TABLE I. Temperature dependence of line widths.

Temperature Kelvin	$\bar{\mu}/\mu$	$P/\Delta\nu$ arbitrary	$(T\Delta\nu\mu)/(\bar{\mu}P)$	$(T^{\frac{1}{2}}\Delta\nu\mu)/\bar{\mu}P$
300	0.54	1±0.02	556±10	32.1±0.6
195	0.516	0.66±0.02	574±15	41.0±1.0

are summarized in Table I. In interpreting the data, it is assumed that the line width is also proportional to the average component of dipole moment $\bar{\mu}$ of the colliding molecules along the angular momentum axis.[2,3] As $\bar{\mu}$ varies slightly with temperature, its ratio to the static dipole moment μ is also tabulated.

The experiment clearly shows that $\Delta\nu$ is inversely proportional to the temperature and hence σ is inversely proportional to the impact velocity, confirming Anderson's theory. These results however should not be extrapolated indiscriminately to all types of microwave collision broadening. They may be expected to hold rigorously only for an inverse cube dependence of interaction energy on molecular separation—exemplified by the above symmetric top dipole-dipole interactions. Experimental and theoretical papers on these and other interactions are now in preparation.

* The research reported in this document has been made possible through support and sponsorship extended by the Geophysical Research Directorate of the Air Force Cambridge Research Laboratories under Contract No. W19-122-ac-35. It is published for technical information only and does not represent recommendations or conclusions of the sponsoring agency.

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Recoil Electron Spectrum of the K^{40} Gamma-Ray

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January 26, 1950

THE observation that the ratio of positron emission to electron capture in the decay of K^{40} is $\lambda^{\beta+}/\lambda^{c}<0.005$, leads to the conclusion that the $A^{40}-K^{40}$ mass difference must be less than 1.6 Mev, if expressions for either third or fourth forbidden beta-transitions and axial vector or tensor interactions are used.[1] As considerations of the K^{40} β^- energy end point[2] seem to indicate that the gamma-ray from K^{40} be placed on the A^{40} side of the decay scheme, it is remarkable that the energy which has been observed[3] for the gamma-ray of 1.55±0.05 Mev should be so close to the maximum possible $A^{40}-K^{40}$ mass difference. It was therefore thought of interest to measure the energy of the gamma-ray more accurately, using the new scintillation spectrometer which we have developed.[4]

The crystal element of activated NaI, $1''\times1''\times1''$, was surrounded by approximately 90 g of KF, and the recoil electron spectrum which was obtained after filtering of the radiation by 4 mm of Al is shown in Fig. 1. The shape of the spectrum was later confirmed using another source of KCl. The pulse height distribution for the background is given and also the recoil electron spectrum of an uncollimated beam of Co^{60} gamma-rays for purposes of comparison and calibration. The Co^{60} scale is greatly reduced and ordinates refer only to the K^{40} and background spectra. In these experiments the spectrometer was enclosed in a three-inch wall lead castle. The photo-cell noise becomes apparent only below 20 kev on the pulse scale and the rise in the recoil electron spectra at low energies is attributed to degenerate radiation entering the crystal, as well as to the loss of recoil electrons from the surfaces and possible low energy gamma-rays in the case of $K^{40}\rightarrow Ca^{40}$. Any differences in the form of the two spectra are due, in addition, to the nature of the extended source in the case of K^{40}, and to the existence of two Co^{60} gamma-rays. It would not be possible from these results to draw any conclusions

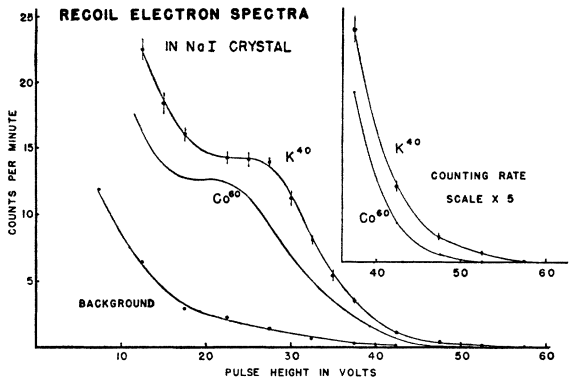

FIG. 1. Differential pulse height distributions obtained with scintillation spectrometer. The curves for K^{40} and Co^{60} have been corrected for background.

regarding a possible complexity of the K^{40} gamma-radiation. Careful consideration has been given to the manner of approach to the axis of the two spectra near the end point (Fig. 1) and, due account being taken of resolving power, the form of the Compton distribution, etc., a value has been estimated for the gamma-ray energy for K^{40} of 1.47±0.03 Mev in terms of the 1.33 Mev Co^{60} gamma-ray. This means that the energy available for electron capture to the excited state of A^{40} is less than 0.13±0.03 Mev. Coincidence experiments are being carried out to elucidate further the decay scheme.

The scintillation spectrometer has been used to measure the possible gamma-activity of certain members of the isobaric pairs of nuclei of neighboring Z. In some cases (notably cerium) activity has been observed but measurements with the spectrometer have indicated these activities to be due in the main to minute traces of thorium. Attempts are being made to have the purest possible materials prepared for this work.

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The Cation Distribution in Ferrites with Spinel Structure

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January 23, 1950

FROM studies of the cation distribution in spinels it was concluded by Verwey and co-workers[1] that, for the ferrites with this structure, zinc ferrite and cadmium ferrite are normal spinels while nickel-, copper-, magnesium-, ferrous- and manganese-ferrite are inverse spinels.[2] In the normal spinel the divalent ions (zinc or cadmium) occupy the tetrahedral position while the trivalent iron occupies the octahedral position. In the inverse spinel the tetrahedral position is occupied by one-half of the trivalent iron ions while the octahedral positions are occupied by a random distribution of the remainder of the iron ions together with the divalent cations (e.g., Cu^{+2}). In addition, it was indicated that a solid solution of a normal-spinel ferrite with an inverse-spinel ferrite (for instance, zinc ferrite in solid solution with copper ferrite) had a structure in which, in the example taken, the tetrahedral positions were occupied preferentially by Zn^{+2}, the remainder of these positions being filled by Fe^{+3}; the octahedral positions were occupied by the remaining Fe^{+3} and the Cu^{+2}.

Néel,[3] however, from a consideration of the magnetic properties of the ferrites concludes that the cation distribution is not as "ordered" as in the description given. The distribution according to Néel may vary so that, for instance, the distribution in copper ferrite is not simply $Fe\,[FeCu]O_4$ but may be $Fe_{0.82}Cu_{0.18}$

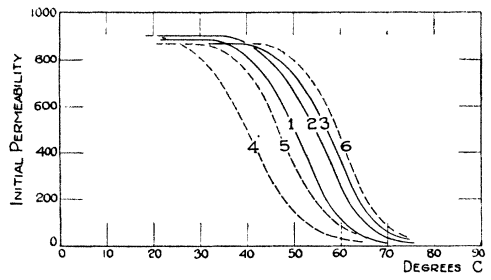

FIG. 1. Effect of quenching of copper-zinc ferrite on permeability *vs.* temperature curves. Curve 1. Quenched in air from 550°C. Curve 2. Quenched in air from 600°C. Curve 3. Quenched in air from 650°C. Curve 4. Slow-cooled from 650°C to room temperature. Curve 5. Quenched in air from 500°C. Curve 6. Quenched in air from 750°C.

$[Fe_{1.18}Cu_{0.82}]O_4$ for slowly cooled copper ferrite and even approximate the most random distribution, $Fe_{2/3}Cu_{1/3}[Fe_{4/3}Cu_{2/3}]O_4$, when quenched, i.e., when neither Fe^{+3} nor Cu^{+2} is located preferentially in tetrahedral or octahedral positions.

This encourages us to report some experiments which were performed prior to Néel's publication and which led to similar conclusions as regards both single ferrites and mixed ferrites.

The experiments were conducted in order to establish whether or not any kind of ordering occurred in ferrites. In mixed ferrites, in particular, it is conceivable that several different kinds of ordering could occur. Accordingly, test pieces of a copper-zinc-ferrite (40 mole percent copper ferrite and 60 mole percent zinc ferrite) were prepared and these were soaked for periods of eight or more hours at elevated temperatures and then quenched quickly in air to room temperature. The initial permeability of the sample so treated was measured as a function of temperature from room temperature to above the ferromagnetic Curie point. The results for different quenching temperatures are shown in Fig. 1. The numbers for each curve indicate the order in which the experiment was performed; that is, the sample was quenched from 650°C as the third treatment to which it was subjected and then for the fourth treatment it was heated to 650°C and slowly cooled to room temperature. After this it was subjected to the fifth and then the sixth treatment. It will be noted that the phenomenon is a reversible one.

It has been demonstrated by Snoek[4] that the Curie temperature of a mixed crystal of a ferromagnetic ferrite with zinc ferrite decreases with increasing zinc ferrite concentration. This fact, together with the results given, suggested that quenching from high temperatures brought about a condition which was equivalent to a reduction of the zinc cation concentration. Since, as described, the zinc ion was assumed to be in the tetrahedral position, it appeared reasonable that the phenomenon was to be attributed to a migration of zinc ions to the octahedral position with replacement of these ions by ferric ions. This is consistent with the fact that the higher the quenching temperature the higher the Curie point became, because it is to be expected that the most random arrangement will occur at the highest temperature.

That no separation of phases occurred in this heat treating was demonstrated by x-ray diffraction, and observation on the weight of the test piece after each heating showed that no loss of material was associated with the treatment.

In discussing these results and this interpretation with Professor G. E. Uhlenbeck and Dr. O. S. Duffendack they pointed out that, if the interpretation is correct, then it should be possible to render zinc ferrite and cadmium ferrite ferromagnetic by suitable heat treatment. Such experiments were carried out and it was found that if zinc ferrite is quenched from 1400°C it becomes slightly ferromagnetic as indicated by its attraction to a permanent magnet. Cadmium ferrite appears to be somewhat more magnetic under the same treatment.

More extensive work along this line has been carried out in the Eindhoven, Holland, laboratories of the Philips Company. A communication by E. W. Gorter of that laboratory will appear in the near future and will describe in more detail the phenomena and their interpretation.

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Note on the Coefficient of Eddy Viscosity in Isotropic Turbulence

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February 2, 1950

IT has been suggested by Heisenberg[1] that the inertial transfer of energy by eddies with wave number less than a particular k can be pictured in terms of an eddy viscosity, ν_k, due to the eddies with wave numbers greater than k; he writes

$$\nu_k=\kappa\int_k^\infty [F(k)]^{\frac{1}{2}}k^{-\frac{1}{2}}dk \tag{1}$$

where $F(k)$ denotes the spectrum of turbulence and κ is a numerical constant. From a comparison with the experimental results on decay of turbulence, Heisenberg obtained for κ the value 0.85. This determination depends chiefly on the region of the spectrum where the ordinary kinematic viscosity ν plays no role.

An alternative determination of κ that depends sensitively on the behavior of $F(k)$ in the region of large k can be made by using the experimental results on vorticity by Batchelor and Townsend.[2] They found that

$$S\equiv -\langle(\partial v_x/\partial x)^3\rangle_{Av}/\langle(\partial v_x/\partial x)^2\rangle_{Av}^{\frac{3}{2}}=0.39 \tag{2}$$

where v_x is the x component of the velocity of turbulent motion. Now, from the Karman-Howarth equation[3] the vorticity equation can be written as

$$-\frac{1}{2}\frac{d}{dt}\langle(\partial v_x/\partial x)^2\rangle_{Av}-\frac{7}{3}\nu\langle(\partial^2 v_x/\partial x^2)^2\rangle_{Av}=\frac{7}{6}\langle(\partial v_x/\partial x)^3\rangle_{Av}. \tag{3}$$

In terms of the spectrum of turbulence, we have[4]

$$\langle(\partial v_x/\partial x)^2\rangle_{Av}=(2/15)\int_0^\infty F(k)k^2dk \tag{4}$$

and (3) can be rewritten as

$$\langle(\partial v_x/\partial x)^3\rangle_{Av}=-\frac{4}{35}\nu\int_0^\infty F(k)k^4dk-\frac{2}{35}\int_0^\infty\frac{\partial F}{\partial t}k^2dk. \tag{5}$$

Since S remains constant during the decay of turbulence, we can use the equilibrium spectrum for stationary turbulence derived from Heisenberg's theory, namely[5]

$$F(k)=F_0\left(\frac{k_0}{k}\right)^{5/3}\frac{1}{[1+(k/k_s)^4]^{4/3}};\quad \frac{k_s^{4/3}}{(F_0k_0^{5/3})^{\frac{1}{2}}}=\frac{3}{4}\frac{\kappa}{\nu}. \tag{6}$$

Using (4), (5), (6) and neglecting the second member of the right side of (5), we can evaluate S. Thus

$$S=\frac{9}{14}\left(\frac{15}{2}\right)^{\frac{1}{2}}\frac{\int_0^\infty[x^{7/3}dx/(1+x^4)^{4/3}]}{\left\{\int_0^\infty[x^{\frac{1}{2}}dx/(1+x^4)^{4/3}]\right\}^{\frac{3}{2}}}\kappa=1.52\kappa. \tag{7}$$

From (2), we obtain for κ the value 0.26. This differs from Heisenberg's determination $\kappa=0.85$. However, since the principal contribution to S comes from the transition region where $F(k)$ changes from the $k^{-5/3}$ to the k^{-7} law, the difference must be traced to the inadequacy of the expression (1) for ν_k for all k and can perhaps be interpreted in the following way: For a given k it is to be expected that only those eddies with wave numbers appreciably greater than k say $\alpha k(\alpha>1)$ can effectively contribute to the eddy viscosity. We may expect α to be a function of k but it must always be greater than one. If one neglects completely the contribution by those eddies with wave numbers