Aug. 20, 1935. H. VOGT 2,011,697

METHOD FOR PRODUCING MAGNET CORES FREE FROM LEAKAGE

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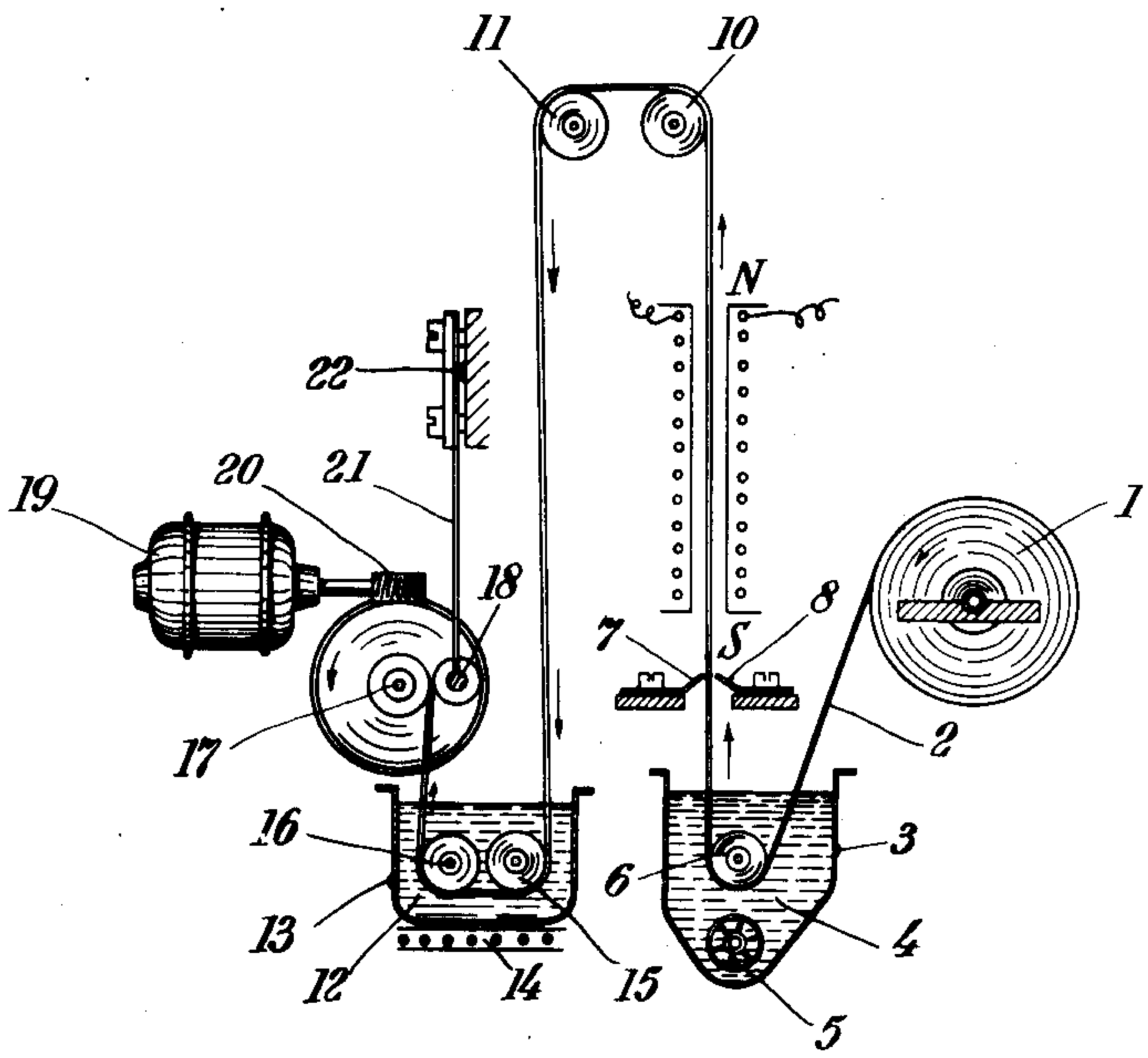

Fig. 1

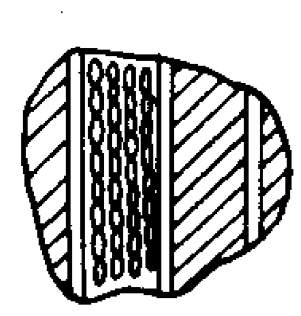

Fig. 2a

Fig. 2b

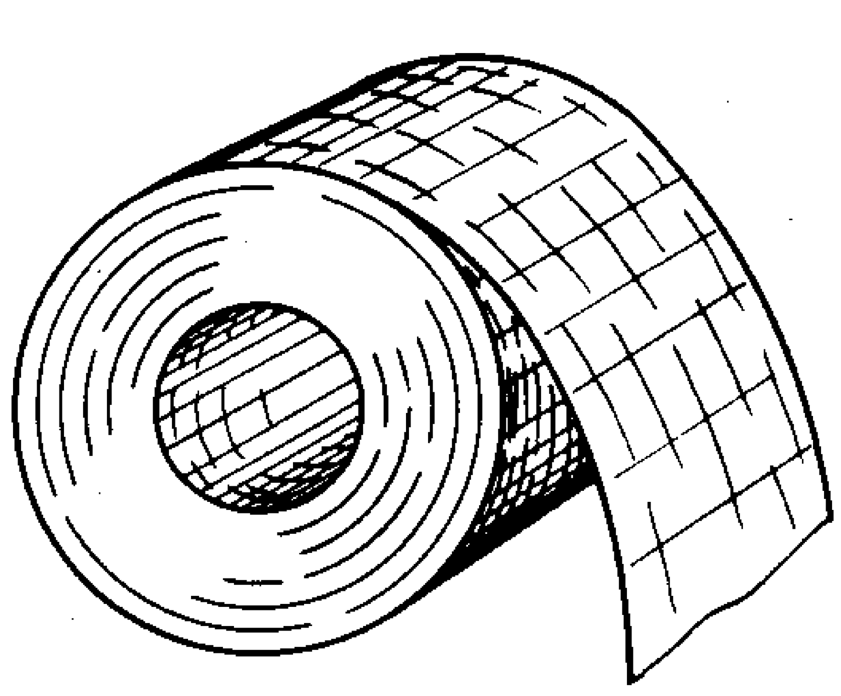

Fig. 3

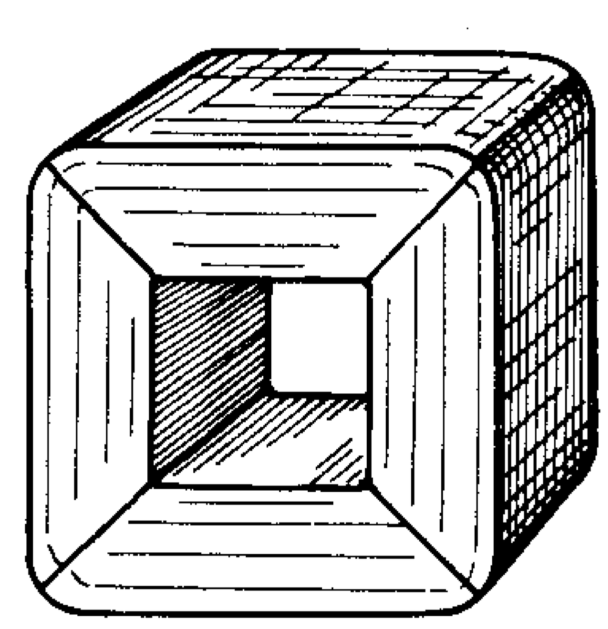

Fig. 4

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METHOD FOR PRODUCING MAGNET CORES FREE FROM LEAKAGE

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The production of cores practically free from leakage for high frequency purposes with a permeability, which is considerably higher than that of air, has not hitherto been possible, so that in high frequency technique air-coils must be employed in spite of the great objections as regards leakage, large volume, capacitive losses and the like.

It has been proposed, to utilize the experiences gained in the production of repeating cores (loading coils) for high frequency purposes, but hitherto without success. The cause is probably the following:—As is known, the magnet cores hitherto produced showing the slightest eddy current losses are made of purely divided, pulverous, magnetic material transpersed with certain binding substances, such as ground shellac, gelatine and the like. The cores are pressed from these mixtures employing heat and high pressure. An examination of such cores, in which the iron particles are apparently well insulated from one another by the above mentioned addition of insulating material, still shows such considerable eddy current losses which make the cores useless for high frequency purposes, for example in tuning circuits.

It has also been proposed, to make high frequency cores from very thin rolled iron or to apply thin continuous layers on varnished paper by means of cathode disintegration or by the metal spraying process. Unsatisfactory results were likewise obtained by these processes as the particles were not insulated from each other.

This invention is based on the observation that a magnetic material for high frequency possesses low losses and the necessary uniformity of permeability and losses, if the methods so far known, i. e. individual insulation of the particles from each other and arrangement of the magnetic powder in thin layers insulated from each other are used in combination, in other words, if the magnet particles are arranged in thin superposed layers deposited on insulating carriers. Applying the magnet mass on the insulating carrier can be effected by spreading, spraying, dipping or the like. Preferably such a material is made by depositing a thin layer of magnet particles, intimately mixed with insulating substances and solvents with binding properties, on an insulating carrier by the dipping process and superposing several insulating strips of this kind, covered with the magnetic composition on both sides, to obtain a solid body. The magnet cores may be cut from the material thus obtained, in known manner, or several parts, stamps from such material, are united to form a core of sufficient thickness. The low losses of a magnetic material of this kind are presumably due to the fact that by the insulating intermediate layers the eddy currents still occurring in the mixed body which is similar to a semi-conductor, perhaps by capacitive coupling between the particles, are safely interrupted and a uniform structure and insulation is thus obtained. In particular, it is also possible to produce an individual insulating skin between the particles and to avoid injuring of the thin insulating film between the particles due to the mechanical stresses, occurring when producing the material. In this way and thanks to the insulating layers the eddy current losses are considerably reduced.

As a matter of fact, the insulating skin on the particles is very thin, and must be very thin, to obtain a sufficient specific density of magnetic material and high permeability. Therefore mechanical stresses which would cause the particles to touch each other and exclude the insulating film which should separate them, must be absolutely avoided. The process of dipping an insulating carrier into an emulsion of magnetic powder, admixtures of insulating substances and solvents to solve these insulating admixtures, has proved to be the best method of obtaining a loose magnetic structure free from internal or external mechanical tensions or stresses. Moreover, by drawing the ribbon out of the bath in vertical upward direction the mechanical stresses due to the weight of particles are eliminated and the particles roll or sink through the insulating liquid during the drying process; thus an insulating skin is produced covering the whole surface of each particle. At the same time the layer is gradually solidified by drying so that any injury to the insulating skin or electrical contact between the particles is avoided.

An embodiment of the invention, for the production of such cores, preferably wound magnet cores, is illustrated by way of example in the accompanying drawing in which:—

Fig. 1 is a diagrammatic view of the apparatus.

Fig. 2*a* shows the arrangement of the magnetic particles in a layer of the material, as in case when employing the comb-like stripping elements 7 and 8 and the magnetic alining device NS.

Fig. 2*b* is a longitudinal section of Fig. 2*a*.

Fig. 3 shows a wound cylindrical body in course of construction.

Fig. 4 shows a wound body of square cross section.

According to Fig. 1 a support for the pulverous magnetic substance, for example a a paper web 2, passes from a roll 1 into a trough 3 containing an emulsion of finely divided magnetic material (such as pure iron, iron-silicon, Häusler alloy, nickel iron compounds, converted into finest disintegration, for example into almost colloidal form, by chemical or physical means) and solvents which remain neutral relative to the magnetic material (such as alcohol, amylacetat and similar cheap solvents) which are transpersed with soluble insulating substance (cellulose, resin, shellac and the like) to obtain an adhesive and insulating binder. To keep the emulsion in an intimately and homogeneously mixed state and to prevent sinking of the heavy metallic particles, the bath is continuously agitated by a vane wheel 5. The strip 2 passes over a roller 6 and is drawn out of the bath in vertical upward direction. Thus a thin layer of the magnetic emulsion is deposited on both sides of the paper strip, which is at first in semi-liquid condition. The heavy magnetic particles roll or sink on the strip through the insulating liquid and thus each particle is covered with an insulating skin on its entire surface. During this process the binder is gradually dried preferably by an electrical heating device NS and the magnetic layer consequently solidifies. Thus a loose magnetic structure results, which is free from internal mechanical tensions or stresses and the tenuous insulating skin deposited on the surface of each particle is not injured. Before drying the magnetic layer may be subdivided longitudinally by travelling past two comb-like stripping elements 7 and 8 which form furrows in the layers of the material, as shown in elevation in Fig. 2*a* and in section in Fig. 2*b*.

The heating coil NS is preferably arranged in the form of a solenoid coil and supplied with direct current of high intensity so as to generate a strong magnetic field, through which the magnetic strip is passed. The particles are thus alined in the direction of the magnetic field to increase the permeability. Figs. 2*a* and 2*b* show diagrammatically the arrangement of particles thus effected. After drying, the paper strip runs over rollers 10 and 11 and then passes a trough 13 heated by an electric heating body 14, and containing an adhesive or binding agent preferably becoming liquid under heat, such as paraffine and the like. The paper strip travels through this bath over rollers 15 and 16 and, if it is desired to produce rolls instead of plates, is wound on a slowly rotating mandrel 17, the shape of which depends upon the intended shape of the desired wound body. The paper strip is pressed tightly in layers onto the mandrel or onto the already wound layers by means of a spring controlled roll 18, which is heated if necessary, so that a very rigid pressed body, composed of superposed layers, is obtained when the binding medium has cooled. The winding mandrel is rotated by a motor 19 through the intermediary of a gearing 20. The pressing roller 18 is resiliently pressed towards the mandrel by a spring 21 held by a bearing 22, the pressure of this spring being adjustable by means of this bearing.

Figs. 3 and 4 show wound bodies of cylindrical (Fig. 3) and square (Fig. 4) cross-section made according to the invention. The bodies are preferably wound in relatively long rolls, from which the coil cores can be subsequently cut.

If plate material or other shaped articles are to be made, which cannot be obtained by winding, the strip, after leaving the adhesive bath 12, is cut into pieces of the desired length. A relatively large number of such strips is superposed and united to form thicker structures by the application of heat and pressure. The shaped pieces which are required to build up a core are cut out of plates in known manner preferably by stamping and several stampings may be arranged superposed to obtain a core of the desired thickness. The stampings or laminations are preferably arranged in such as way in the core, that they are situated parallel to the direction of the magnetic flux, to obtain an additional insulation against eddy current and to offer a continuous magnetic path to the flux without interruption by the paper layers.

An important practical advantage of the invention consists in the fact that in this way a material is produced which can be worked, i. e. stamped and cut in the usual manner. Laminations for building up any magnet core can be produced by stamping or the like and accordingly the manufacture of particular casting or pressing moulds in the shape of the respective core to be produced is dispensed with.

I claim:—

1. A method for manufacturing magnetic cores for high frequency apparatus which consists in intimately mixing particles of magnetic material with neutral solvents, in which soluble insulating substances having binding properties, are dissolved, in covering sheets of insulating material with said mixture, in drying and joining a plurality of said covered sheets under pressure.

2. A method for manufacturing magnetic cores for high frequency apparatus which consists in passing a paper sheet through a mixture of magnetic particles and neutral solvents, in which soluble insulating substances are dissolved, in drying and in joining a plurality of said sheets under pressure.

3. A method for manufacturing magnetic cores for high frequency apparatus which consists in passing a paper sheet through a mixture of magnetic particles and neutral solvents, in which soluble insulating substances are dissolved, said mixture being kept in an intimately and homogeneously mixed state, in drying said sheet by transporting it past a heating device and joining a plurality of said sheets under pressure.

4. A method for manufacturing magnetic cores for high frequency apparatus which consists in passing a paper sheet through a mixture of magnetic particles and neutral solvents, in which soluble insulating substances are dissolved, in drying said sheet while passing it through a strong magnetic field which causes the particles to align in the direction of the flux, and joining a plurality of said sheets under pressure.

5. A method for manufacturing magnetic cores for high frequency apparatus which consists in passing a paper sheet through a mixture of magnetic particles and neutral solvents, in which soluble insulating substances are dissolved, in drying said sheet, in passing it through a bath containing an insulating and adhesive agent becoming liquid under heat, in joining a plurality of said sheets under pressure, and in cutting the core pieces out of said solid body.

6. A method for manufacturing magnetic cores for high frequency apparatus, which consists in passing a paper sheet through a bath containing a mixture of iron particles, and a solvent containing alcohol and amyl acetat, in which cellulose and resin are dissolved, said mixture being kept in an intimately and homogeneously mixed state, in drying said sheet by transporting it past a heating de-

vice, in passing said sheet through a second bath containing an insulating and adhesive agent becoming liquid under heat, in joining a plurality of said sheets to a solid body under pressure, and in cutting the core pieces out of said solid body.

7. A method of producing magnetic cores for high frequency use which comprises maintaining in liquid state a mass of normally solid insulating binder in which particles of magnetic material are dispersed, applying such liquid mass to insulating sheet material, allowing such applied material to solidify thereon, and superposing and uniting a plurality of layers of the resulting coated sheet to form a solid body.

8. An electromagnetizable core material comprising an insulating support of sheet material and a substantially non-conductive deposit of finely divided ferromagnetic particles dispersed in an insulating adherent binder.

9. An electromagnetizable core material comprising an insulating support of sheet material and on each face thereof a substantially non-conductive deposit of finely divided ferromagnetic particles dispersed in an insulating adherent binder.

10. An electromagnetizable core material comprising an insulating support of sheet material and a substantially non-conductive deposit of finely divided ferromagnetic particles dispersed in an insulating adherent binder, said ferromagnetic particles being oriented at least to a substantial extent to provide superior magnetic permeability in the direction of a predetermined axis.

11. An electromagnetizable core material comprising a plurality of mutually adherent laminæ, each embodying an insulating support of sheet material and a substantially non-conductive deposit of finely divided ferromagnetic particles dispersed in an insulating adherent binder.

12. An electromagnetizable core material comprising a plurality of mutually adherent laminæ, each embodying an insulating support of sheet material having on each of its faces a substantially non-conductive deposit of finely divided ferromagnetic particles dispersed in an insulating adherent binder.

13. An electromagnetizable core material comprising a plurality of laminæ, each embodying an insulating support of sheet material and a substantially non-conductive deposit of finely divided ferromagnetic particles dispersed in an insulating adherent binder, said laminæ being united one to another by intervening non-conductive adhesive material.

14. An electromagnetizable core material comprising a plurality of laminæ, each embodying an insulating support of sheet material having on each of its faces a substantially non-conductive deposit of finely divided ferromagnetic particles dispersed in an insulating adherent binder, said laminæ being united one to another by intervening non-conductive adhesive material.

HANS VOGT.