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Authors

Strudel, J.L.
Vincotte, F.
Washburn, J.

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University of California

Ernest O. Lawrence Radiation Laboratory

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Inorganic Materials Research Division, Lawrence Radiation Laboratory,
and Department of Mineral Technology, University of California
Berkeley, California

Both perfect and imperfect dislocation loops are formed by clustering of excess vacancies in aluminum.(1, 2) For diameters above about 50 Å the perfect loop, $\frac{a}{2}\langle 110\rangle$ has the lowest energy.(3) However, as this critical radius is passed, during the arrival of vacancies, transformation requires the nucleation of a loop of $\frac{a}{6}\langle 211\rangle$ dislocation in the stacking fault of the imperfect loop. Because in the absence of high local stresses the activation energy for this process is expected to be several electron volts,(4) $\frac{a}{3}\langle 111\rangle$ imperfect loops should persist. In 99.995 aluminum loops containing a stacking fault were at first thought to be rare(1, 2) but many of those shown in ref. 2 can now be identified as imperfect.

Impurities appear to have a strong effect on the relative numbers of perfect and imperfect loops that are observed. Yoshida, Kiritani and Shimomura (5) and Cotterill and Segall(6) have reported quantitatively on the ratio of perfect to imperfect loops for different purities and quenching conditions. However, they did not explain how the Burgers vectors of the loops were determined.

When the diameter of the loops is greater than about 500 Å they can easily be distinguished as perfect or imperfect because the latter exhibit typical stacking fault contrast,(7) lie exactly on {111} and have a hexagonal shape. However, none of these distinguishing characteristics are reliable for smaller loops.

A typical loop substructure in a quenched and aged polycrystalline aluminum specimen is shown at low magnification in Fig. 1.(8) Loops often occur in colonies with larger loops near the edges. Although this was not zone refined aluminum, it is clear that most of the large loops contain stacking faults. However, by observation of the photograph it is not possible to identify the smaller loops as perfect or imperfect. Therefore it would not be possible to obtain meaningful ratios of the two types.

In the present experiments different electron diffraction contrast conditions were used to identify the Burgers vecotrs of loops too small to be classified by shape, habit plane or stacking fault fringes. Single crystal sheets were prepared of the same aluminum shown in Fig. 1. The surface of the sheet was parallel to (111). For this orientation strong diffracted beams could be obtained from $\pm \bar{2}02$, $\pm 2\bar{2}0$, or $\pm 02\bar{2}$ by slightly tilting the specimen. If it is assumed that the loops are all <u>perfect</u>, then for each of the above diffraction conditions only one of the six $\frac{a}{2}\langle 110\rangle$ Burgers vectors lies in the diffracting plane. Therefore if there is approximately equal distribution of loops among the six Burgers vectors, about one sixth of the loops should be out of contrast(7) for each diffraction condition. Half of the loops will never go out of contrast for any of the three diffraction conditions.

If the loops are assumed to be all <u>imperfect</u> then one of the four $\frac{a}{3}\langle 111\rangle$ Burgers vectors lies in all three of the possible diffracting planes; one fourth of the loops, those on the plane parallel to the surface of the foil, will always be <u>out</u> of diffraction contrast and the other three sets of loops will become invisible one set at a time as the diffracting plane is changed.

The results shown in Fig. 2 are consistent with the assumption that nearly all the loops in this specimen were of the $\frac{a}{3}\langle 111\rangle$ imperfect type. Photographs of the same area for strong diffraction from $(\bar{2}02)$ or $(\bar{2}20)$ show loops on $(1\bar{1}1)$ and $(11\bar{1})$ respectively to be out of contrast. For $(02\bar{2})$ in diffracting position the third set of loops $(\bar{1}11)$ were invisible. Almost no loops remained in good contrast for all three diffraction conditions.

The experiments show that for 99.999 aluminum nearly all the loops can contain a stacking fault. However, because they are only metastable relative to perfect loops, the lower percentages previously reported may have resulted from stress induced transformations. The large loops near the edges of colonies are particularly susceptible to loss of their stacking faults due to the stress fields of dislocations that move during the preparation and mounting of a foil in the microscope.

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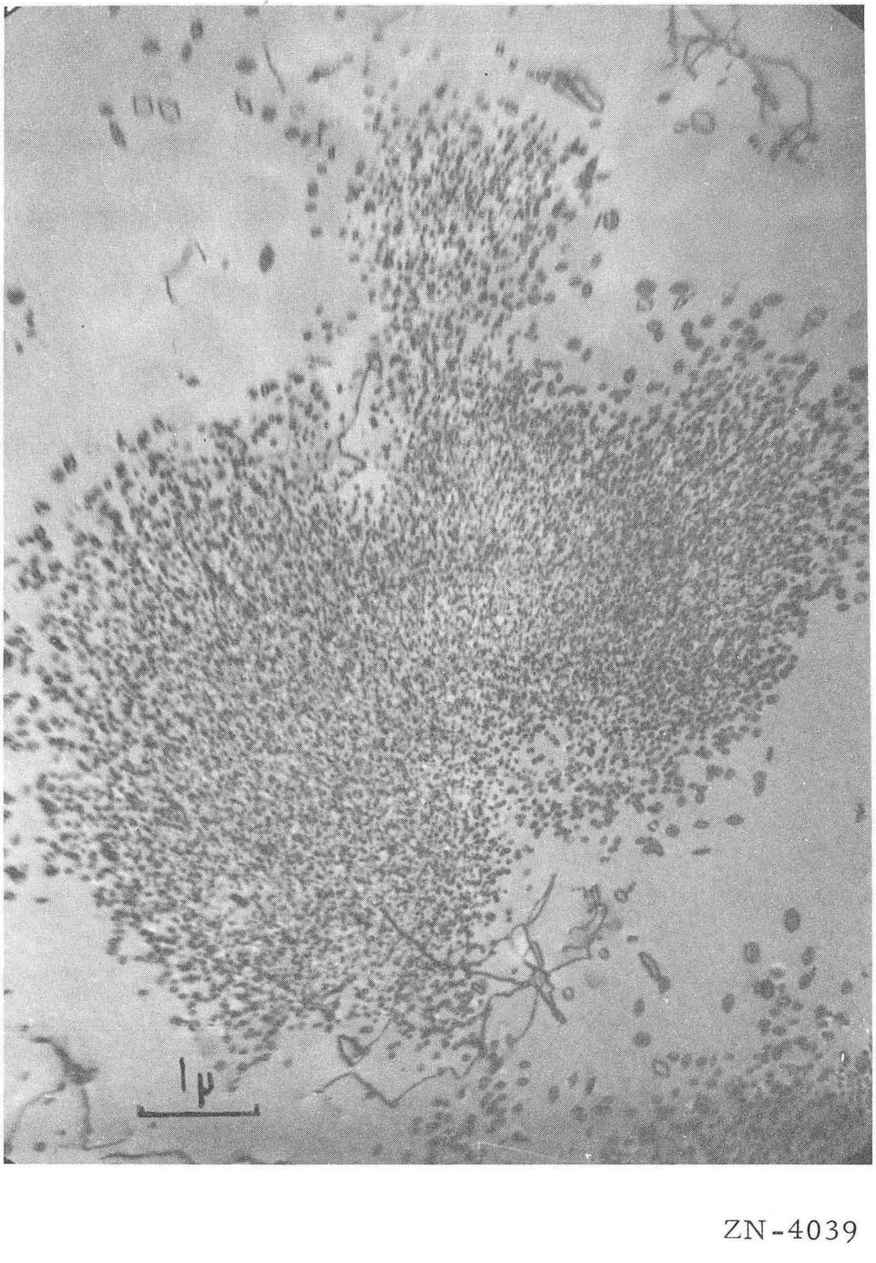
Figure Captions

Fig. 1. Typical colony of loops in quenched and aged 99.999 polycrystalline aluminum.

Fig. 2. Two photographs of the same area showing small loops for two different diffraction conditions. Projection of tetrahedron showing orientation of {111} planes is drawn to a scale of 0.25 μ on an edge.



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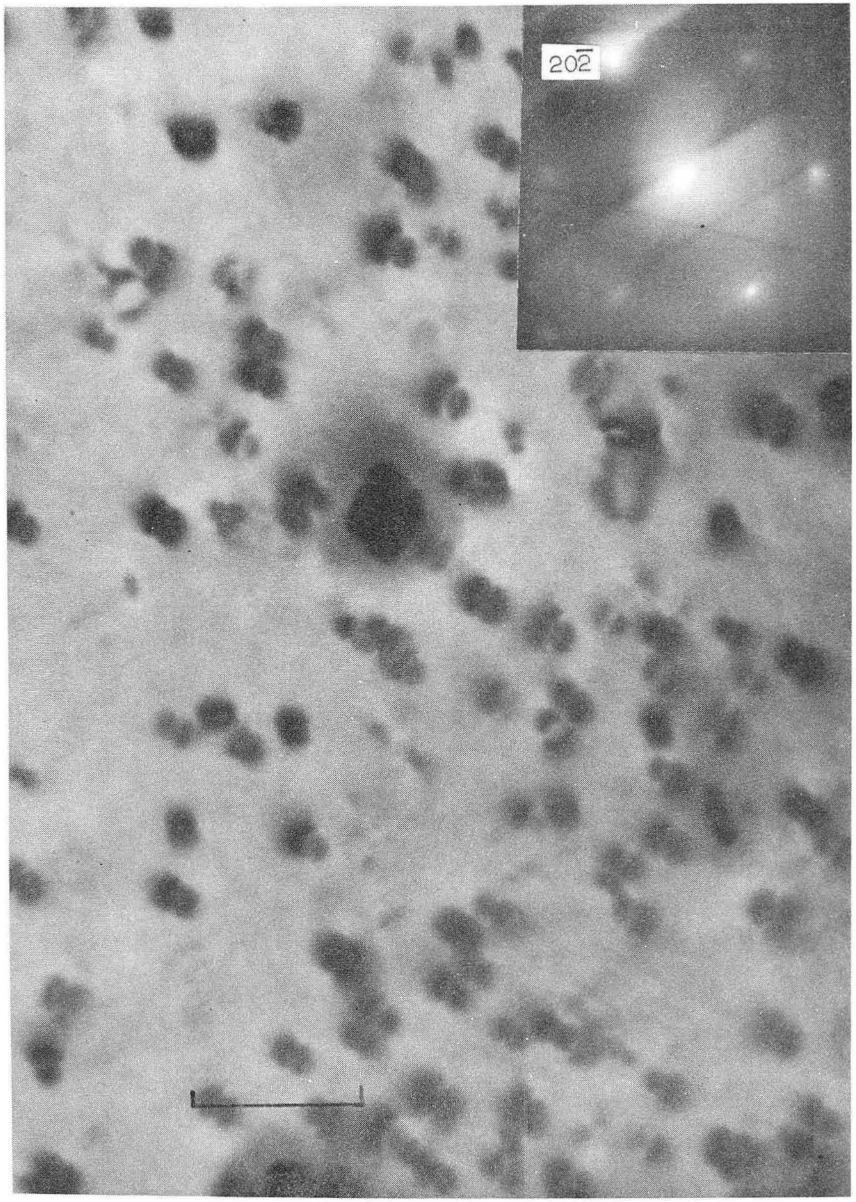

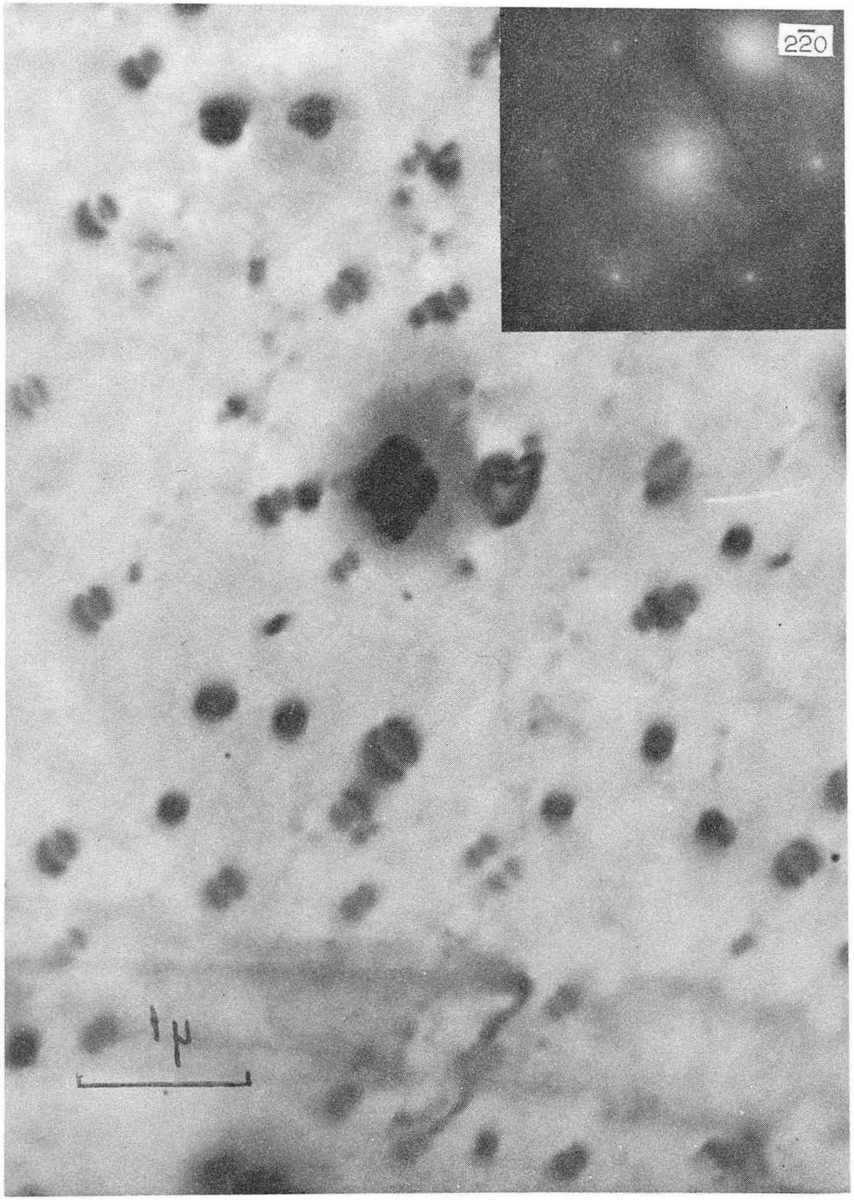

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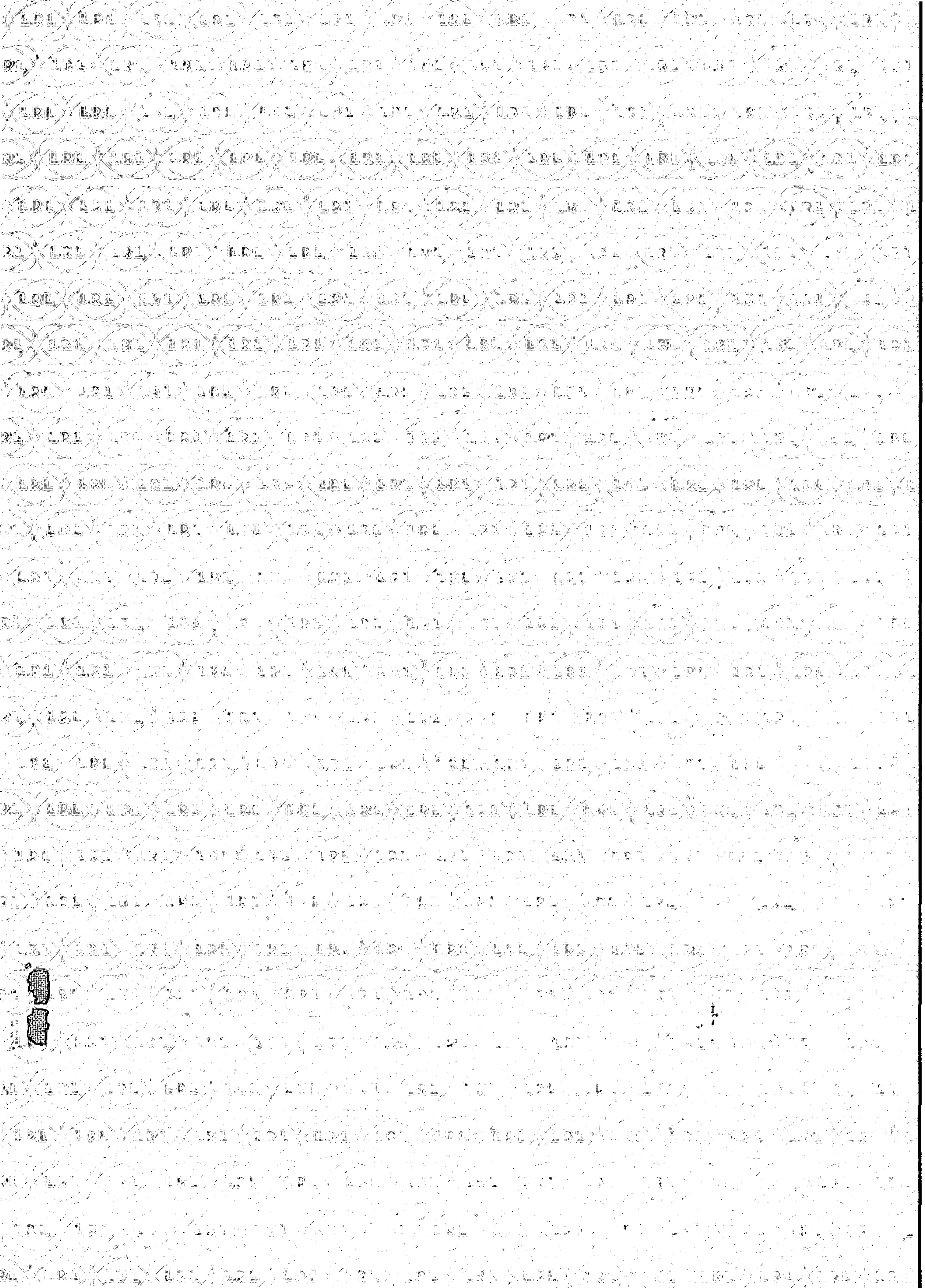
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