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Radiation Laboratory

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SUMMARY OF THE RESEARCH PROGRESS MEETING

of August 18, 1949

H. P. Kramer

October 14, 1949

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Energy Spectrum of Synchrotron X-rays. W. Powell.

When the 335 Mev electrons accelerated in the synchrotron strike a platinum target, bremsstrahlung x-rays are produced. These x-rays possess a continuous energy spectrum whose range extends from 0 to about 327 Mev. The cloud chamber group has undertaken the task of determining the distribution of x-ray quanta in the beam among energy intervals within the available range. The measurement of the energy of x-ray quanta is based on the analysis by means of cloud chamber tracks of the electron pairs which are formed as photons pass in the vicinity of lead nuclei contained in a .001 in. foil that is placed across the cloud chamber.

903 positron-electron pairs emanating from the lead have now been counted. The energy of each particle can be calculated on the basis of the known mass of the electron and the radius of curvature of the track. The energy of the photon that disintegrates into the two particles is then determined by adding the energies of the members of the pair. The graph of Fig. 1 indicates the manner in which the energy is distributed between the two particles. The curve is of course symmetrical and exhibits the fact that it is possible that one partical may acquire practically all of the available energy with the result that the other particle that is produced may not have sufficient energy to escape from the lead foil. However, the number of single positive tracks that have been observed has been negligibly small and the slightly larger number of single negative tracks is attributable to another cause.

The Compton photo-electric effect also may detract from the accuracy of the results of the measurements by contributing single negative electron tracks. However, the frequency of photoelectrons among all electron tracks is so small that no great error is incurred by counting single negative electron tracks as degenerate pairs.

When the point of departure of two tracks is not very clearly identifiable one may commit the error of ascribing tracks produced by a single negative and a single positive electron to one pair when actually each electron may represent a degenerate pair. An example of two tracks which may confuse the count is sketched in Fig. 2.

Another situation which causes difficulty is that typified by the diagram of Fig. 3. In a case of this sort one can not be sure which negative tracks is associated with a certain positive track and therefore there is some uncertainty in assigning the photon energy. However, only five cases in which the photograph gave ambiguous information have been observed and therefore the error occasioned by these uncertainties is not very serious.

Steinberger and Christian of the Theoretical Group have calculated the spectrum of the X-rays from the synchrotron. They assumed that electrons are accelerated to 335 Mev in the synchrotron and that therefore the bremsstrahlung spectrum extended from 0 to 335 Mev. However, the fastest photons that were observed in the cloud chamber possessed energies not in excess of 327 Mev. Moreover, if the calculations are made on the assumption that the synchrotron produces 327 Mev electrons and that the maximum photon energy is therefore also 327 Mev, the calculated curve coincides with notable precision with the experimental data. It is therefore thought quite possible that incorrect data were used in the calcul tion particularly in view of the fact that there is an uncertainty of ± 2.5 percent

in the measurement of the magnetic field of the synchrotron.

Since the cloud chamber magnet has not been calibrated for some time one ought to ascribe an uncertainty of ± 1 percent to the accepted value. The track measurements with a microscope entailed an error of less than 2.5 percent. Therefore, the results that are presented involve an uncertainty of about 3.5 percent.

Figs. 4 and 5 are some interesting photographs of cloud chamber tracks. They demonstrate some of the sources of error in the count.*

It may be of interest that a meson track from photo-excitation has now been detected for the first time with the cloud chamber. The experimental arrangement which made this possible is shown in Fig. 6. The cloud chamber is shielded on the beam side by a block of lead. Photons pass along one side of the chamber and strike a carbon target within the magnetic field. The meson track appeared in the position indicated in Fig. 6. With the same apparatus, two proton tracks were observed: one represented a 108 Mev proton and the other one a 68 Mev proton. In the future the carbon target will be replaced by beryllium, which, because of the higher density should give a larger number of interesting events.

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* The spiral track of Fig. 5 is particularly challenging because it presents the possibility of tracing the complete life history of an electron. Every change of curvature of the track is indicative of a loss in energy either through radiation or through collision.

A New Nd^{139} Isotope. Betsy Jones.

The discovery of the new isotope resulted from a study of the neutron deficient rare earth elements. The only stable praseodymium isotope, Pr^{141}, was bombarded with 40 and 50 Mev protons.

As a result of the bombardment with 40 Mev protons for periods varying from one to four hours, activities with the following half-lives were observed: 3.3 days, 5.5 hours, and 20 ± 5 minutes. After 30 minute bombardments with 50 Mev protons, the 5.5 hour and the 20 ± 5 minutes activities were again seen although the previously observed 3.3 day half-life was not encountered.

The 5.5 hour activity was examined in detail and was found to decay by the following modes:

Mode	Energy (Mev)	Relative Frequency
β^+	3.1	0.06
e^-	0.28	0.06
K		1.00
γ	1.1	0.15

The positron was detected and analyzed by absorption and a magnetic counter.

The chemical identification of the neodymium isotope was made by means of hydroxide fluoride cycles and a separation of Nd and Pr was carried out with a 4 cm. exchange column. The activity of the neodymium fraction was followed and it was observed that the ratio of counting rates of the 3.3 day and the 5.5 hour activities remained constant. Since the 3.3 day activity is known to be due to Nd^{140} it was concluded that the 5.5 hour activity must also be ascribed to Nd. Fig. 7 indicates the degree of separation that was achieved with the

exchange column.

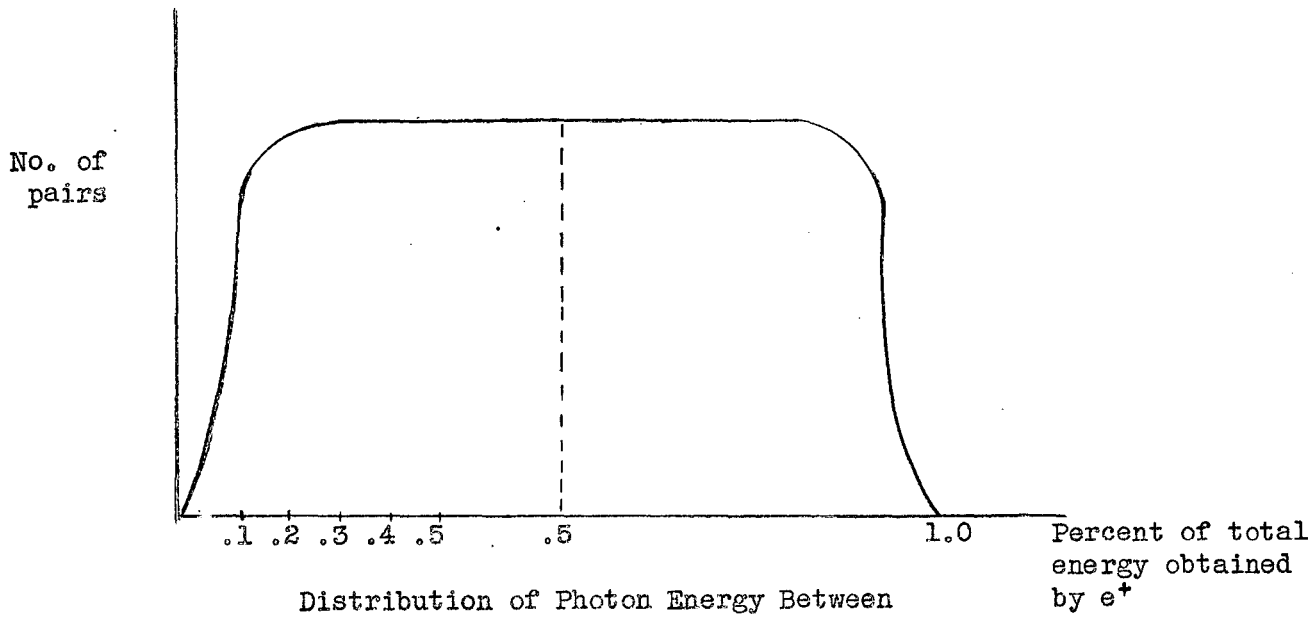
The mass assignment of the 5.5 hour Nd activity was made on the basis of the 140 d K-capture Ce^{139} isotope which was grown and separated from the Nd fraction.

The possibility was considered that the 20 ± 5 minutes activity might be assigned to Pr^{139}, the intermediate K-capture daughter of Nd^{139}. In order to test this hypothesis, Nd and Pr were partially separated and placed in a counter 6 min. after the chemistry had been completed. The 20 ± 5 minutes activity was not seen to grow and for this reason it was concluded that it is not associated with the Pr daughter of Nd^{139}. It was however established by chemistry that this activity is due to one of the rare earths.

For purpose of orientation, the affected portion of the table of isotopes is reproduced below:

	138	139	140	141	142	Mass Number A
$_{60}Nd$		5.5 hr. β^+, γ K	3.3 d K	2.5 hr. 3%β^+ 97%K		
$_{59}Pr$		short K	3.5 min. or 1 min. β^+			
$_{58}Co$		140 d K		28 d β^- 30.6 d γ		
$_{57}La$						

Atomic Number Z



Distribution of Photon Energy Between the Members of Pairs.

Fig. 1

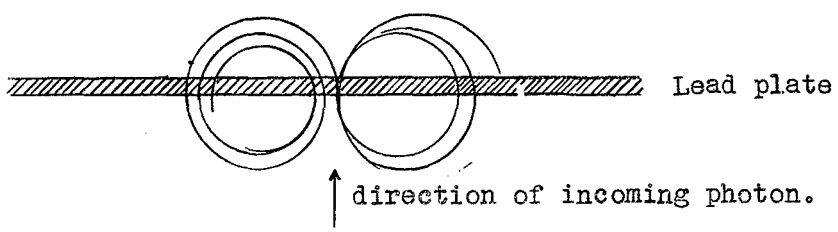


Fig. 2

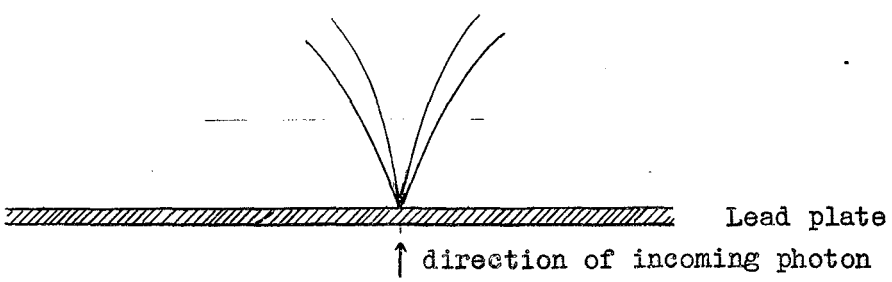


Fig. 3

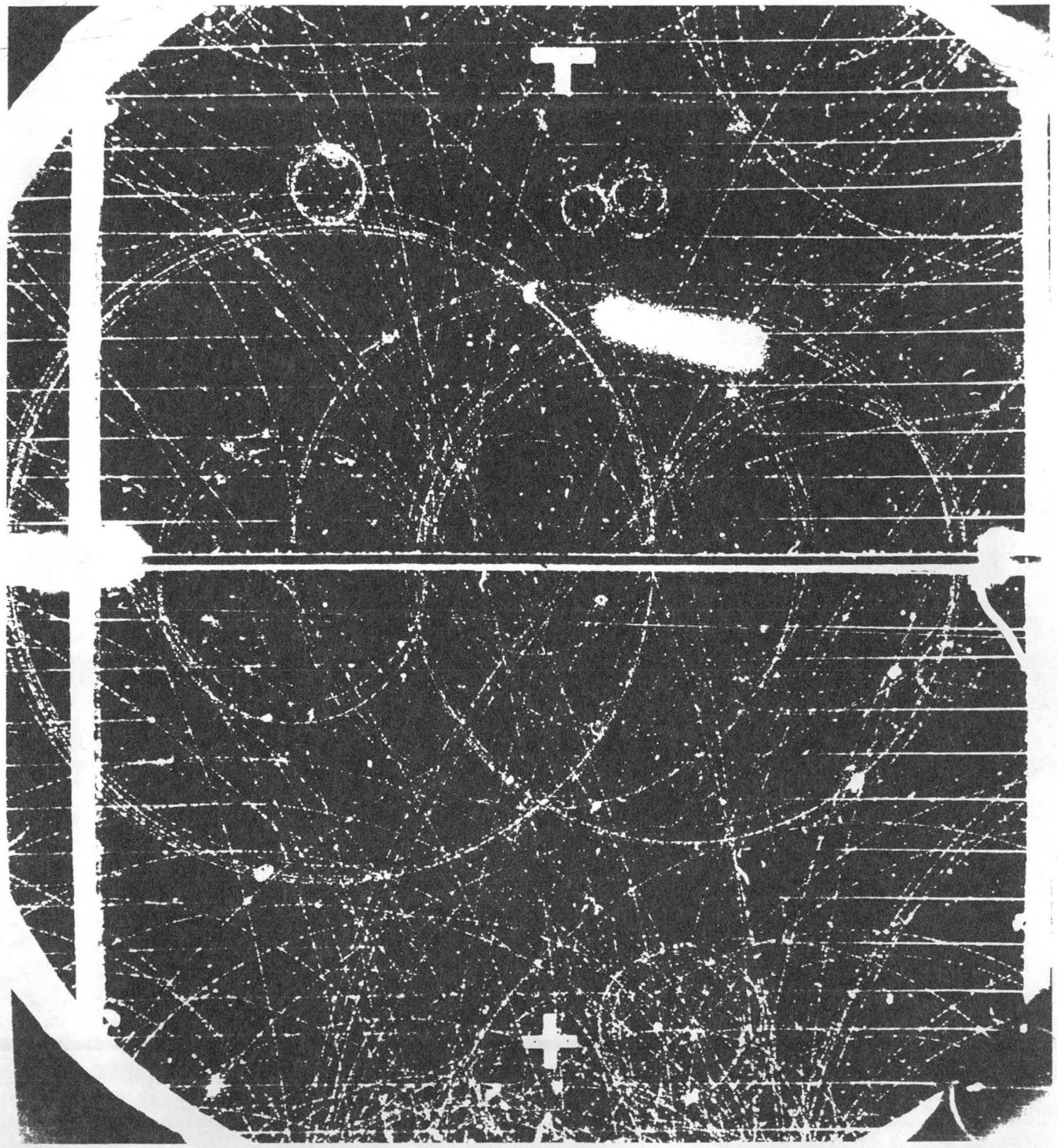


FIG. 4

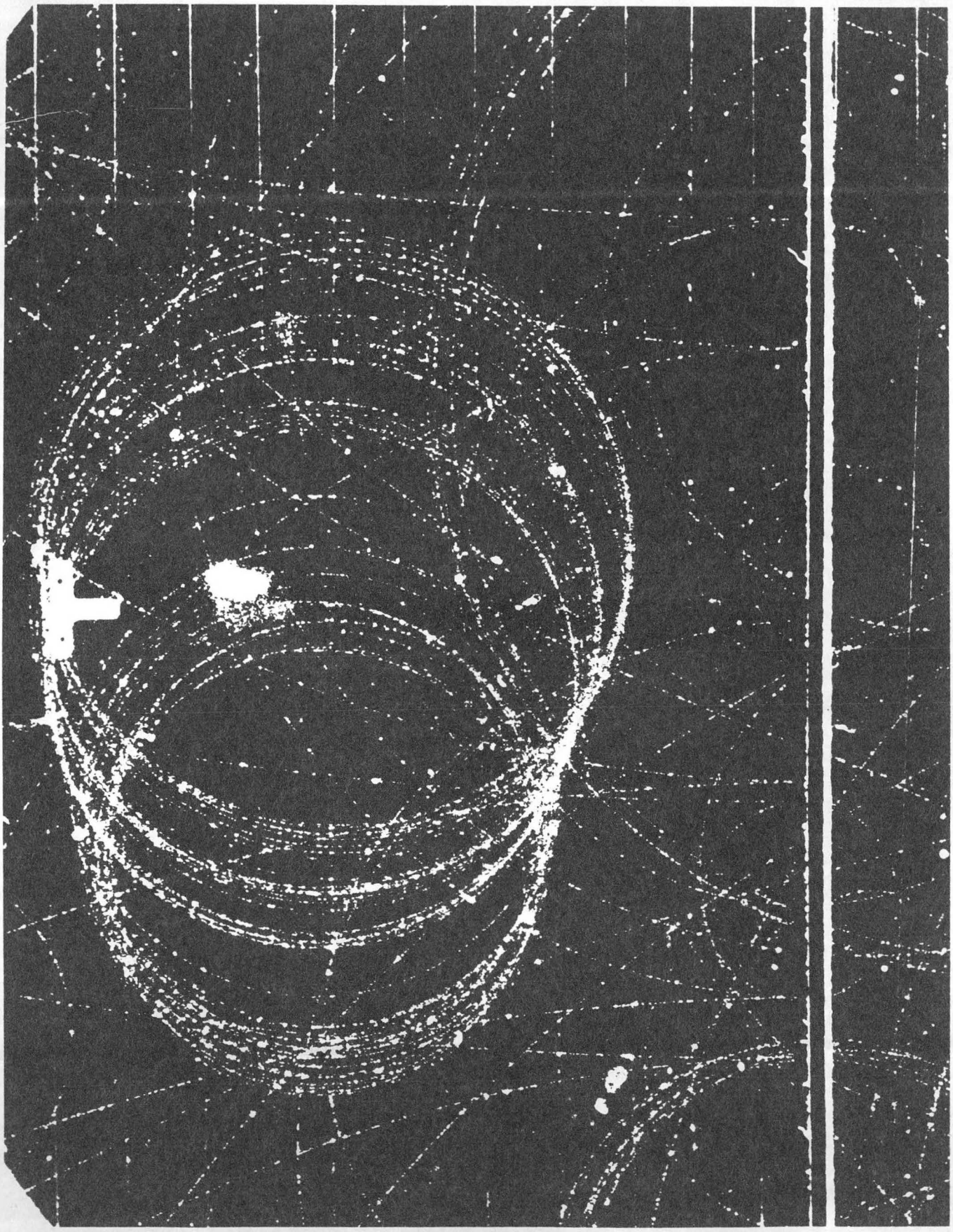
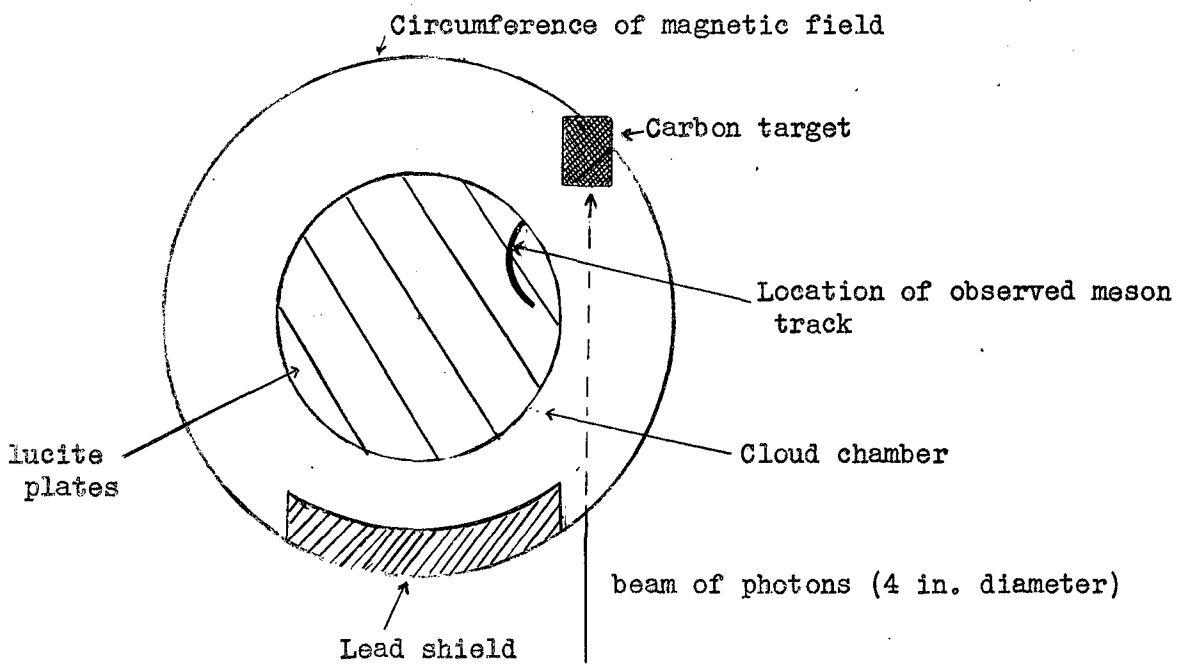
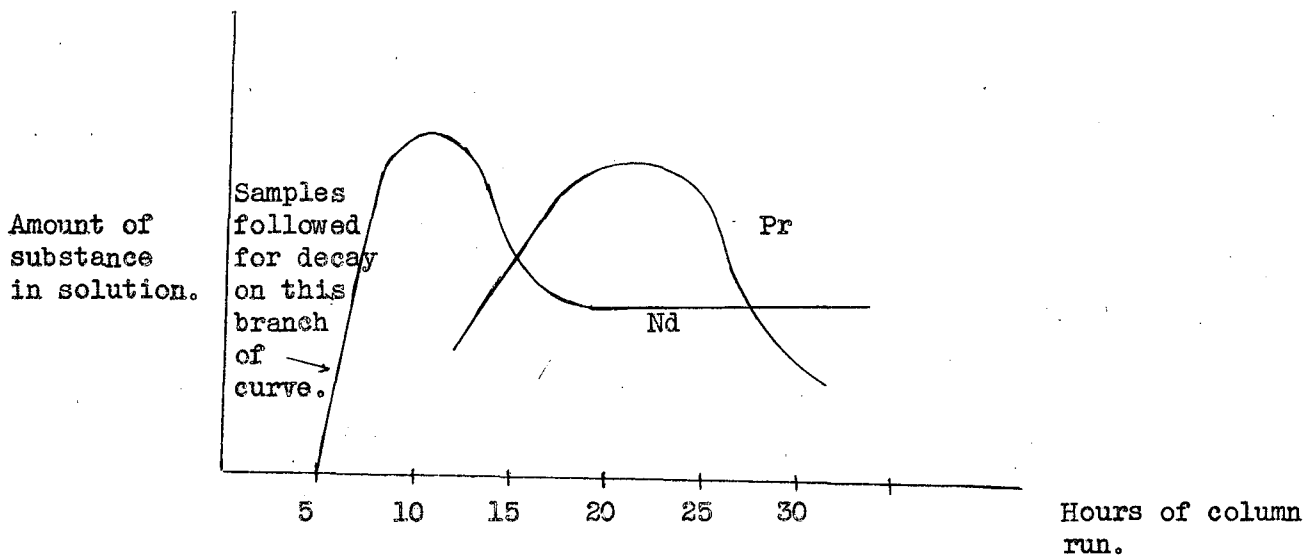


FIG. 5



Apparatus With Which Photon Meson Was Observed

Fig. 6



Column Separation of Nd and Pr

Fig. 7