tracks in the 6000 pictures was 1.8×10^6. Comparison of this number with the 69 higher energy tracks gives a branching ratio of one to an upper limit of 26,000. It was only possible to give an upper limit to this phenomenon; the total number of positron tracks belonging to the higher energy spectrum would be higher than the number counted for two reasons. First, tracks emerging at certain angles are obscured by the dense cloud of low energy tracks. Secondly, only those of sufficiently high energy to reach the glass baffle were included. Those tracks of energy less than 0.95 Mev could not be identified positively as tracks due to positrons.

Figure 2 exhibits a typical case of a high energy positron originating at the source and stopping in the glass baffle.

* Assisted by the Joint Program of the ONR and AEC.
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Positive Particles Associated with Beta-Ray Emitters

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In a nine-inch cloud chamber using air at atmospheric pressure, a search has been made for the positive particles reported to accompany the decay of certain beta-ray sources.[1,2] Stereoscopic photographs of sources S^{35}, UX, Ra$(D+E)$ and P^{32} were taken, the chamber being illuminated by a beam of light approximately one inch in height. A lead foil, 34 mg/cm² was stretched across the chamber ten cm from the source. Collimated and uncollimated sources were used.

An initial count with an uncollimated UX source giving approximately 50 tracks per picture produced 0.1 positive tracks per electron. Count of apparent pairs produced by electrons in the lead foil gave a cross section of the order of 10^{-22} cm². Both figures disagree with theory.[3,4]

The confusion resulting from large number of tracks and reflections from every surface in the chamber made these results untrustworthy. Accordingly, a source of reduced strength was collimated so that emergent particles were limited to the illuminated part of the chamber. With these modifications many of the "positive" tracks were seen to be reflections back to the source. Only positive tracks which showed no indication of being reflections were counted.

In Table I appear the counts made on this basis with collimated sources of UX, Ra$(D+E)$, and P^{32}, with the recent results of other workers where available.

It is possible that even these so-called positive particles were reflections back to the source, of electrons for which part of the track was outside the illumination. A count was therefore taken of the number of definite reflections from all surfaces. Considering the relative source and chamber diameters, the ratio of the number of tracks which could be reflected back to the source, to the number of electron tracks, has the following values for UX, Ra$(D+E)$, and P^{32}, respectively: 0.01, 0.003, and 0.003. These figures are greater than the corresponding values of N^+/N^- in Table I.

Table I. Maximum possible positive particle count with UX, Ra$(D+E)$, and P^{32}.

	Approximate number of tracks per picture	Total number of electrons (N^-)	Total number of positive particles (N^+)	N^+/N^-	N^+/N^- observed by others recently
UX	31	5340	8	0.0013	——
Ra$(D+E)$	17	3490	6	0.0017	0.001[a]
P^{32}	13	6100	6	0.0010	0.0011[b]

[a] C. B. A. McCusker, Nature **161**, 564 (1948).
[b] T. H. Pi and C. V. Chao, Phys. Rev. **72**, 638 (1947).

The majority of the positive tracks included in the counts were of the order of 0.1 Mev, judging by their curvature. Bethe's scattering formula[5] shows that for electron energies less than about 0.1 Mev, the scattering radius of curvature is of the same order as that due to the magnetic field (250 gauss) used in this work. In confirmation of this, photographs of S^{35} (maximum energy 0.12 Mev) showed tracks which were completely disordered. It was quite impossible to determine the direction of the magnetic field from the photographs.

From these results, one may conclude that the positive particles which have been reported are one of the (a) electrons which have been reflected back to the source, (b) electrons whose tracks are nearly closed circles, part of the track being out of the illumination or obscured by other tracks, or (c) electrons of low energy with "positive" curvature due to scattering.

It is worth noting that the theoretical work of Arley and Møller[4] gives N^+/N^- a value of zero for internal pair conversion by electrons from sources whose end-point energy is less than 4 Mev.

Numerous apparent pairs produced in the lead foil by incident electrons were found. Upon examination however, these were seen to be one of the (a) electrons which penetrated the foil and curved back to strike the foil again in the same vertical line as another electron which had penetrated the foil, or (b) electrons which penetrated the foil and curved back to the foil, being reflected at a point in the same vertical line as another electron whose track could be distinguished only up to the foil.

From the results of these experiments it seems unnecessary to propose either the existence of positive particles of lighter mass than the electron[1] or positive particles of greater mass than the electron.[6]

Groetzinger *et al.*[6] have reported four cases of positive particles branching from tracks of electrons with a P^{32} source. In two cases, a change of curvature of the electron track appeared at the branch point, but in no case was there a change in direction. The experiments here reported included a careful search for such events. None were found.

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A Precise Determination of the Proton Magnetic Moment in Bohr Magnetons*

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We have completed an experimental determination of the ratio of the precession frequency of the proton, $\omega_p=\gamma_pH_0$, to the cyclotron frequency $\omega_e=eH_0/mc$ of a free electron in the same magnetic field. The result, ω_p/ω_e, is the magnitude of the proton magnetic moment μ_p, in Bohr magnetons, since $\gamma_p=2\mu_p/\hbar$.

The proton resonance absorption in mineral oil was observed by the bridge technique[1] at a frequency of 14.24 Mc/sec. The electron resonance, at approximately 9360 Mc/sec., was obtained as follows. An evacuated rectangular wave guide, its broad dimension parallel to H_0, is traversed by a beam of slow electrons which originate outside the wave guide, enter the guide through a 2.0×0.1-mm slit in the narrow wall, and drift across the guide in the direction of the magnetic field. The field prevents the ribbon-shaped beam from spreading, so the electrons can pass through a similar slit in the opposite wall of the guide, to be collected. If now the guide is excited by a source of frequency ω_e, the oscillating electric field expands the helical trajectories of the electrons. We had intended originally to recognize this condition by the decrease in collector current resulting from the failure of the expanded beam to get through the second slit. The effect was indeed observed and it behaved as predicted by an analysis of the electron trajectories. It was found, however, that when the beam current was limited by a space-charge potential minimum within the wave guide and when a very weak microwave field was applied, a peak in the collected current appeared at resonance, owing to the expansion of the electron cloud at the minimum with a consequent reduction in the depth of the minimum. Because the depth of the minimum is very sensitive to the presence of those electrons that nearly stop there and are exposed for an unusually long time to the oscillating field, this resonance effect is very sharp. It was used for the determination of ω_e/ω_p. The full width of the current peak, at half-maximum, was about 1 in 10^4.

The electron beam and the proton sample were about 1.5 cm apart; their positions could be interchanged to eliminate the effect of field inhomogeneity. The two resonances were displayed simultaneously on an oscilloscope while the magnetic field was modulated at 60 c.p.s. After adjustment for symmetry and coincidence, the ratio of the frequencies was determined by comparing the 657th harmonic of the proton frequency with the electron frequency ω_e. As the difference was only a few megacycles, the error introduced in this step was negligible.

Nine complete experiments were carried out, over a period of a month. The mean value of the ratio ω_e/ω_p, uncorrected for diamagnetism, was 657.4752 with a mean deviation of 0.0037 and a maximum deviation of 0.0056. The accuracy of the result depends, however, on the extent to which systematic errors can be excluded. We have carefully investigated possible sources of systematic error (magnetic field of filament, magnetic contamination of parts, effect of space charge on ω_e, etc.) and we believe that the true ratio, uncorrected for diamagnetism, lies within the range:

$$\omega_e/\omega_p = 657.475 \pm 0.008.$$

The diamagnetic correction to the field at the proton is 1.8×10^{-5} in the case of atomic hydrogen.[2] If we apply the same correction here, the proton moment, on Bohr magnetons, becomes:

$$\mu_p = (1.52100 \pm 0.00002)\times10^{-3}(eh/2mc).$$

This is to be compared with the result $(1.52106\pm0.00007)\times10^{-3}$ obtained by Taub and Kusch.[3] The agreement may be regarded as further confirmation of the correction[4,5] to the spin-moment of the electron, for our experiment amounts to a comparison of the orbital g-factor (n very large!) of the electron with the proton g-factor, whereas Taub and Kusch compared the proton g-factor and the g-factor of a $^2S_{\frac{1}{2}}$ state, applying the factor $2(1+\alpha/2\pi)$ to obtain the number just quoted.

Our result, like that of Taub and Kusch,[3] can be combined with the absolute γ_p measured by Thomas, Driscoll, and Hipple,[6] to yield e/mc, and with cR_∞ and the hydrogen h.f.s. splitting[7] to yield α. The accuracy of e/mc is still limited by the uncertainty in γ_p. The value of α is improved to the point where the present uncertainties in c and in the theoretical formula become important.

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Gamma-Radiation from Br^{82}

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THE γ-radiation from Br^{82} has been re-examined in this laboratory using higher resolution than in the previously published investigation.[1] The radiation was studied in a double-focusing spectrometer ($\rho=50$ cm) with the resolution of the instrument set to ~one percent. The radiation was earlier thought to consist of three γ-rays of equal intensity emitted in cascade after a simple β-spectrum. The result of the present investigation show that the disintegration is more complicated. The spectrum is complex and there are seven γ-rays of different intensities. We have found the photoelectron lines from a lead converter corresponding to these γ-rays and also the internal conversion lines in the β-spectrum. The internal conversion spectrum (all K lines) is shown in Fig. 1.

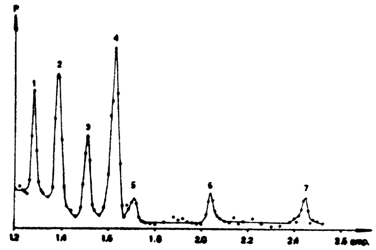

FIG. 1. Internal conversion spectrum of Br^{82}.

The energies of the γ-lines as obtained from the photo and internal conversion line spectrum are given in Table I together with the relative intensities of the corresponding internal conversion lines.

TABLE I. Energies of the γ-lines as obtained from the photo and internal conversion line spectrum of Br^{82}.

No. of γ-ray	1	2	3	4	5	6	7
Hr. from secondary electron spectrum (Mev)	0.553	0.613	0.685	0.772	0.826	1.045	1.317
Hr. from internal conversion spectrum (Mev)	0.547	0.608	0.692	0.766	0.823	1.031	1.312
Relative intensities of the conversion lines	0.68	0.78	0.42	*1.00*	0.13	0.18	0.14

A complete description of the experiments is planned together with a discussion of the disintegration scheme.

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The Transformation between One- and Three-Dimensional Power Spectra for an Isotropic Scalar Fluctuation Field

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WE should like to call attention to a mathematically simple result that may have some significance in the (still unformulated) theory of the relative behaviors of vector and scalar quantities in the incompressible turbulent flow of a continuum.

W. Heisenberg[1] has shown that in isotropic turbulence the one-dimensional velocity power spectrum can be expressed in terms of the three-dimensional power spectrum as follows:

$$F_1(k_1) = \tfrac{1}{4}\int_{k_1}^{\infty} [F(k)/k][1-(k_1^2/k^2)]dk, \tag{1}$$

where k is the magnitude of the radius vector in the wave number space and k_1 is a coordinate. The $[1-(k_1^2/k^2)]$ factor arises from the fact that the velocity spectral vector is always perpendicular to the wave number vector (due to continuity), whereas $F_1(k_1)$ is proportional to the energy in a differential slab perpendicular to the k_1 axis.