of the alloy is gradually coming back. In the case of Bi_5Tl_3 the result was analogous.

When the field was switched off, the resistances of the bismuth wires did not return to their normal value[2]; we have not yet determined exactly the maximum value of the magnetic field which may remain in the alloy, but it seems to be of the order of magnitude of the critical field. We are inclined to believe that the critical value of the field, that is, the value at which the field starts to penetrate into the alloy, as distinguished from the threshold field at which the resistance is coming back, may come into play in several phenomena, for example, in experiments on thermal conductivity[3].

A detailed account of the influence of a magnetic field on alloys will shortly appear in *Physica*.

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[1] W. J. de Haas and J. M. Casimir-Jonker, *Physica*, **1**, 291; 1934.
[2] cf. T. C. Keeley, K. Mendelssohn, J. R. Moore, NATURE, **134**, 773, Nov. 17, 1934.
[3] W. J. de Haas and H. Bremmer, *Leiden Comm.*, 220 *c*.

Further Experiments with the Magnetic Cooling Method

CONTINUING our experiments[1] with the magnetic method, we investigated the suitability of a number of substances. The efficiency of a substance for this purpose can be defined by a characteristic temperature θ_m, which may be calculated by means of a formula which we derived under certain simplifying assumptions about the splitting of the ground state of the magnetic ions. According to this formula, the final temperature reached in demagnetising to the field zero is inversely proportional to the initial magnetic field, proportional to the initial temperature and to the temperature θ_m, characteristic for each substance, defined by $\theta_m = U/k$ (U = energy difference between the adjacent levels of the ground state, k = Boltzmann's constant). Thus, the smaller θ_m, the more suitable is the substance for attaining low temperatures.

We found that the numerical values of θ_m for the substances investigated lay between about 0·2° and 0·06°. Gadolinium sulphate[2] has the highest value; next, approximately equal, come manganese ammonium sulphate and chromium potassium alum (the substance chiefly used in the Leyden experiments[3]). Manganese ammonium sulphate, however, shows at very low temperatures deviations from the formula of a kind which suggest the existence of a Curie point slightly below 0·1°[4]. Finally follows iron ammonium alum which proved to be the most suitable of the substances we investigated. With it, for example, a temperature of 0·04° was obtained, starting at 1·25° and 14 kilogauss. Preliminary experiments with mixed crystals showed that by diluting the magnetic ions one can reduce the characteristic temperatures.

The technique was further developed, so that there is now no special difficulty in reaching the lowest temperatures, or in keeping even small amounts of substances (some tenths of a gram) at these temperatures for considerable periods. We generally chose a rate of warming up between $\frac{1}{3}$ and 1 millidegree per minute.

Investigations on supra-conductivity in this region were also continued. Two further new supraconductors were found, namely, zirconium and hafnium, pure samples of which were very kindly lent to us by Dr. J. H. de Boer of the Philips Company. The transition point of zirconium lies at $0{\cdot}7_0°$, the initial slope of the magnetic threshold values being about 300 gauss per degree. In the case of hafnium we could use only a very small sample (25 c. mm.) so that the accuracy of the numerical values is not very high. Extrapolation to zero measuring field gives a transition point between 0·3° and 0·4°. Copper, gold, germanium, bismuth and magnesium, at least the samples used by us, did not become supra-conducting down to 0·05°.

In investigating these metals we had still another purpose. It is to be expected that the entropy due to the random distribution of the nuclear spins will vanish within the new temperature region, where kT may be of the order of the interaction energy between the nuclear spin and the surrounding particles[5]. From their hyperfine structure (separation 10^{-2} cm.$^{-1}$ to 1 cm.$^{-1}$) it appears that the corresponding temperature for the free atoms should lie in the region between 0·01° and 1°. For compact metals nothing can be accurately predicted, but it is likely that the interaction energies will be smaller than in the gas.

By mixing a substance with a paramagnetic salt, one should be able to render observable the entropy due to the change of the distribution of the nuclear spin, since in this case one would not reach such low temperatures as with the pure salt. In cooling to 0·05°, using a mixture of equal volumes of metal and salt, one should detect these effects if the separation were greater than about 10^{-2}–10^{-3} cm.$^{-1}$. As no difference in the final temperatures which could be definitely attributed to this effect was found, it appears that the separations in the solid are lower than the limit mentioned above. In the case of bismuth this means that the separations are reduced, at least by the factor 100, on passing from the gaseous to the metallic state.

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[1] N. Kürti and F. Simon, NATURE, **133**, 907; 1934. *Physica*, **1**, 1107; 1934. A detailed report will appear shortly.
[2] Our results with this substance agree satisfactorily with those of Giauque and MacDougall, *Phys. Rev.*, **44**, 235; 1933.
[3] W. J. Haas and E. C. Wiersma, *Physica*, **1**, 779; 1934.
[4] See Debye, *Sitzungsber., Math. Phys. kl. Sachs. Akad. Wiss.*, **85**, 105; 1934.
[5] See, for example, F. Simon, *Z. Phys.*, **81**, 826; 1933.

The Vortex Concept

RECENTLY Great Britain has lost two of its chief promoters (W. M. Hicks and H. Lamb) of vortical hydrodynamics, a science which was in the main line of physical suggestion forty years ago. Some historical reflections are thereby suggested.

One would think at first glance that the whole affair is implicit in a few sections at the end of Lagrange's "Mecanique", when he asserts, but without irreproachable proof, that every portion of uniform non-viscous fluid whose motion at any time involves a velocity potential continues to move subject to that restriction. For the Lagrangian principle implies that portions of the fluid mass the motion of which is vortical remain separate from the surrounding non-vortical portions. Rather, that inference ought to have come immediately to Stokes