Letters to the Editor

PUBLICATION of brief reports of important discoveries in physics may be secured by addressing them to this department. The closing date for this department is five weeks prior to the date of issue. No proof will be sent to the authors. The Board of Editors does not hold itself responsible for the opinions expressed by the correspondents. Communications should not exceed 600 words in length and should be submitted in duplicate.

IMPORTANT ANNOUNCEMENT

BEGINNING with the issue dated July 1, *The Physical Review* will no longer carry Letters to the Editor. These will be published in a supplemental semimonthly journal tentatively called ***Physical Review Letters***. By the use of offset printing the Letters will appear about two to three weeks after receipt instead of the present six to ten weeks. The new *Physical Review Letters* will also print copies of the abstracts of future Physical Review articles.

Physical Review Letters will initially be sent gratis to all subscribers of *The Physical Review*. However, beginning January, 1959, a subscription price will be charged amounting to $5 for members of the American Physical Society and $10 for nonmembers. At that date the publication charge in *Physical Review Letters* will be set at $30 instead of the present $25 per page.

The aim of *Physical Review Letters* is to improve communication among physicists, thereby speeding up the flow of ideas, increasing the interaction of results on related work, and reducing duplication of effort. It will make important results available promptly to all physicists and not merely to the privileged few whose names happen to appear on mailing lists for preprints.

Such a fast-publishing journal may become very popular with authors and could soon grow beyond reasonable bounds. It is therefore our intention to maintain the same strict standards for *Physical Review Letters* as are now in operation for Letters to the Editor. We expect that on the average only about fifteen letters will be acceptable for each issue. Letters will be accepted only if they contain important new discoveries or cover topics of high current interest in rapidly changing fields of research. Contributions that do not conform to these requirements do not deserve the very special handling given Letters and, no matter how short they may be, should be submitted for publication as Articles in *The Physical Review*. Letters must be self-contained in that readers should be able to understand the physics of the contribution—i.e., the procedure followed and the arguments used. We shall reject all Letters which *merely* claim results, announce future publications, or advertise papers published elsewhere. We shall also try to discourage the publication of a research program in a series of Letters instead of in a comprehensive article.

We have never adhered strictly to the size limitation of Letters (600 words) but we prefer that they be less than a printed page (1000 words) and contain no more than two figures. Contributions of excessive length cannot be accepted as Letters.

Since speedy publication allows no time for thorough refereeing, the Editor is likely to make mistakes and to include occasionally Letters of minor importance or below our usual standards. Such occurrences cannot be used as a precedent to require the Editor to accept similar Letters later on.

To assure speedy publication it is absolutely essential that manuscripts reach us in well-edited form. We have no time to perform a library research to complete faulty references, to locate references in the text, to correct errors in equations, to define undefined symbols, or to identify unclearly written symbols (s or S, κ or k or K, etc.). Figures should be in India ink with the lettering and symbols (also in India ink) large enough so that they are readable after reduction of the figure to three-inch width. Improperly prepared manuscripts will be returned, thereby being delayed in publication.

As in the past, Letters must be submitted in duplicate. From now on we request authors of each Article submitted to *The Physical Review* to enclose a duplicate copy of the abstract of their paper.

Dr. George L. Trigg is the Assistant Editor for *Physical Review Letters*. Circulation and subscriptions will be handled by the American Institute of Physics, 335 East 45 Street, New York 17, New York.

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EDITOR

Discrete Recovery Spectrum below 65°K in Irradiated Copper

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(Received March 10, 1958)

IT has been realized for some time that the recovery of radiation-induced electrical resistivity which occurs between 20°K and 80°K cannot be described by a single-rate equation with a unique activation energy.[1,2] Recently Palmer, Magnuson, and Koehler,[3,4] reporting on a deuteron-bombarded sample, have shown that a plot of the density of recovery *versus* activation energy shows four peaks. Their curve was determined from the analysis of a sequential isothermal annealing experiment. This Letter reports an experiment on electron-irradiated copper which demonstrates directly, independent of analysis, that at least four

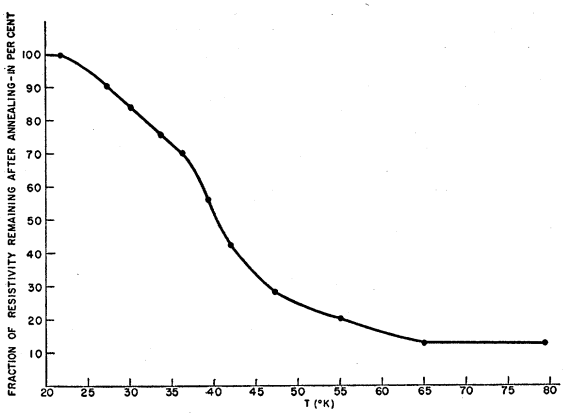

FIG. 1. Limited isochronal annealing. This curve shows the fraction of the resistivity introduced by bombardment at ~20°K which remains after annealing at higher temperatures.

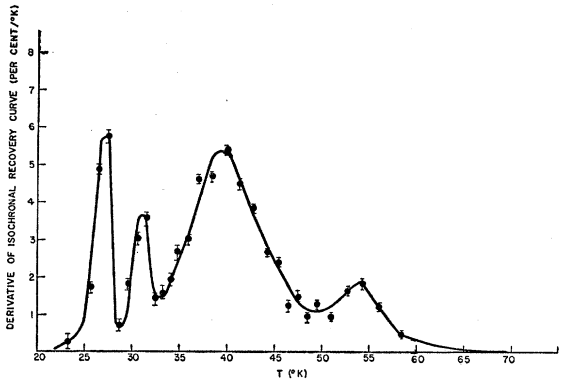

FIG. 3. "Derivative" of the detailed isochronal curve. The fractional recovery per degree calculated from successive pulses is plotted *versus* the temperature midway between successive annealing temperatures.

regions of recovery exist in the temperature range 20°–80°K.

The experiment is a refinement of the isochronal annealing run described in reference 2. In this isochronal pulse annealing technique the sample temperature is quickly raised from 20.4°K to some annealing temperature and is maintained there for 10 minutes. The sample is then quenched to 20.4°K for measurement. Subsequent annealing pulses are performed at successively higher temperatures—each being for the same length of time. The present experimental conditions are the same as the previous ones with the exception that liquid hydrogen, rather than liquid helium, is used as the refrigerant. We have already reported[5] that the use of either coolant gives the same results. The sample was formed from AS&R 99.999% pure copper that was zone-refined, rolled to 0.00125 inch, and then annealed at 450°C for one-half hour. The residual resistivity of this foil was 1.5×10^{-9} ohm cm. The sample was held at ~20°K during irradiation and was bombarded with 1.4-Mev electrons. The total radiation-induced resistivity increment was 2.99×10^{-10} ohm cm which corresponded to 2×10^{-6} atomic concentration of defects based on a value of 1.45 micro-ohm cm per atomic percent Frenkel pairs.[2]

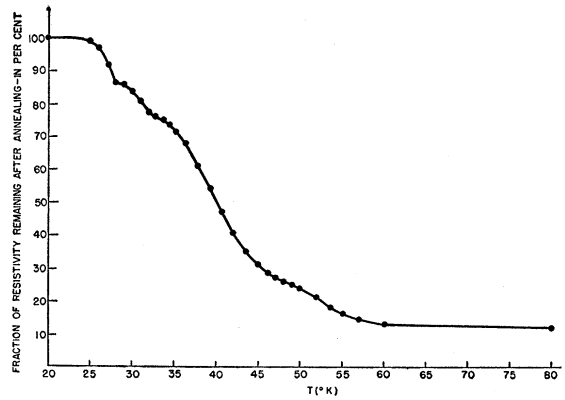

FIG. 2. Detailed isochronal annealing.

Figure 1 shows the previously reported isochronal recovery experiment in which 11 points were used to construct the recovery curve. The present experiment in which 27 points were used is shown in Fig. 2. From this curve we see that at least four separate regions of recovery are present. This is most clearly seen by examining Fig. 3 which shows the derivative of the detailed isochronal of Fig. 2. Since the present experiment provides no information about activation energies, the four peaks in Fig. 3 cannot be compared directly with the peaks obtained by Magnuson.[3,4] However, the temperatures at which the stages occur and the relative amounts of recovery in each stage appear similar, although there are significant differences in detail. A more detailed comparison of the two experiments will be made in a forthcoming paper that will report extensive isothermal annealing experiments in the temperature range 20°–80°K. These isothermal experiments confirm the existence of the discrete recovery spectrum.

The similar structure observed in both the deuteron and electron experiments suggest, but do not prove, that the discrete recovery stages are due to intrinsic processes and are not associated with chemical impurities. In this regard, the peak at 55°K has been shown to exhibit effects associated with long distance migration.[5] The question of the assignment of the different recovery regions to specific processes will be discussed in a future article.

[1] Blewitt, Coltman, Holmes, and Noggle, *Lake Placid Conference on Dislocations* (John Wiley and Sons, Inc., New York, 1957), p. 603; Blewitt, Coltman, Klabunde, and Noggle, J. Appl. Phys. **28**, 639 (1957).

[2] Corbett, Denney, Fiske, and Walker, Phys. Rev. **108**, 954 (1957).

[3] Palmer, Magnuson, and Koehler, Bull. Am. Phys. Soc. Ser. II, **2**, 357 (1957).

[4] G. D. Magnuson, Ph.D. thesis, University of Illinois, 1957 (unpublished).

[5] Corbett, Smith, and Walker, Bull. Am. Phys. Soc. Ser. II, **2**, 356 (1957).