Physics. — *On the super-conductivity of Gallium.* By W. J. DE HAAS and J. VOOGD. (Communication N⁰. 193*b* from the Physical Laboratory at Leiden).

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§ 1. The behavior of the electric resistance of gallium placed in liquid helium was examined by TUYN and KAMERLINGH ONNES. They generated an induction current in a gallium ring, and showed that the gallium they examined was not super-conducting at $T = 1°.6$ K. in a field of 17 Gauss.

As the place that gallium takes in the periodic system (three electrons in the outermost shell, 18 in the following one) is of importance to the problem of super-conductivity we thought it would be of interest to investigate the course of the resistance by direct resistance measurements down to the lowest temperature attainable and only in the earth magnetic field, which is not compensated.

§ 2. The gallium we used was supplied by ADAM HILGER LTD. According to the firm's spectroscopic analysis, this gallium contained in impurities 0.16 % indium, 0.10 % zink, 0.01 % lead and a trace of sodium.

By forcing the liquid gallium into a glass capillary tube and letting it crystalize and then etching away the glass we obtained a wire, of which we made the resistance *Ga-2-'28*. As tension wires for the resistance measurements gallium wires were fused on just within the two extremities. The resistance thus contrived was mounted tension free upon an ivory rod.

We also made a resistance *Ga-3-'28* in the same way, of gallium with an impurity of 0.3 % of indium.

The resistance measurements were made in the usual way with a DIESSELHORST compensation apparatus. As the value of the resistance, by which should be understood the quotient of potential difference and strength of current, proved in both resistances at a low temperature to be strongly influenced by the strength of the current causing the potential difference, we made measurements with various strengths of current.

The results will be found in the accompanying tables and figures.

§ 3. The resistances, even at the lowest temperature that we could attain, did not become super-conducting.

At the same time the curve (Fig. 1) has all the characteristics of super-conductivity and we may presume that at a temperature slightly lower than 1°.1 K. gallium would become super-conducting. Gallium would then be

TABLE 1.

Ga—2—'28				
T	p_{helium} in mm.	$37^1/_2$ mA.	10 mA.	$2^1/_2$ mA.
293		1.5698 Ω		
273.09		1.4680		
4.20	758	0.003749	0.003750	
3.42	311	0.003728	0.003723	
3.37	289	0.003727	0.003728	
3.00	165	0.003719	0.003710	0.00373
2.50	62.3	0.003711	0.003709	0.00370
1.98	16.9	0.003701	0.003695	0.00367
1.35	2.25	0.003673	0.003643	0.00355
1.1	0.46	0.003590	0.003364	0.00268

TABLE 2.

Ga—3—'28 [1])		
T	p_{helium} in mm.	$37^1/_2$ mA.
293		0.1066 Ω
4.20	758	0.000068
3.42	311	0.000068
3.37	289	0.000066
3.00	165	0.000060
2.50	62.3	0.000048
1.98	16.9	0.000034
1.35	2.25	0.000014
1.1	0.46	0.000006

the 6th super-conductor [2]). It is another question, however, whether this

[1]) This wire was more sensitive to current than *Ga*—2—'28. We hope to return to the question of current sensitivity at a future time.

[2]) Recently however Dr. W. MEISSNER found Tantal also to be super-conduction Phys. Zeitschr. **29**. 1928. p. 897.

super-conductivity is connected with the trace of indium in the gallium. Fresh experiments with more pure gallium will be needed to put this to the test.

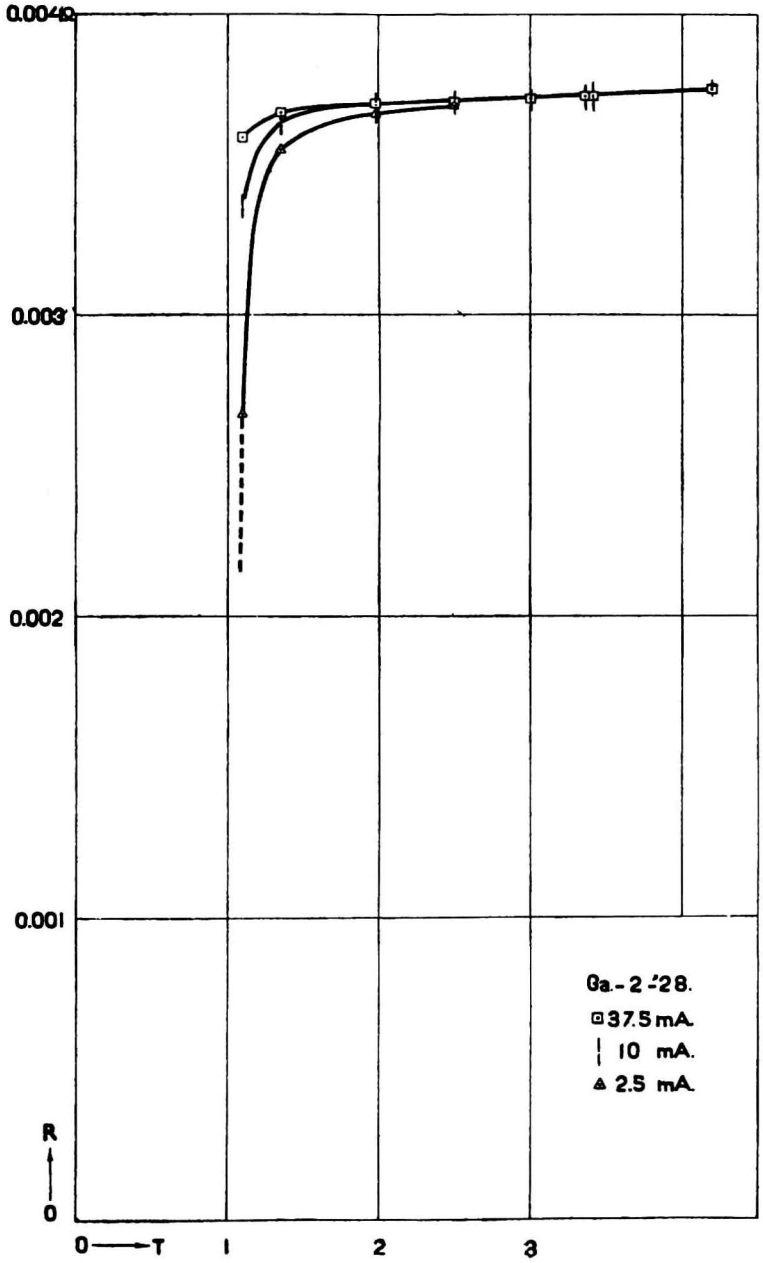

Fig. 1.

§ 4. *Abnormal phenomena.*

We wish to point out the following abnormal phenomena.

1. The fall of the resistance is of an abnormal character. As can be

seen in the figures, the resistance-temperature lines are very curved at low temperatures, the curve extending over a range of temperature of several

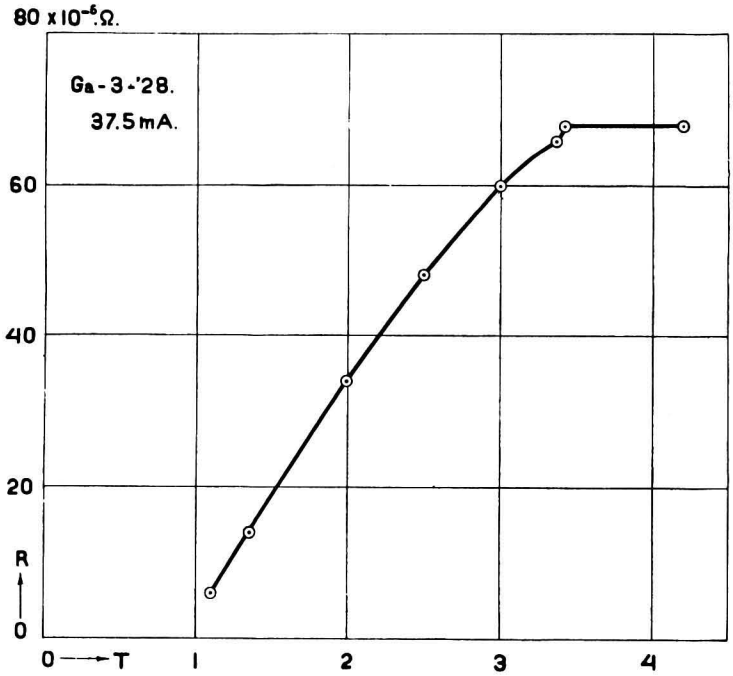

Fig. 2.

degrees. (With ordinary super-conductors the curve only extends over a few 100ths of a degree).

2. The resistances, as stated above, are very sensitive to current.

3. At the transition point of indium (3°.42 K.) in *Ga-3-'28* a slight extra decrease of resistance appears. Fig. 2.

4. If the behavior of the two resistances is compared it is found that *Ga-3-'28*, with more indium impurity, decreases much more in the temperature range 4.2 K. to 1.1 K. than *Ga-2-'28* does.

In the same way (contrary to MATTHIESEN's rule) the resistance at 4.2 K. as compared to that at ordinary is much more reduced in *Ga-3-'28* (the impure) than in *Ga-2-'28*.

5. The result from *Ga-3-'28* seem to show a similarity with those found by TUYN and KAMERLINGH ONNES for some cadmium resistances.