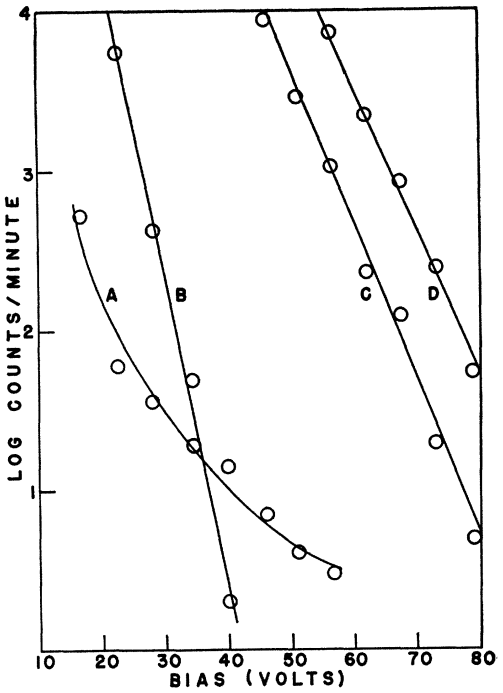

FIG. 1. A plot of net counts/min. *vs.* bias setting in volts for a series of structurally related organic crystals. A = average background, B = 1,2-diphenylethane, C = 1,2-diphenylethylene and D = diphenylacetylene.

and were utilized in conjunction with a 931-A photomultiplier tube to count the scintillations produced by alpha-particles from a polonium source. The potential divider and amplifier circuits were similar to those used by Marshall, Coltman, and Bennett.[1] The discrimination of the pulses was made with a Higinbotham[2] amplitude discriminator and the counting was done with a decade scale-of-a-1000 circuit constructed in this laboratory. No refrigeration was used in these experiments.

The results are summarized in Fig. 1 where the log of the counts/min. less background are plotted against discriminator bias in volts. It is clear that the signal to noise ratio increases as one goes from diphenylethane to stilbene and then to diphenylacetylene. The naphthalene curve, if plotted on this scale, would fall in the region between diphenylethane and stilbene and possesses an intermediate slope. It will be noted that diphenylacetylene is about 6 times better than stilbene which is the best material previously reported in the literature.[3]

When these crystals were used for x-ray detection, a similar correlation between conversion efficiency and the unsaturation of the non-benzenoid linkage in the molecules was observed.

In early studies on scintillation properties of crystals there was a tendency to associate these properties with condensed-ring systems, however, the work on stilbene[3] and the present work on diphenylacetylene indicate that conjugation of the multiple bonds is a more determining factor than condensation of rings. This is really not too surprising in view of the numerous correlations that have been observed between certain optical properties of organic materials and the conjugation of double and triple bonds.

In future work it is planned to investigate the spectral distribution of the scintillations, and to further explore the apparent correlation between structure and conversion efficiency.

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[2] Higinbotham, Gallagher, and Sands, Rev. Sci. Inst. **18**, 706 (1947).
[3] Gittings, Taschek, Ronzio, Jones, and Masilun, Phys. Rev. **75**, 205 (1949).

Vacancies and Diffusion in NiAl*

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THE intermetallic compound NiAl (and CoAl) has a CsC-type of structure and is able to dissolve certain excesses of the two elements. It has been shown by Bradley[1] that on the Ni-rich side the extra atoms of nickel substitute for aluminum atoms, while on the other side the extra atoms of aluminum cannot replace the much smaller atoms of nickel and so instead some nickel atoms are missing. A study of diffusion in this compound seemed to be of considerable interest in view of the role of vacancies in the mechanism of diffusion and the possibility of changing their concentration. The concentration of vacancies in metals due to thermal excitation is usually a small fraction of one percent, and so an addition of several percent of aluminum, thus of several percent of vacancies should increase the order of magnitude of the diffusion coefficient. As explained below, a closer examination of the vacancy mechanism shows this conclusion to be incorrect.

Figure 1a shows the cube projection of the ideal NiAl lattice, the rest of the figure shows the three basic kinds of monatomic defects possible in that lattice. A Ni-vacancy, $V(N)$, which is shown in Fig. 1b, is due either to thermal excitation or to an excess of aluminum, and it cannot move by itself because, as mentioned above, the space between the eight Al-atoms is too small to accommodate a central Al-atom. Such a vacancy could move by itself only by an interchange with a second neighbor Ni-atom, which is quite unlikely. In Fig. 1c we have an excess Ni-atom substituting for an Al-atom and finally in Fig. 1d is illustrated an Al-vacancy, $V(A)$, which is due to thermal excitation and which is able to move in the lattice because a Ni-atom can occupy an Al-vacancy and in turn an Al-atom can occupy a Ni-vacancy if not all neighbors of that vacancy are Al-atoms. This is shown in in Figs. 1e and 1f.

There exists an important interchange between these defects. The Al-vacancies moving around can bring into contact a Ni-vacancy with an excess Ni-atom and thus produce a new Al-vacancy, $V(N)+\mathrm{Ni}\rightarrow V(A)$. Of course the opposite is also possible: An Al-vacancy can, with the help of another Al-vacancy, transform itself into a Ni-vacancy plus an excess Ni-atom substituting somewhere for an Al-atom, $V(A)\rightarrow V(N)+\mathrm{Ni}$. These processes alter the balance of vacancies and thus affect the diffusion rate. At the 50:50 composition one expects an excess of $V(N)$ over $V(A)$ and $(V(N)-V(A))$ nickel atoms substituting for Al-atoms. As the concentration of aluminum increases the number of $V(N)$ rapidly increases with a small influence on the number of $V(A)$ (since there are few excess Ni-atoms available) which alone are responsible for diffusion. On the Ni-rich side the number of the excess Ni-atoms increases rapidly and thus many of the $V(N)$ are transformed into $V(A)$ and so the diffusion coefficient should

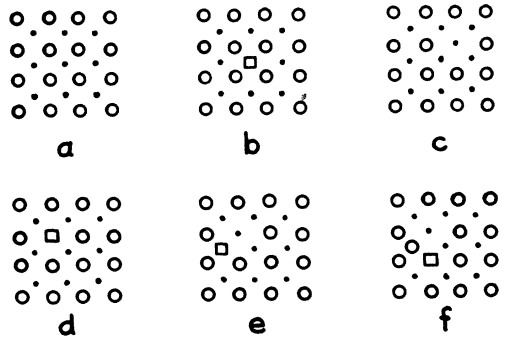

FIG. 1. Atomic configurations in NiAl: (a) perfect lattice at 50:50; (b) Ni-vacancy or excess Al; (c) excess Ni; (d), (e), (f) three positions of an Al-vacancy. Open circles represent Al, dots represent Ni.

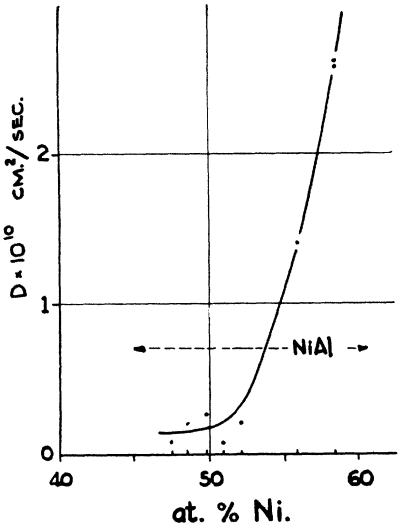

FIG. 2. Diffusion coefficient in NiAl at 1150°C.

increase. The amount of this increase will depend upon the balance between the production and annihilation of $V(A)$.

As illustrated in Fig. 2 experimental results confirm these considerations. Since, at the time the experiments were started, radioactive nickel was not conveniently available, the measurements were made using radioactive cobalt which is known to form a similar compound with aluminum[2] and can substitute for nickel in NiA. Since these alloys are difficult to prepare and on the aluminum-rich side are brittle, a very small quantity of radioactive cobalt was plated on the surface of the sample and the diffusion coefficient computed from the decrease of the activity due to the penetration of cobalt into the samples during 18 hours at 1150°C. The experiment is being repeated with radioactive nickel.

*Research sponsored by ONR.
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[2] A. J. Bradley and G. C. Seager, J. Inst. Metals **64**, 81 (1939).

Removal of Space-charge in Diamond Crystal Counters

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IT is well known that a steady decrease in the size of the pulses with time is produced in a crystal counter when subjected to ionizing radiations, owing to the setting-up of space-charge inside the crystal. This space-charge is produced by electrons, and possibly positive holes, being held in electron-traps distributed throughout the crystal. Various authors have neutralized the effect of the space-charge by applying an alternating field across the crystal,[1] the supposed explanation being that during the positive half-cycle, the freed electrons are carried from the surface layers into the body of the crystal where they become trapped; and during the negative half-cycle, positive holes migrate into the crystal where some will re-combine with the trapped electrons while others become trapped themselves. The net effect of a continual repetition of this process is, under favorable conditions, to neutralize the space-charge. It has also been suggested[2] that once a space-charge has been set up, the crystal could possibly be returned to its original state by irradiating it with visible light and heat, after which the counting cycle could be repeated. In a theoretical paper by Newton,[3] the depths of most of the traps in diamond are estimated to be between 0.25 and 0.75 electron-volt, corresponding to photon wave-lengths of approximately 5 mμ and 1.6 mμ, respectively. Thus, irradiation of the specimen with a spectrum extending from about 1 mμ to 10 mμ should be sufficient to de-trap most of the electrons. This spectrum is conveniently produced by a Nernst filament.

In this laboratory, experiments have been performed in which light was focused on to the crystal simultaneously with bombardment by alpha-particles from polonium. It was found that with the Nernst light, no photo-conductivity was detected. The temperature of the crystal was that of the room and was kept fairly constant. The field across the crystal was such that, at high intensities of Nernst irradiation, there was a saturation of counting-rate with applied voltage. Only pulses of height greater than twice the noise-level of the amplifier were recorded. The procedure was to allow the counting-rate to decay to zero while the crystal was in the dark and then, to irradiate it with the Nernst illumination. The following change in counting-rate with time was observed, the curve shown being typical of the many obtained.

Portion OA of Fig. 1 shows the decay prior to irradiation. The illumination was begun at A and the counting-rate rose rapidly, being followed by the peculiar "kink" after which, over the part BC, it gradually approached a saturation. At C, the light was removed and the counting-rate was found to decay exponentially and when it had reached its original value, the whole cycle could be repeated. These curves were plotted for various light intensities and as was to be expected, a curve of saturation counting-rate against light intensity itself showed a saturation for the higher intensities, corresponding to conditions in which a high percentage of the incident alpha-particles was being recorded

The use of radiation of suitable wave-lengths to remove space-charge appeared as satisfactory as the method of field reversal, since, when the latter was carried out, the pulse heights were the same as those reached when the higher intensities of light were used.

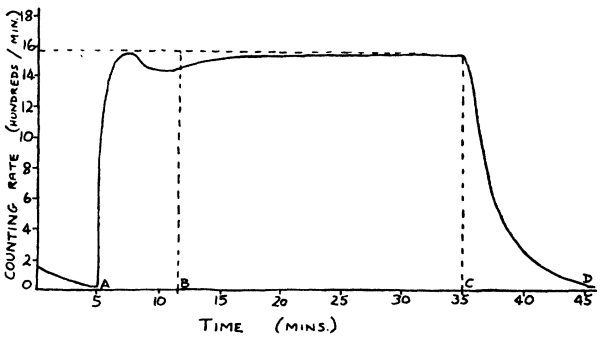

FIG. 1. Variation of counting-rate with time on irradiating the diamond with a Nernst light.

Most of the above experiments were performed on one specimen only, but the behavior of other diamonds differed only in degree.

No simple explanation of the kink in the curve seems forthcoming but it is interesting to note that Newton obtained from theoretical considerations a curve exhibiting the same appearance, though his theory deals with slightly different experimental conditions. It is not clear whether our experiments can be interpreted directly in terms of Newton's curve but this point is being investigated.

[1] L. F. Wouters and R. S. Christian, Phys. Rev. **72**, 1127 (1947). K. G. McKay, Phys. Rev. **74**, 1606 (1948).
[2] R. Hofstadter, Nucleonics (April, 1949).
[3] R. R. Newton, Phys. Rev. **75**, 234 (1949).