

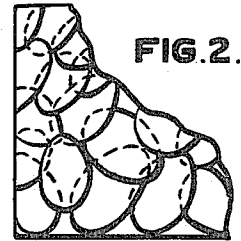
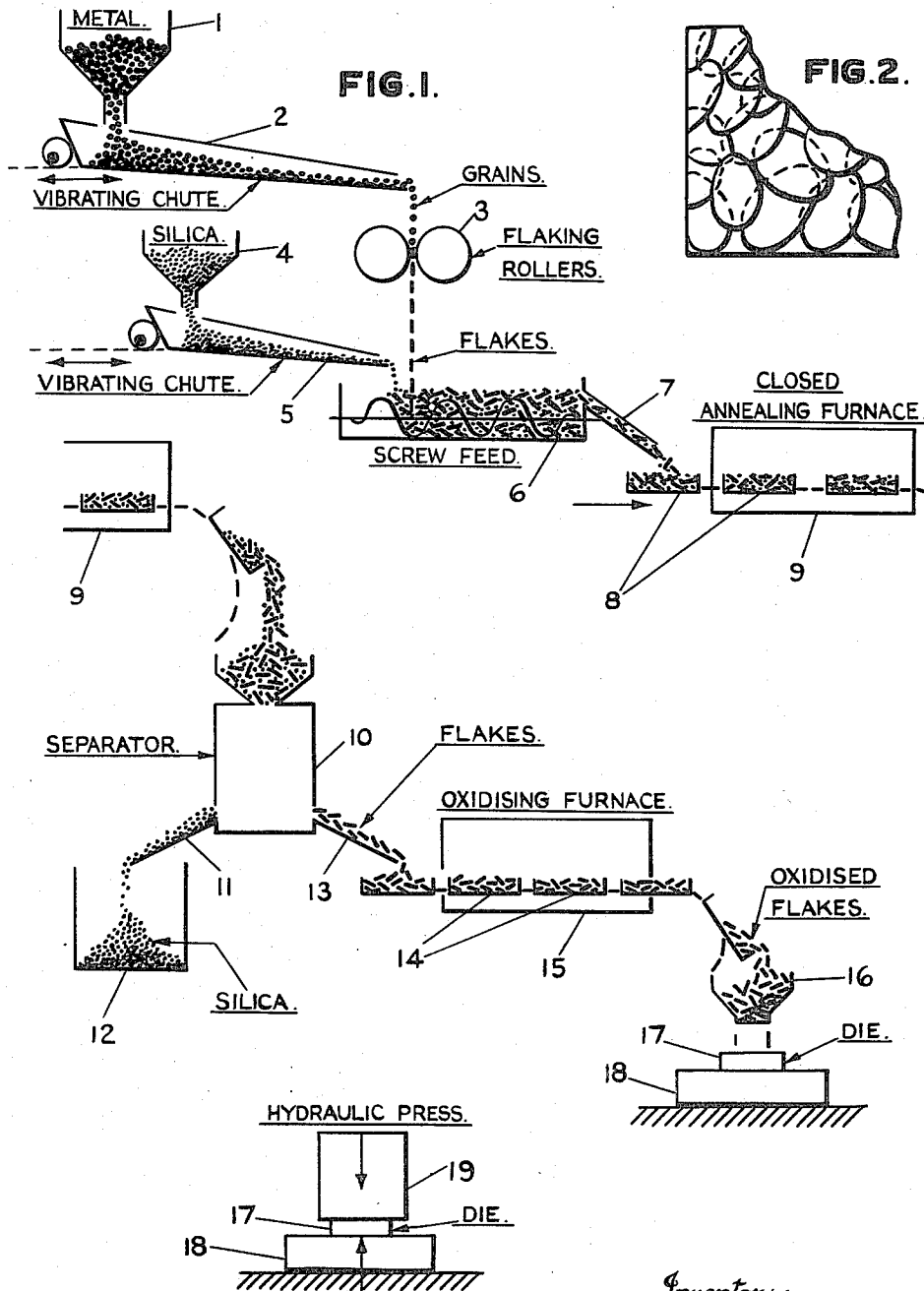
Sept. 21, 1954

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2,689,398

METHOD OF MAKING MAGNETIZABLE COMPACTS

Filed March 24, 1948



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UNITED STATES PATENT OFFICE

2,689,398

METHOD OF MAKING MAGNETIZABLE
COMPACTS

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Application March 24, 1948, Serial No. 16,644

6 Claims. (Cl. 29—160.5)

1

This invention relates to magnetizable com-
pacts and to methods for the production thereof.

As is well known, magnetic bodies subject to
alternating flux conditions require to be sub-
divided in order to reduce losses. For cores or
the like associated with low-frequency reactors
(which term is intended to include transformers
as well as chokes) the subdivision is now attained
by forming the body from an assembly of wires
or laminations whilst for high-frequency re-
actors the usual practice is to employ a so-called
dust core. The present invention is more par-
ticularly (but not exclusively) directed to bodies
for use with low-frequency reactors; i. e. reactors
operating at power frequencies or audio-frequen-
cies such as ballast chokes, smoothing chokes,
inter-valve transformers and transducers, and
has for one of its objects to provide a magnetiz-
able body in the form of a compact which can be
of any arbitrary shape and thus is not subject
to the manufacturing limitations inherent in the
assemblies of wires or laminations hitherto used
in the prior art.

Another object is to provide a magnetizable
compact which is formed of flakes of iron or
other ferromagnetic material metal (including
alloy) held together wholly or substantially by
the physical effects of pressure applied during
formation and hence not relying on a binder for
any, or any essential degree of mechanical
strength.

Other objects of the invention will appear from
the following description taken in conjunction
with the accompanying drawings, in which:

Fig. 1 is a block diagram illustrating one
method of carrying the invention into practice,
and

Fig. 2 is an enlarged detail view.

As has been outlined above a compact produced
in accordance with this invention is formed of
flakes of ferromagnetic material held together
wholly or substantially by the physical effects of
pressure applied during formation. Among the
materials that we may use are ferromagnetic
compounds (such as oxides), electrolytic iron,
silicon-iron and nickel-iron, with or without
coatings of other materials such as a metal with
a so-called non-magnetic structure. The flakes
may be obtained in any convenient way. The
most practical method known to us at present
resides in flattening particles of a metal in pul-
verulent form but it is also possible to punch the
flakes from thin metal foil or tape or to flatten
metal in wire form.

The superficial area and thickness of the flakes
are not critical, nor is it necessary for the flakes

2

in any one batch to be uniform in size. Gen-
erally speaking, the upper limit for size is de-
pendent upon the occurrence of difficulties in the
pressing operation which is applied to the flakes
to obtain the compact and this in turn depends
upon such factors as the shape and size of the
die cavity. For low-frequency reactors the lower
limit of flake size depends chiefly on the ad-
missible magnetic loss.

We will now describe a method that we have
successfully practiced to produce cores for bal-
last, chokes such as are employed with fluore-
scent lamps, such cores being constituted by flake-
metal compacts formed from electrolytic-iron
powder and exhibiting a total loss (i. e. hysteresis
and eddy-current losses combined) not exceeding
2.5 watts per lb. at a flux density of 10 kilogauss
and a frequency of 50 cycles per second; the
eddy-current loss taken alone does not exceed 0.3
watt per lb. at the same flux density and fre-
quency. The flakes are compacted by pressure
without the addition of a binder and the com-
pact has sufficient mechanical strength to be
handled and used without further treatment.
However, we prefer to impregnate with a ma-
terial such as wax to increase the mechanical
strength and/or to reduce or inhibit corrosion.

The powder used is obtained from any well-
known source of powder, for example, from a ball
mill. In the method to be described we have used
a selected portion of the output from a mill from
which 60% of the powder obtained will pass a 44-
mesh screen in accordance with British Standard
Specification No. 410-1943 (nominal size of screen
apertures 0.353 mm.) but will be retained by a
150-mesh screen according to the same standard,
with a nominal aperture-size of 0.104 mm. This
60% (or such other fraction) forming the se-
lected portion is next subjected to the action of
a pair of rollers which flatten the particles of
powder. Referring to Fig. 1 of the drawings, the
powder is dropped from a hopper 1 on to a feed-
chute 2, which may be of the vibratory type. It is
important that the delivery outlet of the hopper
should be of sufficient height (some inches)
above the chute to permit the particles to sepa-
rate as they bounce on to the chute; if the said
outlet is too close to the chute the particles may
tend to agglomerate. From the chute 2 the said
particles are delivered to a pair of flaking
rollers 3.

Rollers 3 may be four inches long and three
inches in diameter; their speed is not critical but
may conveniently be 400 revolutions per minute.
The pressure between the rollers is adjusted to
give the desired size of flake; in our successful

tests the flake thickness is from 0.015 to 0.025 mm. and the transverse dimension (across the face of the flake) from 0.2 to 0.5 mm. In the drawing we have assumed that there is only one pass through the flaking rollers but, because of the cold-work hardening that occurs, we sometimes pass the material through the rollers twice or more times; in this event we treat the material between passes by heating it in trays for about one hour at 700° C. in an atmosphere of cracked ammonia or hydrogen, followed by cooling over a period of about two hours. This softens the iron and reduces the load on the flaking rollers.

After passing through the rollers (or after the final pass as the case may be) the flakes exhibit cold-work strain which requires to be removed in order that they may be amenable to subsequent processing, particularly pressing. They may also exhibit grain orientation, usually advantageous. Strain is removed in a closed annealing furnace in which heating occurs at 900° C. for one to two hours in an atmosphere of cracked ammonia or hydrogen, followed by cooling in a cooling annex of the furnace over a period of about two hours. To prevent sintering at the annealing temperature the flakes are mixed with silica, fused magnesia, zirconia, alumina, thoria, kaolin or other inert material in sufficient quantity to prevent the flakes from adhering. For instance, there may be one part of silica powder for every two parts of iron, the silica being of a size to pass a 200 mesh screen according to British Standard Specification No. 410-1943 (nominal size of screen apertures 0.076 mm.). Thus, referring again to Fig. 1, the flakes from rollers 3 are fed to a conveyor 6 to which silica powder from a hopper 4 is also fed by vibrating chute 5, the delivery chute 7 at the outlet end of conveyor 6 feeding into trays 8 which are passed into the annealing furnace 9. Instead of mixing in the conveyor we may use any well known form of powder blender.

The cooled mixture of flakes and silica is taken from the cooling section of furnace 9 to a separator 10. This may be a magnetic separator which acts by virtue of the differing magnetic properties of the two components of the mixture or a classifier which depends for its operation upon the difference in and weight of the two components; both these types of separator are well known and require no further description. Silica delivered at 11 and collected at 12 is available for repeated use. The iron flakes are delivered at 13 into trays 14 and passed to a furnace 15.

Furnace 15 is used for the purpose of forming a superficial oxide-film (of the order of 0.05 micron thickness) on the flakes. Oxidation is effected by heating to about 200-250° C. in the presence of air; we believe at present that optimum results are obtained by heating at 230° C. for 30 to 60 minutes. The purpose of the oxide is to insulate the flakes from one another when pressed together in the pressing operation which now follows. It is, however, to be understood that this oxidising step may be omitted since we have proved by test that the oxide is not essential. After oxidation the flakes are collected in a hopper 16 or other receptacle.

The oxidised flakes are now batched to the correct weight and placed in dies such as 17 for pressing. It is important that the flakes should be located in the die in positions in which they lie parallel or substantially parallel to the magnetic lines of force set up in them during subsequent use, and for this reason it is evident that the

flakes must, as far as possible, lie flat against one another in parallel planes as shown in Fig. 2. This can be readily achieved by dropping the flakes from a hopper or funnel into the die, the height of the outlet of the hopper or funnel above the die being sufficient, i. e. a few inches, to allow the flakes to float into the die in a horizontal position and the die being shaped so that this horizontal positioning is, in the finished compact, the positioning corresponding or at least substantially corresponding to the path of the magnetic flux. The die and the two punch tools which co-act therewith operate and are designed in accordance with the principles set forth in co-pending application No. 601,736, now Patent No. 2,431,232, in the name of Norman C. Moore, i. e. the die is located between two hydraulic cylinders 18, 19 each having a tool entering the die, the die is either of multi-part construction or tapered so that the side-release of pressure is available, and relief of pressure subsequent to compacting is effected in stages. Further details may be found in the said co-pending application and need not be repeated here.

The flakes having been positioned as stated, a compact is formed by applying a pressure of 15 to 30 tons per sq. in. to the faces of the flakes. No binder is used and a lubricant is not essential although we may use a lubricant such as stearic acid applied in solution, e. g. in ether. This compact, notwithstanding the absence of binder, is strong enough to be handled and can be used as it stands if it is not subject to undue shock during assembly with a winding or windings to form the desired reactor or during use of the assembled reactor; although we do not desire to be limited to any particular theory, we believe that the physical effects which result from the pressure applied in forming the compact and which give the compact its strength arise chiefly from interlocking of the flakes although it is also possible that cohesion (of an atomic or molecular character) occurs between the flakes. However, we prefer to impregnate the compact to give it additional strength and/or improve its resistance to corrosion. The impregnant may be a wax, a synthetic resin or other like material. Good results have been obtained by immersing the compact for 5 mins. in chlorinated naphthalene wax at 150-160° C. This may be followed by a dip in varnish (e. g. a varnish of the phenol formaldehyde type) to enhance the resistance to corrosion.

We claim:

1. The method of making a magnetizable compact which comprises feeding ferromagnetic particles by free fall under the effect of gravity from a predetermined minimum height to an inclined surface thereby to prevent agglomeration of the particles, vibrating said surface to deliver the particles into the bight of a pair of rolls, rotating said rolls to apply rolling pressure to the particles and to convert them into flakes, annealing said flakes under conditions substantially completely preventing sintering, introducing the annealed but unsintered flakes into a mold to constitute a laminated structure, and applying pressure to said structure to form a self-supporting compact of substantial mechanical strength.

2. The method of making a magnetizable compact which comprises feeding ferromagnetic particles by free fall under the effect of gravity from a predetermined minimum height in the order of a few inches to one end of a surface thereby to prevent agglomeration of the particles, vibrating

5

said surface to deliver discrete particles at the other end of said surface into the bight of a pair of rolls, rotating said rolls to convert the particles into flakes, annealing said flakes under conditions preventing sintering, dropping the annealed flakes into a mold by free fall from a height in the order of a few inches sufficient to allow the flakes to float into the mold in a horizontal position, and applying pressure to said horizontally oriented flakes to form a laminated compact of substantial strength.

3. In a process of making laminated magnetizable compacts, the improvement which comprises dropping ferromagnetic flakes under the effect of gravity into a mold from a height sufficient to allow the flakes to float into the mold in a horizontal position, and applying pressure to said horizontally oriented flakes to form a laminated compact.

4. The method of making a magnetizable compact which consists in feeding ferromagnetic powdered particles by free fall under the effect of gravity from a predetermined minimum height to one end of an inclined surface to insure separation of the particles, vibrating said surface and dropping discrete particles from the other end of said surface into the bight of a pair of rolls, rotating said rolls to convert the discrete particles into separate flakes, admixing an inert powder with said flakes, heating the mixture of powder and flakes to the annealing temperature of the flakes while preventing sintering of the flakes by the presence of the said inert powder to soften the flakes and relieve them of work-hardening

6

stresses, removing said powder from the mixture, and then compacting the soft, annealed and unsintered flakes into a self-sustaining body having a laminated structure.

5. The method as set forth in claim 4 wherein the soft, annealed and unsintered flakes are dropped into a mold by free fall from a height sufficient to allow the flakes to float into the mold in a horizontal position to constitute a laminated structure, prior to the compacting of the flakes.

6. The method according to claim 1 including the step of impregnating the compact with a liquid material adapted to increase the strength of the compact.

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