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2,114,183

METHOD OF MAKING MAGNETIC MATERIAL

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Fig. 1.

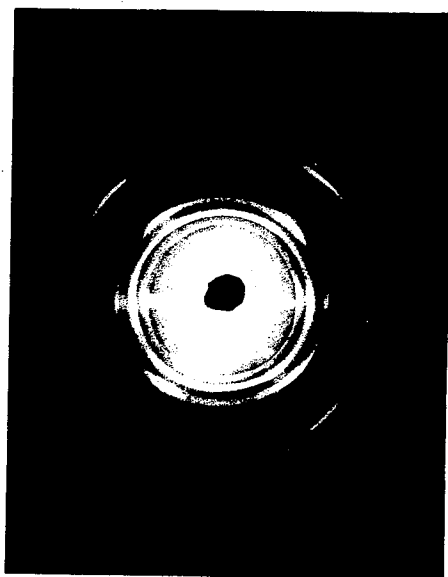
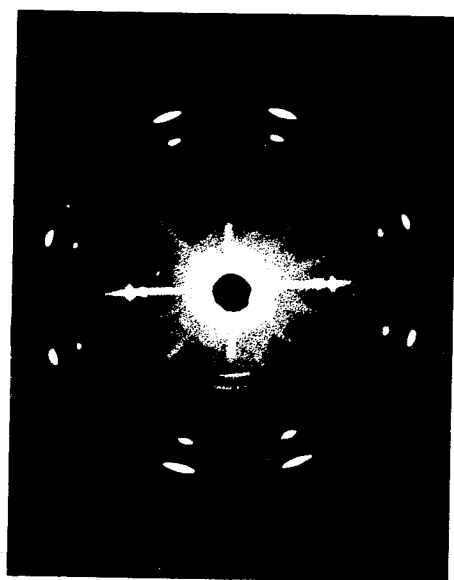


Fig. 2.



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METHOD OF MAKING MAGNETIC MATERIAL

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1 Claim. (Cl. 148-12)

In Goldschmidt et al. Patent 1,801,150 a core is described which is used for magnetic purposes, especially such purposes where slight instability is important and where the required instability is produced, not by spatial subdivision of the path of the lines of force, but by a suitable treatment of the material itself. A suitable method of obtaining the desired low instability in the material has been found to be a cold deformation after the last annealing. The most favorable ultimate degree of elongation, in this case, varies according to the choice of material. For the binary iron-nickel alloys the most favorable degree of elongation with regard to the lowest possible instability desired was found to be about 25%. With higher degrees of elongation, an increased instability occurs. However, the material behaves otherwise with regard to hysteresis. The hysteresis constant steadily decreases with an increasing degree of elongation, but since with the high degree of elongation, in the case of the binary iron-nickel alloys, the instability is increased, the favorable influence of high degrees of elongation on the hysteresis could not be utilized in the case of these alloys. On the other hand, if a third constituent is alloyed with the iron-nickel alloy, such, for example, as aluminum, and particularly copper in suitable quantities, the resulting alloy behaves differently. A result can thereby be obtained whereby the instability, which has attained its most favorable low value in these alloys with a 25-40% reduction in thickness, is not impaired again by a further increase in the degree of elongation but remains substantially constant, while the hysteresis decreases in the same way as in the binary alloys with an increasing degree of elongation. The ratio

$$\frac{h}{u_0}$$
 hysteresis constant
initial permeability

which is characteristic for the quality of a magnetic field, may be reduced in this case to values not inconsiderably below those obtained with compressed iron powder cores.

The subject of the present invention is a method by means of which ternary alloys and materials other than those mentioned above can be brought into a condition in which the hysteresis and the instability simultaneously or almost simultaneously reach their lowest values. This method takes into consideration not only the magnitude of the ultimate degree of elongation but also the magnitude of the degree of elongation which precedes the last annealing and which

hereinafter is designated as a preliminary degree of elongation in contradistinction to the subsequent degree of elongation which is intended to represent the ultimate degree of elongation to which consideration was alone hitherto to given. The magnitude of this preliminary degree of elongation was regarded hitherto as unimportant, since it was thought that by a high degree of annealing and further considerable cold elongation the effect of the cold elongation preceding the annealing was entirely neutralized, in so far as work was not accomplished just within the range of the so-called critical degree of elongation which, however, was generally avoided.

In the following, the method according to the present invention is illustrated in detail by means of an example. As material, a binary alloy sintered from nickel and iron carbonyl with 40% nickel and 60% iron was employed. This alloy was worked up into strips of 0.06 mm. thickness. The preliminary degree of elongation amounted to 50% in tests set forth in column 1 of the following table, while in the tests set forth in column 2, it was greater than 90%. In both columns the values for the hysteresis constant h , quality factor

$$\frac{h}{u_0}$$

and instability s are indicated, the latter in percent, existing with equal final degrees of elongation. It is found that, on the one hand, all the values in the tests carried out with a high preliminary degree of elongation, are substantially more favorable and the more so, the higher the preliminary degree of elongation, and that on the other hand, the individual properties exhibit a fundamentally different behavior in dependence on the subsequent degree of elongation according to the preliminary degree of elongation chosen.

Column 1				Column 2			
Preliminary degree of elongation				Preliminary degree of elongation			
50%				90%			
Final degree of elongation	h	$\frac{h}{u_0}$	s	h	$\frac{h}{u_0}$	s	
40 percent	185	22.4	-2	19.6	2.5	+0.7	
60 percent	170	19.7	-4.5	41.6	4.9	+0.6	
85 percent	120	12.8	-9.6	50.2	6.1	-0.20	
90 percent	92	11.3	-11				

Whereas, with a preliminary degree of elongation of 50% corresponding to the previously discovered behavior of the binary iron-nickel alloys, the hysteresis constant h and quality factor

$$\frac{h}{u_0}$$

progressively decrease with an increasing degree of elongation without, however, attaining the values of the alloys treated with a high preliminary degree of elongation, both properties, with the high preliminary degree of elongation, have a pronounced minimum which does not fully coincide with the minimum of instability, but which is nevertheless associated with a value of instability which can be regarded for all cases occurring in practice as excellent and not requiring further improvement. It is, therefore, found that by a suitable choice of the preliminary degree of elongation and subsequent degree of elongation, if necessary, taking into account the most advantageous heat treatment between the two cold deformations, the course of the two most important magnetic properties, namely, the instability and the hysteresis, can be so influenced in dependence on the subsequent degree of elongation that a subsequent degree of elongation may be chosen whereby both properties may have substantially their optimum value.

The novel features which are characteristic of our invention are set forth with particularity in the appended claim. The invention itself, however, will be best understood from references to the following specification when considered in connection with the accompanying drawing, in which Fig. 1 is a reproduction of an X-ray defraction pattern of a 40-60% nickel-iron alloy which has been given a preliminary elongation of 50% and a subsequent elongation of 90%; while Fig. 2 is an X-ray defraction pattern of the same alloy which has been given a preliminary elongation of 98% and a subsequent elongation of 60%.

Figs. 1 and 2 of the drawing illustrate the difference which exists with regard to the structure of material produced by the process according to the invention and a material produced by

the hitherto usual process. It is seen that in the material illustrated in Fig. 2, the atomic arrangement obtained is of a different character and is essentially more clearly marked than that illustrated in Fig. 1. Thus by means of the high preliminary degree of elongation in conjunction with the temperature of the following heat treatment a predetermined recrystallization temperature is obtained which on its part, leads to a particularly well defined atomic arrangement in the last treatment. The conditions of tension and hardness produced by the cold elongation in the material, therefore, occur simultaneously with a position of the crystallites particularly favorable for magnetization.

The use of the process according to the invention is, of course, not limited to binary iron-nickel alloys but can also be used with other alloys such, for example, as the well-known ternary alloys or quaternary alloys, etc. or with alloys in the case of which equally favorable values hitherto could not be obtained. The method can also be used to obtain the most favorable magnetic properties obtainable in the case of alloys rich in iron, without the expensive nickel and thus render the cheap alloys applicable for many purposes for which hitherto more expensive alloys had to be used. The most favorable value of the preliminary degree of elongation and subsequent degree of elongation in this case varies, of course, according to the material chosen. It can, however, be experimentally determined in every case without difficulty. In the same way the influence of the most favorable method of heat treatment between the two cold deformations and any subsequent annealing treatment can readily be determined by experiment.

What we claim as new and desire to secure by Letters Patent of the United States, is:

The process of making a nickel-iron magnetic material containing about 40% nickel and about 60% iron which comprises cold rolling the material to effect an elongation of about 98%, annealing the material and completing said process by cold rolling the material to effect an elongation of about 60%.

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