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PRODUCTION OF FINELY DIVIDED MAGNETIC BODIES

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At the present time for light electrical work, especially for audio or radio frequency work, magnetic material is used that is finely subdivided perpendicularly to the direction of the magnetic field for the purpose of avoiding eddy current loss, and is also finely subdivided in the direction of the magnetic field for the purpose of increasing the magnetic stability and reducing the hysteresis. The subdivision for reducing the eddy current loss must be more or less electrically insulating while the subdivision for reducing the hysteresis may be electrically and magnetically insulating or only purely magnetically insulating, that is to say electrically but not magnetically conducting.

The requirements for such magnetic bodies are not ony fine magnetic subdivision but also sufficiently high magnetic conductivity for the field strengths in question, which, in general, are very low, together with sufficient mechanical strength.

Such magnetic bodies are made at the present time by pressing insulated iron powder at high pressures. By a suitable choice of the powder it is also possible to shape magnetic cores from the starting materials with comparatively low pressures. Both the use of comparatively high pressures and also the production of an iron powder, which at comparatively low pressures will give a sufficiently dense core, are technically difficult and expensive. In the pressing process each core, or if the core is composed of several individual rings each ring, necessitates a special pressing process in a special mould (matrix).

The present invention affords a new and much improved method of solving the problem of producing finely subdivided magnetic cores with sufficiently high permeability and low eddy current loss. The invention is based on the discovery that in the usual pressing process the actual compression of the starting material is small in comparison with the pressure used. According to the invention a very much greater degree of compression or increase in the density is produced by not merely subjecting the starting material to pressure in a mould but by rolling, hammering, forging or drawing it or subjecting it to a similar working step. This working step must on the other hand be so effected that, in the same way as in the pressing process, the original purely magnetic or magnetic and electrical subdivision of the starting material is to be found at least in part in the finished product.

It is already known to make solid magnetic bodies by sintering and rolling magnetic powder but this known process is concerned with the production of coherent magnetic sheets which are not subdivided magnetically and which are, therefore, useless for the purpose of the present invention.

The rolling or similar working step according to the invention may take place at normal or elevated temperatures, such, for example, as red heat. The individual magnetic elements or particles may consist of powder or of somewhat larger pieces of iron or sheet strips or other material.

The invention may be applied to a mass of individual magnetic parts and insulating material if it is desired to produce a body which will lead to very small eddy current losses. For this purpose it is necessary that the individual iron particles shall be sufficiently finely subdivided in a direction perpendicular to the direction of the field. Particularly for radio frequency purposes the degree of subdivision must be extremely fine. Even with the use of very fine powder the eddy current losses at radio frequency are always substantial in bodies produced by pressing. Nevertheless with such powder only small permeability results even with very high pressing pressure owing to the fine subdivision in the direction of the magnetic field. With the use of mechanical working according to the invention the original approximately round powder particles can be rolled to little sheets so fine that the eddy current loss can be made indefinitely small. Since, on the other hand, the comparatively large surfaces of the little sheets lie in the direction of the field sufficient permeability is nevertheless ensured. Even, however, without insulating material and merely by means of the addition of an electrically conducting non-magnetic material, magnetically stable bodies can be produced which then must be sufficiently finely subdivided into the form of sheets, wires or strips for the purpose of avoiding eddy current losses.

In order that the invention may be clearly understood and readily carried into effect some examples of processes in accordance therewith will now be described in greater detail. It will be understood, however, that the invention is not limited to the methods described in the examples.

1. A mixture of a magnetic powder, for example a hard alloy, with a comparatively small amount of powdered aluminum or copper, is charged into a tube of metal, for example steel or copper, or of other material, and is formed into a flat strip by hammering or rolling. The tubular casing is then removed if necessary. Then in accordance with the kind of working that has been used, and

with the composition of the mixture, the coherent material in sheet or strip form, may be built up into the magnetic body by the addition of insulating material. The sheet of material is subdivided adequately by the aluminum and copper particles in the direction of the magnetic field; however, to prevent undue eddy current losses it is necessary that adjacent sheets be insulated from each other. The conductivity of a body composed of aluminum and iron may, for example, be reduced by heating the product during or after the working step to a temperature at which the aluminum powder, owing to the presence of iron oxides on the iron, is wholly or partially oxidized to aluminum oxide which acts as an insulator.

2. Iron powder is mixed with fine powder consisting of mica, glass, porcelain, or other insulating material suitable for incorporation in magnetic cores, and is rolled between two steel sheets or other solid material. The resultant strip or plate is formed into the desired shape by stamping, cutting, turning, grinding or other process. By adding insulating binding agents such, for example, as rubber, varnish or fibrine to the mixture before the rolling, or by soaking the strips or plates in or painting them with, insulating materials, after the formation of the strip in the manner described above, greater mechanical strength can be produced.

3. Relatively large pieces of iron, coarse or fine iron powder or even little pieces of iron wire, with additional metallic or insulating material, are subjected to a working consisting of rolling, hammering or the like analogous to that of Examples 1 and 2. The iron particles are too big before the working to ensure sufficient freedom from eddy current loss in the finished magnetic bodies for the purpose in question, and in particular at radio frequencies. By the above working, however, they are reduced in one or more dimensions in such a way that they form a core which is, to a very large extent, free from eddy currents. In the case that only metallic material is added to the iron particles, sheets are formed which must be insulated from each other in the building up of the core. In the event that insulating material is added to the iron particles alone or in combination with additional electrically conducting non-magnetic metallic particles, the working operation produces a core which is substantially free from eddy currents.

4. A cylindrical body of very rigid material is surrounded at a distance of, for example, 20 to 50 mm. by a casing of tough material of comparatively small wall thickness. The gap between the two materials is charged with the mixture to be worked. The whole is now subjected to a rolling or drawing process such that the outer casing and the mixture to be worked are strongly pressed together while the cylindrical core of rigid material maintains its original form. The whole is then cut into discs either before or after the inner core is removed and these discs form annular magnetic cores. In order to facilitate the cutting process the inner core may, for example, be composed of ring shaped discs which are held together by a central spindle passing through all of them.

The processes describer can either be combined together either directly or with suitable variations.

What I claim and desire to secure by Letters Patent is:—

1. The method of producing a magnetic body which comprises preparing a mass containing individual magnetic particles and insulating material, and subjecting said mass and said individual magnetic particles to a mechanical deforming treatment at an elevated temperature.

2. The method of producing a magnetic body which comprises preparing a mass containing individual magnetic particles intermixed with electrically conducting non-magnetic particles such as aluminum or copper and insulating material, and subjecting said mass and said individual magnetic particles to a mechanical deforming treatment.

3. The method of producing a magnetic body which comprises preparing a mass containing individual magnetic particles and electrically conducting non-magnetic material such as aluminum or copper, subjecting said mass and said individual magnetic particles to a mechanical deforming treatment to prepare magnetic body portions of small cross-sectional areas, and combining said portions to form the magnetic body therefrom.

4. The method of producing a magnetic body which comprises preparing a mass composed of individual magnetic particles intermixed with electrically conducting non-magnetic particles such as aluminum or copper and insulating material, subjecting said mass and said individual magnetic particles to a mechanical deforming treatment to prepare magnetic body portions of small cross-sectional areas, and combining said portions to form the magnetic body therefrom.

5. The method of producing a magnetic body which comprises preparing a mass containing individual magnetic particles, enclosing said mass between two metal sheets, mechanically deforming said mass and said individual magnetic particles into a sheet form, and building up the magnetic body from said sheets with electrically insulating layers of material therebetween.

6. The method of producing a magnetic body which comprises preparing a mass containing individual magnetic particles, enclosing said mass in a tubular casing, mechanically deforming said mass and said individual magnetic particles into a sheet form whereby said particles are reduced in at least one direction, and building up the magnetic body from said sheets with electrically insulating layers of material therebetween.

7. The method of producing a magnetic body which comprises preparing a mass containing individual magnetic particles and electrically conducting non-magnetic material such as aluminum or copper, enclosing said mass between two metal sheets, mechanically deforming said mass and said individual magnetic particles into a sheet form, and building up the magnetic body from said sheets with electrically insulating layers of material therebetween.

8. The method of producing a magnetic body which comprises preparing a mass containing individual magnetic particles and insulating material, placing said mass in an annular container having a rigid center, and mechanically deforming said mass in an annular shape and simultaneously reducing said magnetic particles in at least one direction.

9. The method of producing a magnetic body which comprises preparing a mass containing individual magnetic particles and insulating material and placing said mass in an annular container having a rigid center, mechanically deforming said mass in an annular form and simultaneously reducing said magnetic particles in at least one direction, and cutting said annular

core into a plurality of discs for the formation of magnetic bodies.

10. The method of producing a magnetic body which comprises preparing a mass containing individual magnetic particles intermixed with electrically conducting non-magnetic particles such as aluminum or copper and insulating material, subjecting said mass and said individual magnetic particles to a mechanical deforming treatment, and subsequently subjecting said mass to a heat treatment.

11. The method of producing a magnetic body which comprises preparing a mass containing individual iron oxide and aluminum particles, and heating said mass to a temperature at which the iron oxide is reduced by the aluminum.

12. The method of producing a magnetic body which comprises preparing a mass containing individual iron oxide and aluminum particles, subjecting said mass and said particles to a mechanical deforming treatment, and heating said mass to a temperature at which the iron oxide is reduced by the aluminum.

13. The method of producing a magnetic body which comprises preparing a mass containing individual iron oxide and aluminum particles, subjecting said mass and said particles to a mechanical deforming treatment whereby said iron oxide particles are reduced in at least one direction, and heating said mass to a temperature at which the iron oxide is reduced by the aluminum.

14. The method of producing a magnetic body which comprises preparing a mass containing individual iron oxide and aluminum particles and insulating material, subjecting said mass and said particles to a mechanical deforming treatment at an elevated temperature whereby said iron oxide particles are reduced in at least one direction, and subsequently heating said mass to a temperature at which the iron oxide is reduced by the aluminum.

WALTHER EHLERS.