It is known[4] that breaking a diaphragm which separates regions of different pressures in a tube produces a shock wave and an expansion wave traveling in opposite directions, and an interface moving between them in the direction of the shock wave. Across the interface, pressure and flow velocity remain constant while the temperature may change. In the region between the shock wave and the interface, the limiting value of Mach number applies while no such limit exists for the gas between the interface and the expansion wave. The gas between the shock wave and the interface is compressed by the former, and therefore, its temperature is raised. If the shock strength is increased to infinity, both the temperature and the flow velocity behind the shock become infinite in such a way, however, that the Mach number approaches the finite limit stated above. If subscripts c and e are used to refer to the compression and expansion chambers, respectively, and if the speed of sound before breaking the diaphragm is denoted by a the pressure ratio across the shock (defined so as to be greater than unity) which will just produce sonic flow in the region between the interface and the expansion wave may be computed as

$$y=1+\frac{\gamma_e(\gamma_e+1)+\gamma_e[(\gamma_e+1)^2+8(\gamma_c+1)a_e/a_c]^{\frac{1}{2}}}{2(\gamma_c+1)a_e/a_c}.$$

(Note that $y=1/\xi$ of reference 1 $=\lambda$ of references 2 and 3.)

For the special case of $a_e=a_c$ and $\gamma_e=\gamma_c=1.4$, this formula yields $y=3.16$. This compares with a pressure ratio of 4.76 to produce sonic flow between the shock wave and the interface computed from the relation given in reference 1. In other words, it is possible to obtain supersonic flow in a shock tube even though the shock is not strong enough to produce supersonic flow immediately behind itself. The Mach number in the region following the interface will always be higher than that in the region following the shock unless the temperature in the compression chamber was so high initially that even after expansion, the speed of sound in the expanded region was still higher than in the compression region between the shock and the interface.

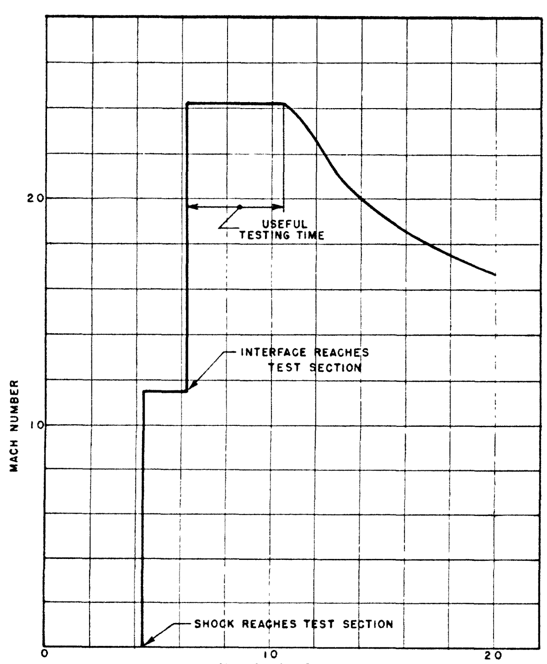

FIG. 1. Variation of Mach number with time at the test section of a shock tube.

To illustrate how the Mach number in a shock tube may reach the value 2.42 presented in reference 1, an example was worked out by means of the method of characteristics. The shock tube was assumed to be filled with air ($\gamma=1.4$) and the initial conditions for pressure, and speed of sound were $p_c/p_e=106$, and $a_c=a_e=350$ m/sec. The length of the compression chamber was taken as 0.70 m and the test section located at a distance of 0.35 m from the position of the diaphragm. The tube was assumed long enough to eliminate effects from wave reflection. Figure 1 shows the value of Mach number at the test section as function of time. As soon as the shock passes the test section the Mach number becomes 1.15. About 200 microseconds later the interface reaches the test section and the Mach number is increased to 2.42. This value is then maintained for about 400 microseconds after which the Mach number decreases gradually. It is seen that using the flow following the interface not only eliminates the Mach number limitation but also may lead to a useful testing time which is considerably longer than that corresponding to the flow ahead of the interface.

The fact that there may be two distinct supersonic Mach numbers occurring during one shock tube experiment is, perhaps, not generally realized and some of the observed transients during which steady supersonic flow is established may, in part at least, be due to the passage of the interface.

* These comments are based on related work on non-stationary gas flow which is being supported by ONR through Project SQUID.

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Shape of the Beta-Spectra of Sr^{90} and Y^{90} *

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THE beta-spectra of Sr^{90} and Y^{90} have been examined in this laboratory, using the magnetic lens spectrometer previously described,[1] and were found to exhibit a shape similar to that recently reported by Langer and Price[2] for the forbidden transition of Y^{91}.

The $Sr^{90}-Y^{90}$ spectra were first investigated here using a composite source,[3] in equilibrium, mounted on a thin Formvar-polystyrene film carried by a Lucite holder. The observational data were corrected at low energies for the transmission of the window of the Geiger-Müller counter; the correction factor for this window, which would pass electrons of energies of 12 kev, was estimated by determining the effect of additional foils in front of the counter and was significant only for electrons of kinetic energy below 230 kev. For making comparisons with the theoretical momentum distributions, carefully computed values of the Fermi function were used which were in very good agreement with the values obtained by the use of Bethe's[4] approximation.

A Kurie plot of the data obtained with the composite source is shown in Fig. 1, in which the points for the spectrum due to Sr^{90} alone were obtained by subtraction of the estimated contribution from the Y^{90} component. The non-linearity of the curves thus obtained indicates that the spectra of these two activities differ significantly in shape from that expected for allowed transitions and frequently found for forbidden spectra. To obtain more definitive data on the spectrum of Sr^{90} alone, a portion of the strontium activity was separated from the composite source and examined in the spectrometer. A Kurie plot of the data so obtained, after correction for residual Y^{90}, is shown in Fig. 2. The non-linear character of this graph resembles closely that illustrated by Fig. 1.

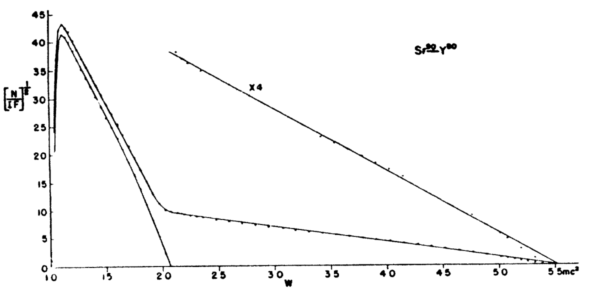

FIG. 1. Kurie plot, $(N/IF)^{\frac{1}{2}}$ *vs.* W, of beta-spectrum obtained with composite $Sr^{90}-Y^{90}$ source.

On the basis of the theory of shell-structure in nuclei, as developed by Feenberg and Hammack,[5] it would be reasonable to consider these transitions to involve a spin change of two units, together with a parity change. Introduction of the factor

$$a=(W^2-1)+(W_0-W)^2,$$

which is theoretically appropriate[6] for transitions of this type, leads to the modified Kurie plots shown in Fig. 3. The linearity

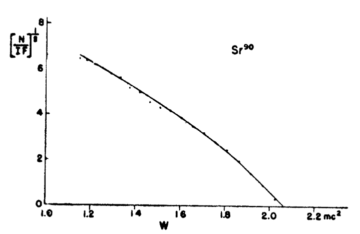

FIG. 2. Kurie plot of beta-spectrum obtained with separated Sr^{90} source.

thus obtained affords evidence that the transitions are of the type indicated, for which the special form found for the spectrum becomes in agreement with that predicted theoretically. These spectra are of perhaps particular interest in that the initial Sr^{90} nucleus and that of the final Zr^{90} product are each of the *even-even* type.

The upper limits found for the Sr^{90} and Y^{90} spectra are, from Fig. 3, 2.05 mc^2 (0.53_7-Mev kinetic energy) and 5.37 mc^2 (2.23-Mev kinetic energy), respectively. These values, determined in light of the special form found for the spectra, differ not inappreciably from those reported by Meyerhof,[7] whose data also, however, give some indication of the same type of departure from the conventional spectral shape as that reported here.

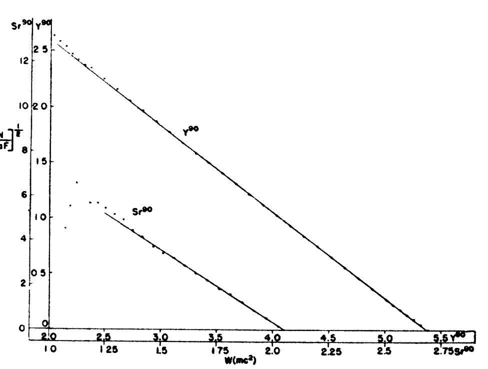

FIG. 3. Modified Kurie plots, $(N/IaF)^{\frac{1}{2}}$ *vs.* W, for the upper, or Y^{90} portion of the beta-spectrum obtained with the composite source and of the spectrum obtained with the separated Sr^{90} source.

We wish to indicate our appreciation of the assistance by Dr. A. F. Voigt and his associates in the Radiochemistry section of this Laboratory for their help in the separation of the Sr^{90} activity and our thanks to Dr. J. M. Keller, Dr. J. F. Carlson, and Mr. A. Paskin for helpful discussions concerning the theoretical aspects of the work. The assistance of Mr. R. T. Nichols in recording and computing the data and of Mr. E. R. Rathbun, Jr., in construction of the Geiger-Müller tubes is also gratefully acknowledged.

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[3] This source was kindly furnished in high specific activity by Dr. C. W. Sherwin, of the University of Illinois, who has been especially interested in the beta-spectrum of Y^{90} in connection with his neutrino-recoil experiments. The active material was grounded electrically, by means of a line of silver paint, to avoid charging effects during the observations.

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Determination of the Energy Distribution of Bremsstrahlung from 19.5 Mev Electrons*

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THE bremsstrahlung spectrum has been measured for 19.5 Mev electrons produced by a betatron and directed against a 0.005-in. thick platinum target. The relative intensity of the x-rays as a function of energy was determined from the energy distribution of the pair electrons produced in the gas of a cloud chamber, which was air. Since the pair production cross section is known for a low Z material (air) to better than 10 percent at energies between 1 and 20 Mev,[1] the x-ray intensity spectrum from platinum can be reliably inferred from the pair electron spectrum.

Two reports on determinations of betatron x-ray spectra have been published.[2] Neither work permits a conclusive test of the Bethe-Heitler bremsstrahlung theory applied to electrons of 19.5 Mev energy.

In the present experiment, the x-rays from the betatron target are collimated by means of a tapered hole in a 16-in. thick lead wall. The defining aperture for the rays was the $\frac{1}{8}$-in. diameter entrance opening of the collimator, which defined an x-ray beam whose total angle was 0.24°. The half-intensity total angle of the x-rays from the thin betatron target was approximately 6°.

Pair electrons produced in an air pressure of 1.4 atmospheres were curved by a magnetic field of 1540 gausses. 40,000 stereoscopic pictures were taken on 35 millimeter film. Of this total number, 10,300 pictures have been analyzed. Data were obtained on approximately 1300 pair electrons produced in the field of a nucleus and 33 pair electrons produced in the field of an electron.

The analysis of pair energies was divided into two parts: (1) The direct image of the film was carefully reprojected on a plane normal to the cloud-chamber magnetic field direction. The x and y coordinates of the pair origin, the radii of the pair particle arcs, and the corresponding chord lengths were measured. (2) The film was reprojected through the original