An Experimental Study of Barkhausen Noise in Nickel-Iron Alloys

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INTRODUCTION

THIS experimental study of the Barkhausen effect in nickel-iron alloys was undertaken in the Magnetics Division of the Naval Ordnance Laboratory as a part of its program of developing improved magnetic materials for military and industrial applications. This particular study has yielded practical results in the form of a high permeability magnetic core material with minimum Barkhausen noise. As a by-product of this development, experimental data were obtained showing the dependence of Barkhausen noise on alloy composition and heat treatment and showing a correlation with initial permeability.

MEASUREMENT TECHNIQUE AND APPARATUS

Figure 1 is a schematic drawing of the apparatus used. The samples under test were 0.014-inch strips, $\frac{1}{8}$ inch wide and 4 inches long. They were cyclicly magnetized by means of a magnet rotating at approximately 33 rpm. This system was used because of its convenience, although it is realized that the direction of the applied field continually changes. The shielded search coils were connected to an amplifier with low input noise level followed by a high pass filter and then a Ballantine electronic voltmeter as the output meter. The average between the maximum and minimum deflections of the voltmeter during a cycle of magnetization was taken as the average noise per cycle.

MEASUREMENT RESULTS

By use of the method described above, measurements were taken on samples of binary nickel-iron alloys ranging in composition from 35–99.5 percent Ni. The samples were prepared from materials melted, processed, and heat treated in the Magnetics Division of the Naval Ordnance Laboratory. Samples of molybdenum nickel-iron alloys were also measured.

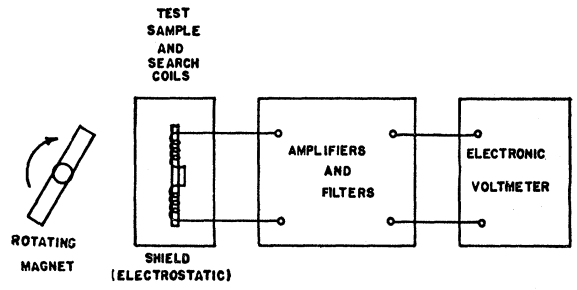

FIG. 1. Block diagram of Barkhausen comparator.

Figure 2 shows average noise per cycle as a function of composition for three conditions of heat treatment; namely, bake, anneal, and quench. This figure clearly shows the dependence of noise on composition and heat treatment for the binary-nickel-iron series.

Figure 3 was obtained from measurements on ternary molybdenum nickel-iron samples (79 percent Ni, 4 and 5 percent Mo), heat treated so as to obtain various

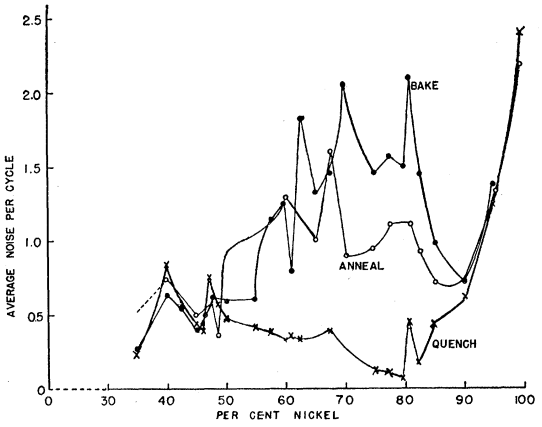

FIG. 2. Variation of magnetic noise with composition and heat treatment of binary nickel-iron alloys.

values of initial permeability. It is a plot of average noise per cycle *versus* initial permeability. The values of initial permeability were obtained from ballistic measurements at $B=20$ gauss on ring laminated samples cut from the same sheets and processed and heat treated simultaneously with the strips used in

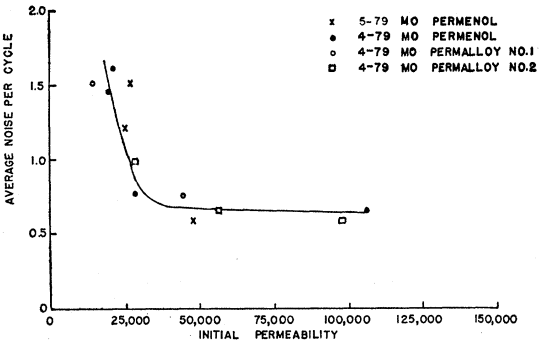

FIG. 3. Magnetic noise *vs* initial permeability of ternary Mo-Ni-Fe alloys.

obtaining the noise data. This figure shows a definite dependence of noise on initial permeability.

CONCLUSION

The results of this brief experimental study summarized in Fig. 2 and Fig. 3 have been presented here with the hope that they may be useful in further development of the theories relating to the Barkhausen effect and the magnetization curve.

It is planned to extend this study further, with (1) improved measurement techniques, (2) different sample configurations, and (3) other alloys.