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FERRITE WITH CONSTRICTED MAGNETIC HYSTERESIS LOOP

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FIG. 1

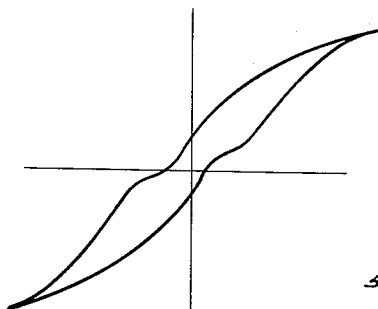


FIG. 2

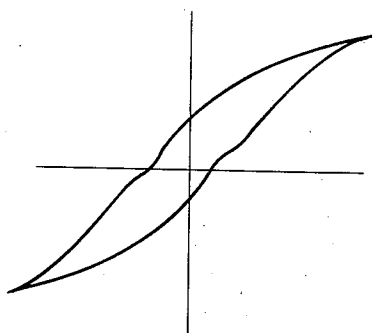


FIG. 4

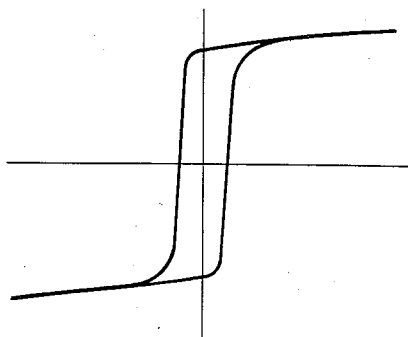
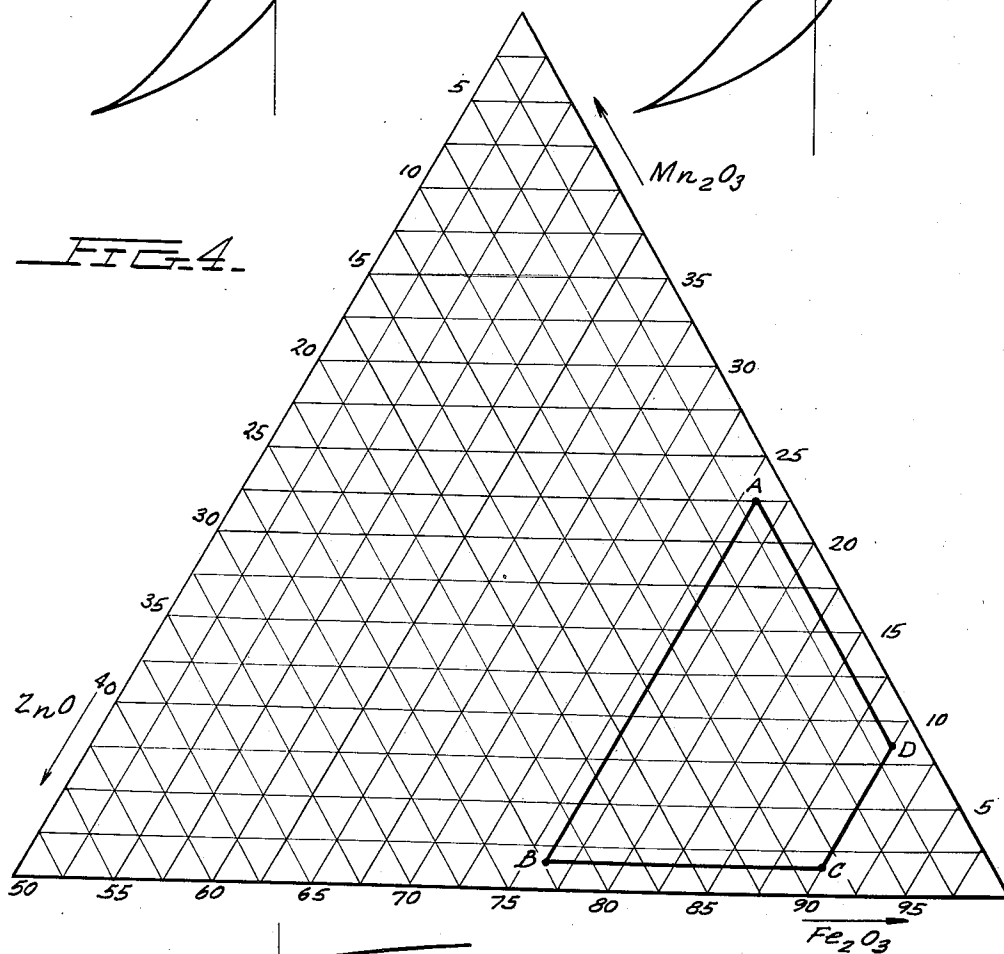


FIG. 5

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FERRITE WITH CONSTRICTED MAGNETIC
HYSTERESIS LOOP

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4 Claims. (Cl. 252—62.5)

Ferromagnetic metals with constricted hysteresis loops (see, for example, Bozorth, "Ferromagnetism," by Nostrand Co., Inc., 1951, pages 498 to 499), have, as is well known, at small field strength within the constriction area, constant permeability, i.e., permeability independent of the field strength equal to the initial permeability, very low hysteresis losses and, in general, small residual losses. As indicated in the above cited literature, such materials may be subjected to thermo-magnetic treatment. By thermomagnetic treatment, in this connection, is meant the passing through a thermic cycle during the simultaneous presence of a magnetic longitudinal or transverse field. The concept of longitudinal or transverse field, in this connection, to be understood as relative to the later measuring field; a longitudinal or transverse field, respectively, means that such field, during the thermomagnetic treatment, is parallel, respectively vertical, to the later measuring field. Through this type of treatment, these ferromagnetic materials display a substantial alteration of the form of the hysteresis loop, and hence a change of the magnetic properties.

This invention is based on the discovery that it is possible to make specific ferrites showing a constricted magnetic hysteresis loop which are, consequently, capable of thermomagnetic treatment similarly as for metals.

The invention teaches the production of such ferrites of the manganese-zinc ferrite-system which can be subjected to thermomagnetic treatment of the above type, and are distinguished from hitherto familiar ferrites by the fact that, under the same manufacturing conditions, they have constricted hysteresis loops.

In accordance with the invention, ferrites with this characteristic in the manganese-zinc-ferrite-system must have a composition of at least 50 mol percent Fe_2O_3 , and a small addition of cobalt oxide. The addition of cobalt oxide is suitably determined between 0.1 and 5% by weight, calculated on the total basic batch of the manganese-zinc-ferrite, expressed in metallic oxides. The invention has shown that it is particularly advantageous to choose the cobalt oxide content between 0.35 and 1.5% by weight, calculated on the basic batch. The manganese-zinc-ferrites in question, which react strongly to the addition of cobalt oxide with a constricted loop, cover, in the three-component system Fe_2O_3 — Mn_2O_3 — ZnO , the area defined in the attached diagram Fig. 4 by the quadrangle A, B, C, D. The compositions at the corners in percent by weight, are (see Fig. 4):

	Fe_2O_3	Mn_2O_3	ZnO
A-----	76	22.5	1.5
B-----	76	1.5	22.5
C-----	90	1.5	8.5
D-----	90	8.5	1.5

The above ferrites may be prepared in the usual way, either by joint or partial precipitation, from corresponding metal salt solutions, or, as is customary in ceramic arts, they may be prepared for further processing by wet

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milling and mixing of the respective metal oxides. The powdered mixtures thus obtained may, after drying, be given the desired form either immediately by dry pressing, extruding, or similar methods, or it may be desirable, before ceramic forming, to proceed with a calcining firing of the entire composition or only a part thereof, preferably between 750° C. and 1200° C. The resultant parts are sintered at between 1250 and 1380° C., depending on the composition. To produce the constricted hysteresis loop in ferrites, in accordance with invention, it is necessary that the cooling take place slowly, particularly in the temperature range between 700° C. and room temperature. The cooling speed is dependent upon the volume of the fired body. As a criterion, it may be stated that for a ring of about 46 mm. outside diameter, 34 mm. inside diameter, and 10 mm. height, the cooling time from 700° C. to room temperature should take not less than 12 hours. If the rings are cooled rapidly, the effect of loop constriction does not occur. However, the constriction may be regained even for rings cooled too rapidly, by re-heating them to a temperature of about 700° C., and cooling them slowly, as above described.

An example of the invention follows hereafter:

In a steel ball mill are ground together 400 g. Fe_2O_3 , 37.5 g. Mn_2O_3 , 62.5 g. ZnO , 3.25 g. CoO . After 6 hours of grinding, the slip is poured through a 4900 mesh screen (4900 meshes per square cm.) into a porcelain dish, and dried. The powder, thus obtained, is pressed, according to ceramic pressing techniques, into rings having dimensions of 59 mm. outside diameter, 35.8 mm. inside diameter, and 12 mm. height, the amount of pressure applied being about 0.5 to 1 ton/cm.². The ring or toroid pieces, thus obtained, are sintered in a kiln at 1350° C., for two hours, whereupon the heat is shut off. The rings are cooled to room temperature in the kiln during a period of approximately 24 hours. The ferrite rings thus obtained are provided with 0.4 mm. copper enameled wire with 100 windings as primary winding, and, as secondary winding, further 200 windings with 0.2 mm. copper enameled wire are applied. The oscillographic photograph of this ferrite, produced in accordance with the invention, is shown in Fig. 1, and one can distinctly recognize the loop constriction of the hysteresis loop, in contrast to a ferrite of the same basic batch but without the addition of cobalt oxide (Fig. 2).

The following experiment proves that ferrites produced in accordance with the invention are susceptible to thermomagnetic treatment:

The ferrite toroid as in the example, with 100 windings as a primary winding, is placed in a kiln. While heating to 600° C., and slow cooling for 12 hours to room temperature, a longitudinal magnetic field is maintained by means of the ring winding by 1 A direct current, corresponding to a magnetic field strength of about 15 A-windings/cm. If the hysteresis loop of the ferrite after this thermomagnetic treatment is recorded in the same manner as described above, the result is analogous to that of metals which have been subjected to heat treatment in the longitudinal magnetic field; a complete change of the form of the hysteresis loop takes place, as may be seen in Fig. 3. In analogous manner, heat treatment in the transverse magnetic field may be carried out with corresponding effect; (see the above cited book by Bozorth).

The technical progress obtained with such ferrites in accordance with the invention, may be seen in the following: with thermic longitudinal magnetization, for example, ferrites with distinctly rectangular hysteresis loop may be produced which are of importance to the entire fields of electronics and for magnetic amplification, for telephone and high-frequency fields; with thermic cross magnetization, ferrites of high quality and

a permeability independent of field strength may be produced, which are particularly suitable for the field of telecommunication.

I claim:

1. A fired ferrite body having a constricted magnetic hysteresis loop on which ferrite is susceptible to thermomagnetic treatments to alter the hysteresis loop characteristics, said ferrite being of the manganese-, zinc-, iron oxide system containing a small proportion of cobalt oxide, the iron oxide content of said composition being at least 50 mol percent expressed in metal oxides, said constricted magnetic hysteresis loop characteristic being obtained by gradually cooling the fired body from 700° C. down to room temperature over a period of at least twelve hours.

2. A fired ferrite body as claimed in claim 1 in which the cobalt oxide content is between 0.1 and 5% by weight and preferably between 0.35 and 1% by weight.

3. A fired ferrite body as claimed in claim 2 in which the manganese oxide, zinc oxide and ferric oxide is within area ABCD of Fig. 4 of the drawing, the corners of said area representing the following compositions:

A=22.5% Mn_2O_3 , 1.5% ZnO, 76% Fe_2O_3 , by weight.
B=1.5% Mn_2O_3 , 22.5% ZnO, 76% Fe_2O_3 , by weight.
C=1.5% Mn_2O_3 , 8.5% ZnO, 90% Fe_2O_3 , by weight.
D=8.5% Mn_2O_3 , 1.5% ZnO, 90% Fe_2O_3 , by weight.

4. A process of making a ferrite body with a constricted hysteresis loop which is susceptible to thermomagnetic treatment to change the hysteresis loop characteristics comprising providing a milled powder mixture, consisting essentially of manganese oxide, zinc oxide, ferric oxide and 0.1 to 5% by weight of cobalt oxide, the pro-

portions of manganese oxide, zinc oxide and ferric oxide being within the area A—B—C—D of Fig. 4 of the drawing the corners of said area representing the following compositions:

A=22.5% Mn_2O_3 , 1.5% ZnO, 76% Fe_2O_3 , by weight.
B=1.5% Mn_2O_3 , 22.5% ZnO, 76% Fe_2O_3 , by weight.
C=1.5% Mn_2O_3 , 8.5% ZnO, 90% Fe_2O_3 , by weight.
D=8.5% Mn_2O_3 , 1.5% ZnO, 90% Fe_2O_3 , by weight.

molding the powder to shape, sintering at about 1250° C. to 1380° C. and thereafter cooling slowly from about 700° C. down to normal room temperature, over a period of at least about twelve hours.

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