition, a group of protons of 66.1-cm range was observed. This 66-cm group was observed both with the $N^{14}-N^{15}$ mixture and with ordinary tank nitrogen in the target cell, but was not observed with CO^2 as the target gas or with the target cell evacuated. Thus there is reason to assign the 66-cm proton group to the $N^{14}(dp)N^{15}$ reaction.

With the same $N^{14}-N^{15}$ mixture in the target cell three groups of alphas were observed. Two of these have been found previously[3, 4] and are from the $N^{14}(d\alpha)C^{12}$ reaction. The other group (5.09-cm range) can be attributed to the $N^{15}(d\alpha)C^{13}$ reaction since it appeared with no target gas except the one containing N^{15}. Further, the Q value, 7.40 Mev, checks sufficiently well with the Q value 7.55 calculated from the mass values.[5] In addition to the three homogeneous groups the intense continuous distribution of alphas arising from the reaction $N^{14}+H^2\rightarrow 4He^4$ was found below 3.9-cm range.

Because of the relatively large number of alpha-particles in the region below 6 cm it was not possible with the present equipment to detect the short range ($\sim$3.5 cm) proton group expected from the $N^{15}(dp)N^{16}$ reaction. It is hoped that with a target of much higher N^{15} concentration it will be possible to detect protons in this region below 6 cm.

TABLE I. *Experimental results of deuteron bombardment of* N^{14} *and* N^{15}.

REACTION	RANGE CM 15°, 760 MM	Q VALUE MEV	EXCITATION LEVEL MEV
$N^{14}(d\alpha)C^{12}$	11.59	13.21	C^{12} gr. st.
	6.37	8.86	4.35
$N^{14}(dp)N^{15}$	90.76	8.41	N^{15} gr. st.
	66.10	6.88	1.53
	20.99	3.10	5.31
$N^{15}(d\alpha)C^{13}$	5.09	7.40	C^{13} gr. st.

The results of the present experiment are shown in Table I. The Q values obtained from range measurements are all lower by about 0.15 Mev than those obtained from mass values.[5] Repeated checks on the method used in measuring the ranges indicate that a systematic error is not likely in this part of the experiment. It is possible that there is an error in the energy value 1.07 Mev of the incident deuterons, although this figure was checked by direct measurement of the deuteron ranges.

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A Radioactive Isomer of Sr^{87}

In connection with studies soon to be reported of the radioactive isotopes of Sr and Y we have given particular attention to a period of 2.7 ± 0.2 hours which appears to be associated with an excited state of stable Sr^{87}.

Stewart, Lawson and Cork[1] reported a 3-hour Sr period produced by $Sr+d$ and $Sr+n$ (slow). They assigned it to an isomeric state of Sr^{89}, rejecting other possible assignments because the activity was electron rather than positron emitting. Cloud-chamber observations showed an apparently continuous spectrum with an upper limit of 610 kev. Our cloud-chamber measurements are similar to theirs, but the beta-ray spectrograph shows that the spectrum consists only of a strong line at $H\rho 2340$ (360 kev). (The broadening of the spectrum in the cloud chamber is undoubtedly due to the scattering which is important at these low energies.) These electrons are evidently K and L conversion electrons accompanying a 370-kev gamma-ray emitted in a K-electron capture or an isomeric transition. This removes the necessity of assignment to Sr^{89}.

We further find that this same period with the same electron spectrum is produced strongly by $Rb+p$ at 6 Mev. Only a $p-n$ reaction could account for the yield, which restricts the assignment to either Sr^{85} or Sr^{87*}. There is also a strong period of $\sim$60 days produced in this reaction. In view of the argument below this may be assigned to Sr^{85}.

Finally an 85 ± 5-hour yttrium activity (produced either by $Sr+p$ or $Sr+d$) shows the same electron line. When Sr is extracted from an aged sample of this activity the Sr fraction decays with the 2.7-hour period while the Y fraction grows with this period. The only Y isotopes which could be produced by both $Sr(p, n)$ and $Sr(d, n)$ are Y^{87} and Y^{88}. The latter has already been assigned[1] a 2-hour (e^+) period, since it is produced also by Y+fast neutrons. Stewart *et al.*[1] reported a 60-hour Y period from $Sr+d$ which they identified with the 60–70-hour Y^{90}, produced by $Y+n$ and $Y+d$, postulating a $Sr^{88}(d, \gamma)Y^{90}$ reaction.