ence of these compounds was supposed to render it impossible to obtain a crystal orientation by solidifying or recrystallizing. Consequently, alloys were prepared by melting in pure argon, starting from pure metals and using crucibles of pure aluminium oxide sintered at about 1900 °C. Rods of these alloys obtained by means of a slightly modified Czochralski method contained large crystals with a [100] axis nearly parallel to the direction of pulling. This was particularly pronounced if the titanium used was iodide titanium⁶. Exceptionally high values of \((BH)_{\text{max}}\) could be obtained in these alloys by a heat treatment according to the isothermal method. For instance: a \((BH)_{\text{max}}\) value of 11·0 million gauss oersteds at a remanence of 11 800 gauss and a coercivity of 1315 oersteds (see fig. 1) could be reached with a pure alloy of the composition 35% Fe, 34% Co, 15% Ni, 7% Al, 4% Cu, 5% Ti.

**Eindhoven, October 1956**

**REFERENCES**

3) Patents pending.

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**THE INFLUENCE OF IMPURITIES ON THE RECRYSTALLIZATION TEXTURE OF COLD-ROLLED 3-% SILICON IRON**

by J. D. FAST

A procedure invented by Goss ¹) makes it possible to produce polycrystalline 3-% silicon-iron sheet wherein the component crystals are oriented such that one of their directions of easiest magnetization is nearly parallel to the direction of cold-rolling. This grain-oriented sheet with texture \((110)[001]\) is produced in fairly large quantities, but the way in which the crystal orientation is brought about is not yet fully understood and the production of the sheet does not always give the desired results.

In order to study the influence of impurities on the crystal orientation we started with making very pure silicon iron by preparing the alloy from the pure elements in a high vacuum and casting it under the same conditions ²). Remarkably enough it proved to be impossible to get the desired orienta-
tion in this pure alloy), whereas the same rolling and annealing produced a good texture in technical silicon iron with the same silicon content. In further experiments we added measured quantities, in each case of one element, to pure silicon iron alloys. It was found that the (110) [001] texture is readily obtained by introducing nitrogen into pure silicon iron before cold-rolling. Introducing nitrogen into technical silicon iron increases the reproducibility of the Goss procedure. The best results were obtained with nitrogen contents lying between 0·01 and 0·1 wt %. In order to obtain good magnetic properties it is necessary to expel the nitrogen in the final heat treatment. This is achieved by heating in very pure hydrogen. An excellent texture is obtained if the heating is effected in two stages, for example by first heating the sheet at about 600 °C, causing primary recrystallization, and subsequently at 950 °C or a higher temperature, causing secondary recrystallization.

In one of the experiments a bar of pure silicon iron containing 2·8 wt % Si was heated at 850 °C in an atmosphere of hydrogen and rolled to a thickness of 3·0 mm while still hot. The sheet was divided in two and nitrogen was introduced in one half by heating it for two hours at 550 °C in a gas stream of the composition 87 vol % hydrogen and 13 vol % ammonia. Small quantities of ammonium chloride were added to the gas mixture in order to prevent the formation of a SiO₂-containing film not readily pervious to nitrogen. After a subsequent homogenizing heat treatment at 760 °C the nitrogen content was found to be 0·076 wt %, whereas the other half in which no nitrogen was introduced was found to contain less than 0·001 wt % N. Both halves were cold-rolled to a thickness of 0·3 mm, the rolling being interrupted at a thickness of 0·6 mm to give the metal a heat treatment at 900 °C in a non-purified mixture of nitrogen and hydrogen. The final recrystallization was carried out in very pure hydrogen (pressure of water vapour less than 10⁻⁴ mm mercury) by heating the alloy for four hours at 600 °C and then for four hours at 950 °C. After this heating the sheet in which nitrogen was introduced consisted of large crystals 10 to 30 mm in diameter. The permeability measured in the normal way in a direction parallel to the rolling direction at a field strength of 10 oersteds was 1850. The nitrogen content had decreased from 0·076 to 0·002 wt %. The other half of the material in which no nitrogen was introduced consisted of crystals only 0·1 to 0·3 mm in diameter. The permeability in the rolling direction at a field strength of 10 oersteds was only 1470.

Eindhoven, October 1956

REFERENCES

1) N. P. Goss, U.S. Patent 1,965,559
3) Belgian Patent 541 487.