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The Wiedemann Effect of the Magnetostriction Alloy "Alfer" at High Temperatures*

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Synopsis

The Wiedemann effect of "Alfer" (12.91 per cent Al–Fe alloy) was measured with the annealed specimen at high temperatures. As the temperature rises, the effect gradually decreases at the constant current through the specimen, and also the higher the temperature is, the weaker the field is for the maximum effect. When the current through the specimen as well as the longitudinal field is constant, the effect gradually decreases with the rise of temperature, and bcecomes extremely small at the magnetic transformation point of the Fe_3Al superlattice, and vanishes at the magnetic transformation point of α phase. The effect of Ni and Fe was measured to compare with that of Alfer. The temperature dependence of the effect of Ni is similar to that of Alfer, but that of Fe is different from both, that is, it gradually increases as the temperature rises, and after reaching a maximum at about 600°C, rapidly decreases, becoming zero at the magnetic transformation point.

I. Introduction

The present authors[(1)] previously measured the Wiedemann effect of the magnetostriction alloy "Alfer" at room temperature. Since then measurements were made on the effect successively at elevated temperatures at intervals of 100°C almost up to the magnetic transformation point. The results will be stated below.

Up to recent year very few research works have been reported on the Wiedemann effect at elevated temperatures but only a few treated of Fe and Ni. C. Knott[(2)] measured the effect of Ni wire up to 100°C and found that the effect decreased as the temperature rose. Tanakadate and Shimizu[(3)] made their experiments on Fe, Ni and Fe–Ni alloy and found out that the effect of Fe gradually increased with the temperature, reached the maximum near 600°C, then decreased, while the effect of Ni was observed to decrease as the temperature rose. Here, it must be considered that the specimens they used were not annealed after being cold worked by drawing, and this may explain the remarkable difference observed between the processes of heating and cooling.

In this experiments, the specimens were previously heated at 1000°C for an hour, then gradually cooled and below 700°C cooled down at the rate of 30° per hour.

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* The 877th report of the Research Institute for Iron, Steel and Other Metals.

(1) Y. Shirakawa, T. Ôhara, T. Abe, Sci. Rep. RITU, **9** (1957), .

(2) C. Knott, Trans. Roy. Soc. Edin., **32** (1883), 193.

(3) S. Shimizu, and T. Tanakadate, Tôkyo Sûgaku Buturi Kiji, **3** (1906), 142.

As to the specimens, the apparatus and the method of observation, a detailed explanation was given in the preceding paper[1].

II. The results of measurements

First, the specimen placed in the magnetizing coil was heated to a constant temperature, then the current of 8 A was passed through it to make the circular field, and after the temperature of the specimen heated by Joull's heat generated by the current in it became constant, the current was passed through the magnetizing coil to measure the effect affected by the longitudinal field, that is, the torsion of the specimen by scale and telescope. Thus, the torsion curves were obtained as shown in Fig. 1. In this figure, the obscissa is the external longitudinal field H in logarithmic scale, and θ is the angle of the twist per unit length.

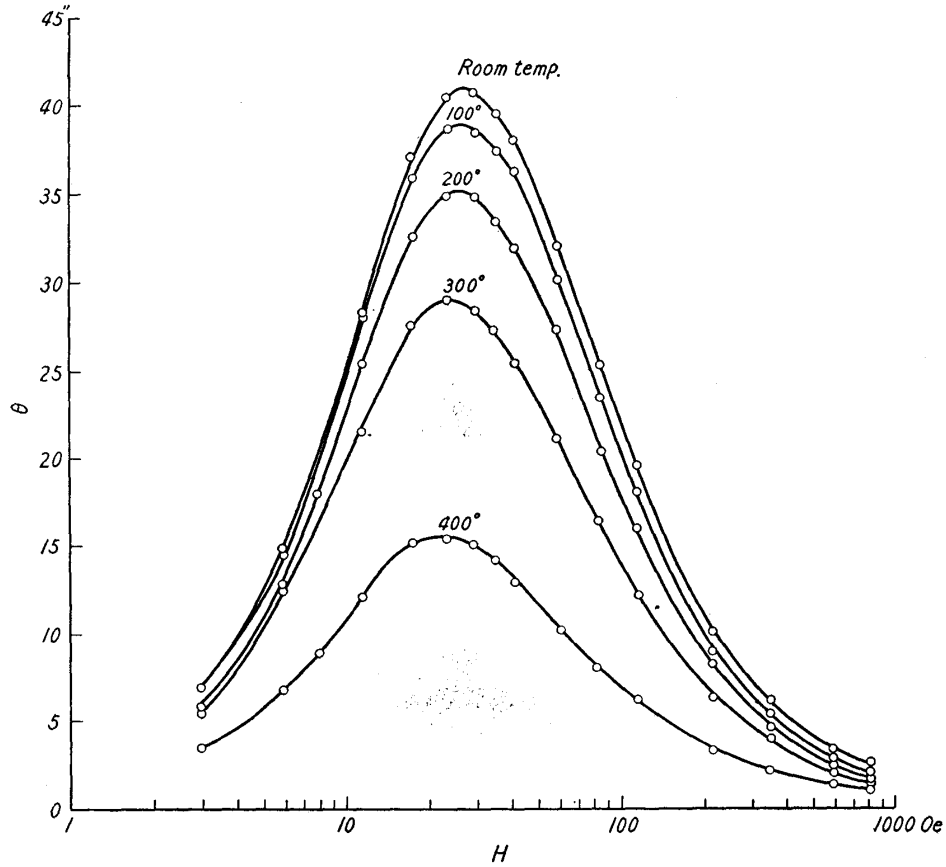

Fig. 1. Relation between twisted angle at i=8A and longitudinal external field at elevated temperatures for Alfer.

The temperature at which measurement was performed is also given on the curve. Here, the density of the current is 1.13 A/mm and the circular field on the surface of the specimen is 10.7 Oe. As shown in the figure, the curves are silimar to one another, that is, as the field H increases, the angle θ increases, first slowly then rapidly until it reaches the maximum at which it begins to decrease. The higher the temperature is, the smaller the effect becomes, and also the longitudinal field H_m showing the maximum of the effect θ_m becomes lower. The relation between

θ_m and H_m is almost linear except the cases at high temperatures. These values are shown in Table 1. From Fig. 1 the relation between θ (the angle of the twist) and T (the temperature) at the constant longitudinal external field was obtained as shown in Fig. 2. At any longitudinal field the influence of temperature on the effect resembles that on the magnetization curves and the effect is seen to decrease

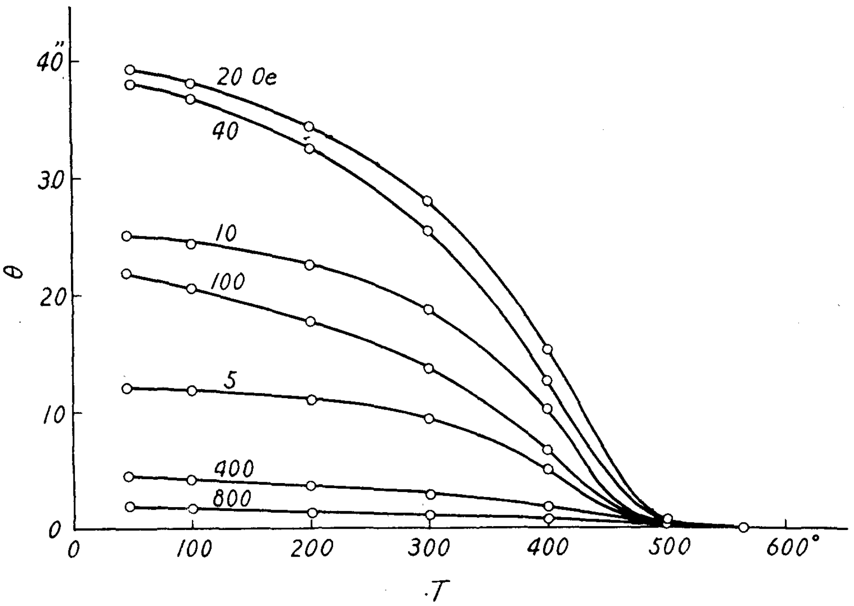

Fig. 2. Relation between twisted angle at $i = 8$ A and temperature at constant longitudinal external field for Alfer.

with the rise of temperature, and at the temperature near the magnetic transformation point of the superlattice of Fe_3Al (about 510°C), the effect suddenly becomes small and then disappears at 580°C, near the magnetic transformation point of α-phase. Such a behavior cannot be observed clearly in the cases of both considerably high and low fields. As the origin of the Wiedemann effect is clearly to be attributed to the longitudinal magnetostriction, the behavior of longitudinal magnetostriction for "Alfer" at elevated temperatures may be estimated from these results of observation.

In the previous paper(1) the effect of Alfer at room temperature was reported together with the effect of Ni and Fe. From these results, it was found that the effect of Ni was quite contrary to that of Alfer in the sign of torsion, while those two effects were nearly equal to each other in quantity and that the effect of Fe was very small as compared with those of Ni and Alfer.

In the present case, the effects of both Ni and Fe were also measured at elevated temperatures, and the results obtained were compared with that of Alfer. The effect of Ni is given in Fig. 3. The sign of torsion for Ni is opposite to that of Alfer, though the whole aspects of both curves are almost similar to each other. From Fig. 3, the longitudinal field H_m corresponding to the maximum twisted angle θ_m was obtained as given in Table 1 at each temperature. As in the case of Alfer, the relation between θ_m and H_m is linear. The θ–T curves for

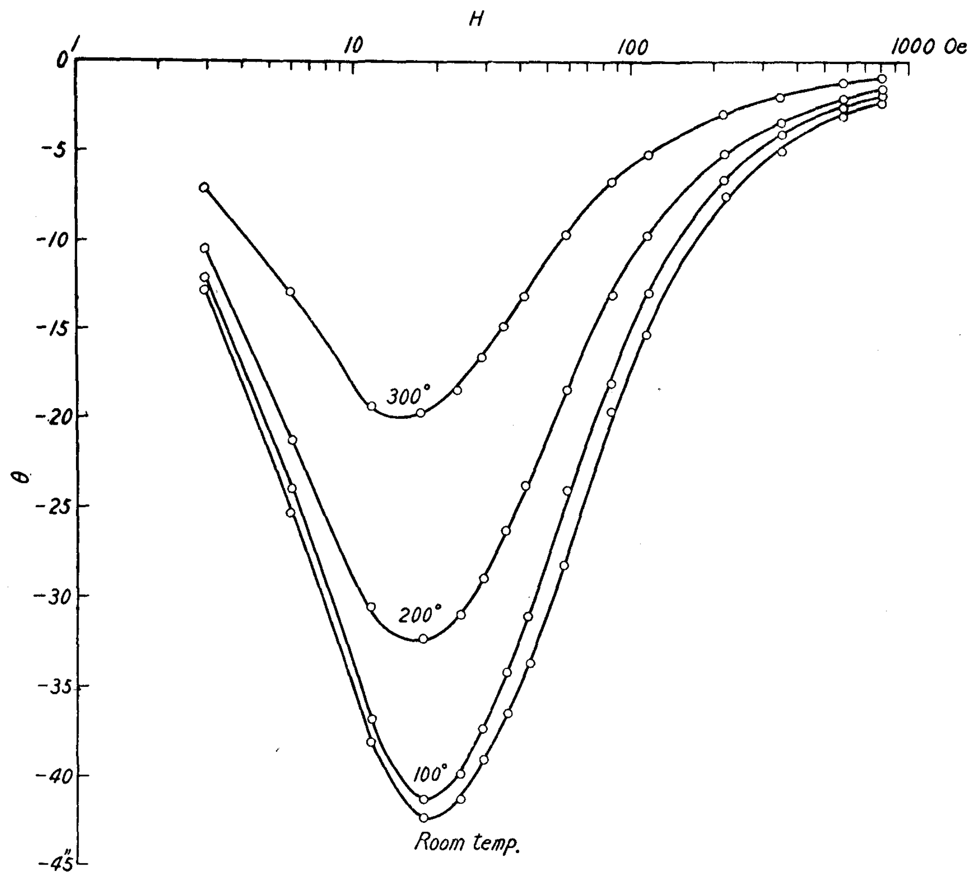

Fig. 3. Relation between twisted angle at $i = 8$ A and longitudinal external field at elevated temperatures for Ni.

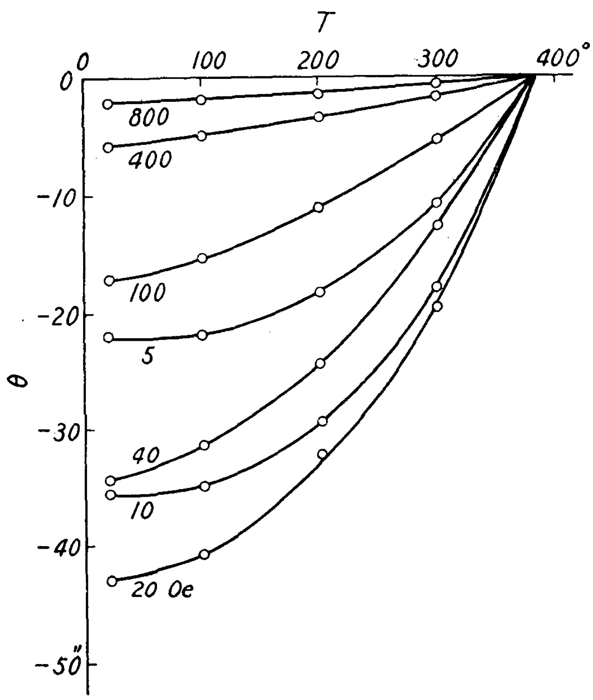

Fig. 4. Relation between twisted angle at $i = 8$ A and temperature at constant longitudinal external field for Ni.

Ni are given in Fig. 4. The absolute value of twisted angle θ decreases as the temperature rises, and then disappears at 380°C near the magnetic transformation point. As the magnetic transformation point of Ni is low compared with that of Alfer, the slope of the θ-T curves for Ni is a little sharper than that for Alfer.

Fig. 5 shows the results of measurement carried out on the specimens made from Blogen iron. As seen in the figure, the torsion curves at elevated temperatures are similar to one another. The longitudinal magnetic field H_m showing

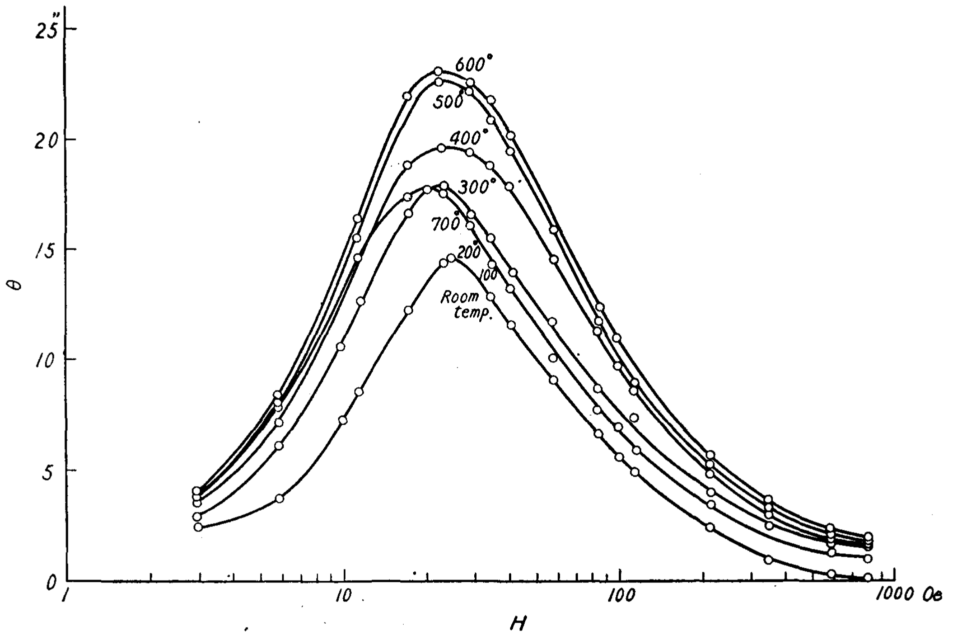

Fig. 5. Relation between twisted angle at $i = 8$ A and longitudinal external field at elevated temperatures for Fe.

the maximum of the twisted angle θ_m at each temperature is given in Table 1. With the exception of the value at 700°C, the relation between θ_m and H_m is almost linear. In the cases of Alfer and Ni, both of them are in proportion to each other, whereas in the case of Fe the relation is inversely proportional. The twisted angle vs. temperature curves at constant longitudinal field are shown in Fig. 6. As reported in the previous paper(1), the effect of Fe is extremely small at room temperature as compared with that of Alfer or of Ni, while at the higher temperatures it becomes larger, that is, the temperature depence of the

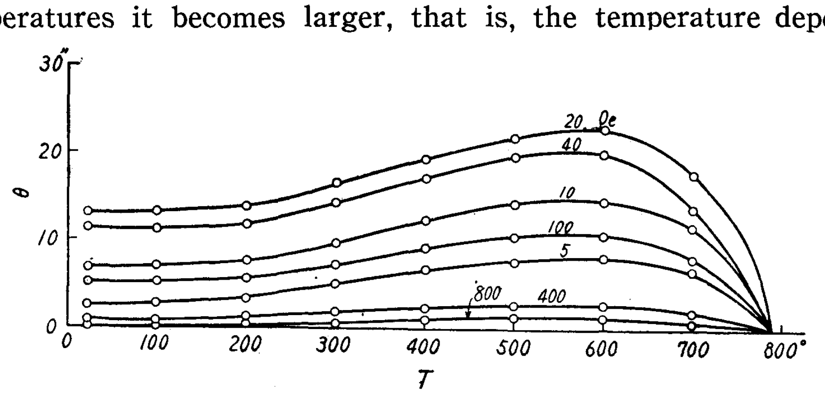

Fig. 6. Relation between twisted angle at $i=8$A and temperature at constant longitudinal external field for Fe.

The following table has been missed in the paper, "The Wiedemann Effect of the Magnetostriction Alloy "Alfer" at High Temperatures" by Yûki SHIRAKAWA, Tôru ÔHARA and Takeshi ABE, in the last issue, Vol. 9. No. 3, Page 184.

Table 1. Maximum twisted angle (θ_m) and longitudinal external field (H_m) at high temperatures (T).

Temperature	Alfer		Ni		Fe	
T (°C)	Maximum twisted angle $\theta_m('')$	Longitudinal field H_m (Oe)	Maximum twisted angle $\theta_m('')$	Longitudinal field H_m (Oe)	Maximum twisted angle $\theta_m('')$	Longitudinal field H_m (Oe)
Room	41.8	27.0	42.4	18.0	14.3	25.0
100	39.0	26.0	41.2	17.5	14.3	25.0
200	35.2	25.0	32.3	16.5	14.3	25.0
300	29.3	23.5	19.8	15.0	17.8	23.5
400	15.6	22.5	—	—	19.6	23.0
500	—	—	—	—	22.7	22.8
600	—	—	—	—	23.1	22.5
700	—	—	—	—	17.8	20.5

effect for Fe is quite different from those of Alfer and Ni. As shown in the figure, the effect at 20 Oe increases first slowly as the temperatures rises, then increases more rapidly at about 200°C and gradually reaches a maximum at 600°C, at which it begins to decrease, disappearing at the transformation point. This behavior becomes more feeble as the field increases or decreases from the value of 20 Oe, which almost coincides with the data by S. Shimizu and T. Tanakadate, and may be explained from the experimental result of magnetostriction of Fe at higher temperatures.

Summary

The Wiedemann effect of new magnetostriction alloy "Alfer" was measured at intervals of 100°C and the following results were obtained:

(1) The effect decreases as the temperature rises and it becomes extremely small near the magnetic transformation point of the Fe_3Al superlattice, and vanishes at the magnetic transformation point of α phase (580°C).

(2) The longitudinal magnetic field (H_m) corresponding to the maximum value of the effect (θ_m) in the constant circular magnetic field decreases as the temperature rises. The relation between H_m and θ_m is linear.

(3) In a constant longitudinal magnetic field, the relation between the effect and the temperature is similar to that between the magnetization and temperature.

(4) The same measurements were carried out on Ni and Fe with the following results. The influence of the temperature on Ni is similar to that on Alfer, that is, the effect decreases as the temperature rises, and on the other hand, the effect of Fe gradually increases as the temperature rises, and reaches the maximum at about 600°C and then decreases as in the cases of Ni and Alfer until it vanishes at the magnetic transformation point.

In conclusion, the present authors wish to express their hearty thanks to Dr. Hakaru Masumoto, the president, under whose kind guidance and encouragement this experiment was performed. They also thanks cordially to Mr. Yoshiyuki Satô for his co-operation to the adjustment of measuring apparatus.

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