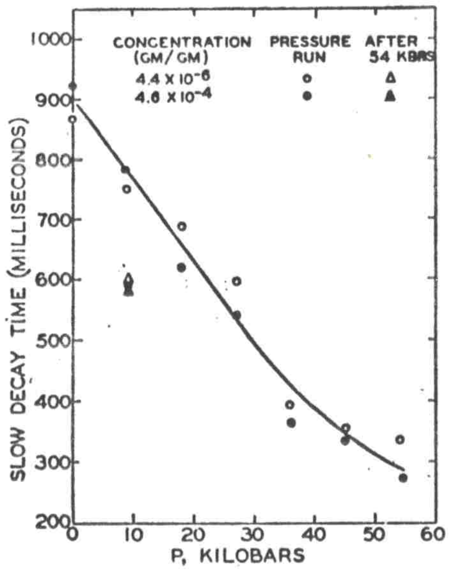

FIG. 5. Slow component decay time vs pressure for two concentrations—fluorescein in boric acid.

from the T_1 state to the S_0 state, called beta emission, and (2) the thermal re-excitation of the electron through point y to the S_1 state from where it then makes the radiative transition to the S_0 state, called alpha emission. The intensity of the alpha emission is quite temperature dependent, whereas that of the beta emission is not as much so. At room temperature, depending on the phosphor, one of these processes may be controlling or they may take place with nearly equal probability.

A spin-forbidden transition is totally forbidden if the spin and orbital momentum of the electron are completely separate. However, under the proper conditions there may be a certain amount of coupling between

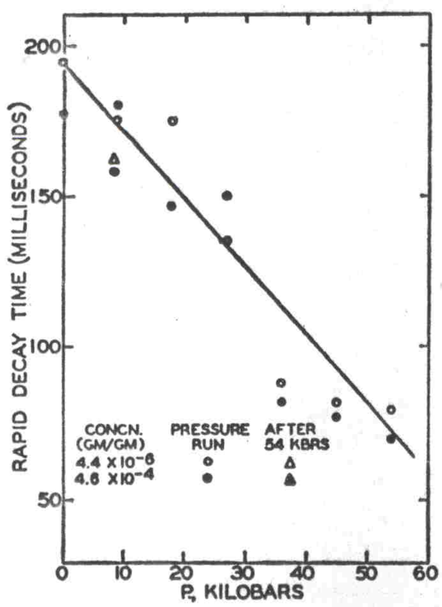

FIG. 6. Rapid component decay time vs pressure for two concentrations—fluorescein in boric acid.

them making the transition partially allowed. The coupling allows a state of spin a to mix with a state of spin b and the degree of mixing may be found from second-order perturbation theory and is given by[5]

$$\psi^1=\psi_{(s=a)}{}^0 + \sum_j \int \psi_{(s=a)}{}^{0*}\left[\sum_i \zeta_{nl} l_i s_i\right]\psi_{j(s=b)}d\tau \Big/ (E_a-E_j)\psi_{j(s=b)}. \tag{1}$$

The mixing coefficient may be abbreviated to $K\zeta_{nl}/\Delta E$, where k is in the order of unity. ζ_{nl} is the coupling coeffi-

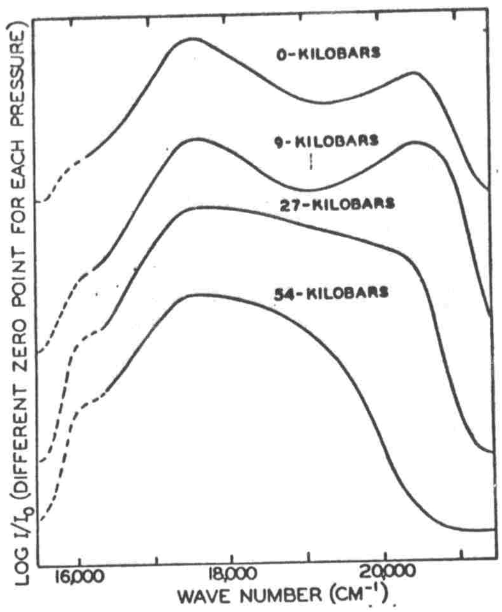

FIG. 7. Emission spectra of fluorescein in boric acid 4.6×10^{-4} g/g.

cient. In terms of oscillator strength we have[5]

$$f_{ab}=f^0(K\zeta_{nl}/\Delta E)^2, \tag{2}$$

where f^0 is the oscillator strength of an allowed transition between states of the same multiplicity.

Forster[6] shows that the oscillator strength is related to the decay time as follows: $1/\tau=Kf$, where K is a coefficient containing several terms which are not important for this argument. One then obtains

$$\tau=K'(\Delta E)^2. \tag{3}$$

The above discussion applies mainly to beta decay where the transition is from the T_1 state to the S_0 state.

If the model in Fig. 2 is valid and if the alpha, beta, and any monomolecular quenching decay processes are the only means by which the electron trapped in the triplet state returned to the ground state one would expect an exponential decay. The deviation from an

[5] D. S. McClure, *Solid-State Physics* (Academic Press Inc., New York, 1959), Vol. 9, p. 400.

[6] T. Forster, *Fluoreszenz organischer Verleindungen* (Vandenhoek and Ruprecht, Göttingen, 1951).