inside neutral lines give no extra divergence. This also leads to the finiteness of all neutron magnetic moment graphs, pointed out by Matthews as essential for renormalization to go through.)

By use of the above technique we easily get the following identities:

$$\Lambda_\mu{}^a(p,p) = -(1/2\pi)\partial\Sigma_P{}^*(p)/\partial p_\mu,$$
$$\Lambda_\mu{}^b(p,p) = -(1/2\pi i)\partial\Sigma_M{}^*(p)/\partial p_\mu,$$
$$\Theta_{\mu\nu}(p,p,0) = \tfrac{1}{2}\partial\Lambda_\mu{}^b(p,p)/\partial p_\mu,$$

so that

$$L^a = -B/2\pi, \quad L^b = R = -C/2\pi i,$$

while M^b is finite. The procedure above covers reducible as well as irreducible graphs.

To have a complete proof of renormalization one still must take account of scattering of mesons by mesons (M parts) and also of considerable overlaps between vertex and C parts. It has been verified, however, that the three-field mixture introduces no great complexities besides those associated with mesons in the electromagnetic field. Work on the complete problem is in progress.

After the above work was completed, the author received a communication from Mr. F. J. Dyson, proving similar identities for interaction of mesons with electromagnetic field, from general arguments of gauge invariance.

Acknowledgments are due Dr. P. T. Matthews, for suggesting the investigation and numerous discussions, and Dr. N. Kemmer for continual help and encouragement.

[1] P. T. Matthews, Phys. Rev. (to be published).
[2] F. J. Dyson, Phys. Rev. **75**, 1736 (1949).
[3] J. C. Ward, Phys. Rev. **77**, 293 (1949); **78**, 182 (1950).

Isotope Effect and Lattice Properties in Superconductivity*

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IN a recent communication,[1] Serin, Reynolds, and Nesbitt have suggested that the isotopic dependence of the superconducting transition temperature in mercury can be expressed by the approximate relation $M^{\frac{1}{2}}T_c$ = constant, where M is the average atomic mass and T_c is the transition temperature. From this they have inferred that the ratio of the Debye temperature to the transition temperature is a constant for each of the different isotopes.

It should be pointed out, however, that the data represent a relatively small spread in M and T_c and consequently in trying to fit a relation of the form $M^\alpha T_c$ = constant, one finds that the product is approximately constant, to the degree noted by Serin, Reynolds, and Nesbitt, for a comparatively large range of α's. We have examined all of the available data on the isotopes of mercury for the purpose of determining the best value of the exponent. These data are given in Table I and are plotted for mercury in logarithmic form in Fig. 1. A least-squares fit of the best straight line to the points of Fig. 1 yields a slope of 0.378 $\pm$0.021. A line of slope $\frac{1}{2}$ is shown for purposes of comparison.

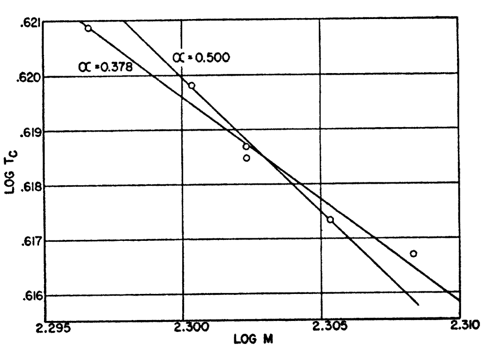

FIG. 1. Plot of $\log T_c$ *vs.* $\log M$ for mercury.

TABLE I. Isotope effect on the transition temperature.

Element	M	T_c
Hg^{198}	198.0	4.177[a]
Hg^{199}	199.7	4.167[b]
Nat. Hg	200.6	4.154[b]
Nat. Hg	200.6	4.156[a]
Hg^{202}	202.0	4.147[b]
Hg^{204}	203.4	4.137[b]
Sn^{124}	123.1	3.662[c]
Nat. Sn	118.7	3.715[d]

[a] E. Maxwell, Phys. Rev. **78**, 477 (1950).
[b] Serin, Reynolds, and Nesbitt, Phys. Rev. **78**, 813 (1950).
[c] E. Maxwell, Phys. Rev. **79**, 173 (1950).
[d] E. Laurmann and D. Shoenberg, Proc. Roy. Soc. **A198**, 560 (1949).

TABLE II. Possible theoretical relations of the form $M^\alpha T_c$ = constant.

Physical quantity assumed constant	Relation between M and T_c
Thermal energy of the lattice[a]	$M^{3/8}T_c$ = const.
Ratio of thermal energy to zero-point energy[a]	$M^{1/2}T_c$ = const.
Mean square linear momentum[a]	$M^{5/8}T_c$ = const.
Mean square thermal velocity[a]	$M^{1/8}T_c$ = const.
Ideal part of normal conductivity just before transition[b]	$M^{2/5}T_c$ = const.

[a] From the Debye theory.
[b] A. Sommerfeld and H. Bethe, *Handbuch der Physik* (Springer, Berlin, 1933), Vol. 24, part 2, p. 529, Eq. (37.16).

Recent results[2] on the isotope effect in Sn^{124} tend to reinforce this conclusion. One finds a value of 0.394 for the exponent using the data for tin in Table I.

We may ask whether the equation, $M^{0.378}T_c$ = constant, corresponds to the invariance of any significant physical quantity.[3] In Table II we list the relation between M and T_c which would hold if various quantities have critical values (independent of the particular isotope) at the transition temperature. From a purely empirical point of view the total thermal energy of the lattice is indicated as a first choice and the ideal part of the normal conductivity as a second. Evidently more experimental data are needed.

* Supported in part by the ONR.
[1] Serin, Reynolds, and Nesbitt, Phys. Rev. **78**, 813 (1950).
[2] E. Maxwell, Phys. Rev. **79**, 173 (1950).
[3] This constant is not the same for all elements, of course.

Ionization Chamber Bursts at Very High Altitudes

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AN investigation is being conducted to study the atmospheric absorption and the latitude dependence of the radiation which produces high energy nuclear disintegrations in the upper part of the atmosphere. The balloon-borne instruments which are being used throughout the projected series of measurements, contain a cylindrical electron-collection ionization chamber 20 cm long and 6.4 cm in diameter filled with pure argon at a pressure of 5 atmospheres. The ionization pulses are amplified and fed into a radio transmitter keying circuit which is biased to respond to pulses exceeding a preset amplitude. Each chamber contains