may point out that instead of the conservation of Q and I_3 one may of course use the conservation of Q and U. Possible reactions (including electromagnetic) will therefore be obtained by requiring (a) the usual conservation of fermions, (b) the conservation of charge, (c) the use of the following rule: denote by "isofermions" the nucleons, the θ, and the anti-Ξ, and by "anti-isofermions" the antinucleons, the anti-θ (charge conjugated), and the Ξ; then *the number of isofermions minus the number of anti-isofermions must be conserved.*

[1] M. Gell-Mann and A. Pais. Proceedings of the Glasgow Conference on Nuclear and Meson Physics, 1954 (to be published), p. 342. See also A. Pais, Phys. Rev. **86**, 663 (1952); Physica **19**, 869 (1953); Progr. Theoret. Phys. (Japan) **10**, 457 (1953); Proc. Natl. Acad. Sci. U. S. **40**, 484, 835 (1954).

[2] M. Gell-Mann, Phys. Rev. **92**, 833 (1953).

[3] T. Nakano and K. Nishijima, Prog. Theoret. Phys. (Japan) **10**, 581 (1953).

[4] E. Cartan, *Leçons sur la théorie des spineurs* (Hermann & Cie, Paris, 1938), Vol. I, especially Chap. III.

[5] Other choices of fields also leading to a constant U are possible; they give the same physical results. (1) is obtained from the invariance of the total Lagrangian with respect to the transformation $\psi_A \rightarrow \psi_A e^{i\alpha}$, $\psi_B \rightarrow \psi_B e^{-i\alpha}$, $\varphi_\Delta \rightarrow \varphi_\Delta e^{i\alpha}$.

[6] Some considerations on the total Lagrangian show that this assumption is indeed the most natural one.

Bevatron *K*-Mesons*

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To facilitate the search for K-mesons from the Bevatron, two of us (L.T.K. and D.H.S.) have suggested the use of a strong-focusing spectrometer (Fig. 1),[1] consisting of a magnetic quadrupole focusing lens[2] followed by an analyzing magnet. Particles of any desired momentum can be brought to a focus, forming an image of the target at a point behind the analyzing magnet. Emulsion stacks are placed at this point. With this arrangement we have found examples of four types of heavy mesons first established in cosmic-ray work.[3] Particles of different mass can be separated according to their ranges in emulsion. For particles of momentum 360 Mev/c, the range of K's is 4.6 times the range of the protons, and pions pass through the emulsion stack at minimum ionization.

A stack of 107 Ilford G.5600-μ pellicles,[4] 3.5 in. by 3.5 in., has been exposed so that 114-Mev K-particles stopped in the center of the stack. The proper time of flight for such particles from the target to the emulsion is about 10^{-8} sec.

This stack has been scanned in a swath across the direction of the meson flux for tracks lying in the plane of the emulsion whose ionization is visibly greater than minimum. Particles stopping in the stack (beyond the position of the swath) have masses less than 1200 m_e. Particles that go all the way through the stack have masses less than 800 m_e.

The tracks are followed until they stop and the endings are examined for decays. To date 300 decays have been observed. Twenty of these are π^+ mesons whose unique decay into three charged pions is readily identifiable. Among the others, all of which decay into one lightly ionizing secondary, only those with a secondary that is flat or with an ionization obviously higher than minimum have been categorized. Three examples have been found of what is assumed to be the alternate decay of the π into one charged and two neutral pions, with the pion stopping in the emulsion stack. Two events decay into low-energy muons (less than 55 Mev) and are presumably examples of the κ or $K_{\mu 3}$.

To establish the existence of the $K_{\pi 2}(\theta^+,\chi^+)$ or of the $K_{\mu 2}$ mesons, either very large emulsions are needed to stop the long-range secondary or else very accurate measurements of the multiple scattering and the ionization must be made. Measurements on four fortuitously flat secondaries at a distance of 5 cm from the decay point revealed that three of the primaries were $K_{\pi 2}$'s and one presumably a $K_{\mu 2}$, as determined by the tentative identification of the secondary as a high-energy muon. Excellent calibration on grain count is available from the π mesons of known energy traversing the same region of the emulsions. From the number of K-mesons found here compared to the number found at about 25 cm from the target,[5] it is unlikely that the mean life of any of the K's seen is less than 3×10^{-9} sec.

In the initial exposure, the momentum resolution as determined from the proton ranges allows a mass determination to $\pm 40\ m_e$ on each K-meson. With a few exceptions, all particles with lightly ionizing secondaries fall within a distribution of this width centered about 20 m_e below the average for τ mesons plotted separately (Fig. 2). In a subsequent exposure the momentum resolution has been improved. The scattered points on the high-mass side of the main distribution may be due to particles that suffered inelastic collisions, or scattered off the channel. A

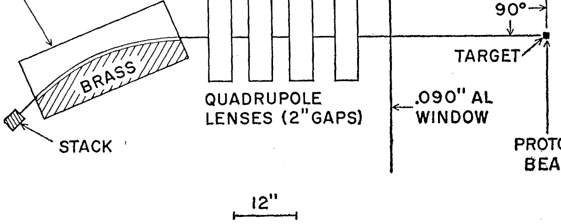

FIG. 1. Strong-focusing spectrometer.

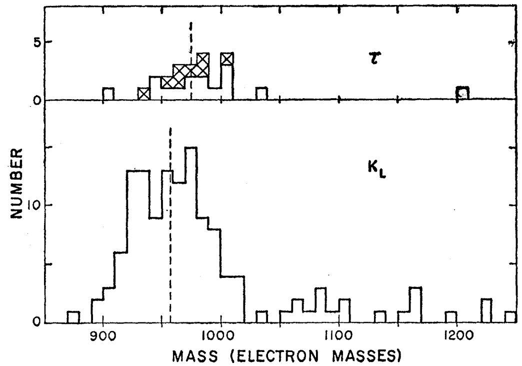

FIG. 2. Mass distributions: Upper histogram represents τ mesons. Crossed squares refer to τ's found nonsystematically. Lower histogram is made up of particles decaying into a single lightly ionizing secondary.

comparison of the measured τ meson mass of (974 ± 6) m_e with the accepted value[3] of 966 m_e indicates a possible systematic error.

This work was done with the encouragement and guidance of Professor Chaim Richman. Most of the scanning was performed by Mrs. Beverly Baldridge, Miss Irene d'Arche, Mrs. Marilynn Harbert, Mrs. Edith Goodwin, and Miss Kathryn Palmer.

It is with pleasure that we acknowledge the help and advice in nuclear emulsion techniques given us by Professor Powell's group at Bristol. The assistance of the Bevatron crew, under the direction of Dr. Edward J. Lofgren, and their skillful operation of the machine are greatly appreciated.

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† National Science Foundation Predoctoral Fellow.

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14-Mev (n,α) Cross Sections in Zirconium. I*

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IN a survey of neutron-induced reactions, Paul and Clarke[1] quote a value of 194 ± 107 mb as a lower limit for the 14.5-Mev (n,α) cross section in Zr^{90}, and 63 ± 25 mb for this process in Rh^{103}. Brolley and Dickinson[2] conducted a direct search for the alpha particles from these elements using neutrons of about 14.3 Mev in an attempt to observe any variation in barrier height with angle. In this work the valuable help of the nuclear plate and Cockcroft-Walton groups is gratefully recognized. Their study indicated considerably smaller cross sections than reported by Paul and Clarke. The problem has been re-examined using several different methods by A. Armstrong and J. E. Brolley, Jr., F. L. Ribe and R. W. Davis, and the present authors. In the following Letters the results and the compatibility of the several experiments are discussed by A. Armstrong and J. E. Brolley, Jr., and F. L. Ribe and R. W. Davis.

We have bombarded various samples of normal zirconium metal with neutrons of average energy 14.1 and 14.9 Mev produced by the Cockcroft-Walton machine. Strontium was chemically separated from the zirconium and counted with a Na(Tl)I crystal whose sensitivity was known for the γ radiations from Sr^{87m} and Sr^{91}. Table I presents the results.

The standard deviations indicated are essentially those of counting. The Zr^{90} cross sections apply to the production of the isomer only. The diminution of these cross sections with increasing neutron energy may possibly be associated with competition from the $(n,2n)$ process. These cross-section values fall markedly below the trend of $\sigma_{\text{obs}}/\sigma_{\text{calc}}$ cited by Paul and Clarke. Though all nuclei in these processes have magic numbers or near magic numbers of neutrons (50), the (n,α) cross sections of neighboring nuclei are not sufficiently well established to discern a correlation with neutron number. We are indebted to R. W. Davis for invaluable help in the irradiations.

TABLE I. (n,a) cross section in mb. Neutron energy, E_n, in Mev.

E_n	14.1	14.9
Zr^{90}	3.1 ± 0.2	3.0 ± 0.2
Zr^{94}	4.9 ± 0.6	3.9 ± 0.5

* Research performed under the auspices of the U. S. Atomic Energy Commission.

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14-Mev (n,α) and (n,p) Cross Sections in Zirconium. II*

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FURTHER confirmation of a low value for the (n,α) cross section for zirconium bombarded by 14.1-Mev neutrons has been obtained in still another experiment, in which nuclear plates were used as detectors of the reaction products.