A MACHINE FOR MAKING SETS OF MAGNETIC RIBBONS FOR USE IN DISTRIBUTION TRANSFORMER CORES

Current machines and methods for making sets of a plurality of magnetic ribbon for distribution transformer cores are disadvantageous because complicated feeding means, a complicated indexing transport system, and manual transport between the set forming and nesting locations are required. The present invention responds to the need in the art by providing a machine comprising: (a) means for feeding and cutting a plurality of magnetic ribbons to form a group; and (b) means for assembling a plurality of groups by moving all formed groups of the current assembly from the cutting means by an index distance. The present invention also provides a method of making sets of a plurality of magnetic ribbons for use in distribution transformer cores.
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A MACHINE FOR MAKING SETS OF MAGNETIC RIBBONS
FOR USE IN DISTRIBUTION TRANSFORMER CORES

BACKGROUND OF THE INVENTION

The present invention provides a machine for making sets of magnetic ribbon for use in distribution transformer cores and also a method of making sets of magnetic ribbon for use in distribution transformer cores.

Amorphous metal alloys, also known as glassy metal alloys or metallic glasses, are metastable materials lacking any long range order. Amorphous metal alloys are conveniently prepared by rapid quenching from the melt using processing techniques which are conventional in the art. Examples of such amorphous metal alloys and methods for their manufacture are disclosed in commonly assigned U.S. Patent 3,865,513. The advantageous soft magnetic characteristics of amorphous metal alloys have been exploited in their wide use as materials in a variety of magnetic cores such as in distribution transformers.

Distribution transformers step down high-voltage power lines to household voltages. Distribution transformers made of conventional electrical silicon steel consume electrical energy which turns into heat. Distribution transformers made of amorphous metal alloys and in particular, iron-silicon-boron alloys advantageously have a reduction in electrical losses up to 70% compared with these silicon-iron units. Typical distribution transformers run from 25 to 500 kilovolt-amp (kVA).

In the production of cores made from silicon-iron materials, the most automated method for cutting and winding involves the use of an integrated cutting and winding machine wherein a single strip of core material is cut and then immediately wrapped into a circular
shape. The cuts are made at precisely located positions so that the resulting circular core has the desired joint structure. Such a machine is commercially available from Tranco Company of Canada. However, this manufacturing method is unsuitable for processing amorphous metal ribbon. Because amorphous metal alloy ribbon is much thinner than silicon-iron material, multiple layers of amorphous metal alloy ribbon would have to be cut simultaneously and then fed into the winding mechanism in order to achieve efficient production. Because amorphous metal alloy ribbon is very hard, cutting many layers of amorphous metal alloy ribbon simultaneously is difficult. Also, amorphous metal alloy ribbon is less rigid than silicon-iron materials and thus, the conventional guiding and pushing methods employed with silicon-iron materials are unsuitable for amorphous metal alloy ribbon. Additionally, some types of distributed gap joints such as the completely overlapping joint disclosed in U.S. Patent 4,741,096, have been found to be preferred for amorphous metal alloy ribbon. The aforedescribed Tranco machine produces a joint containing short sheets, which is not the preferred joint disclosed.

Because amorphous metal alloy ribbon is so thin, groups comprising a plurality of ribbons are typically formed in order to increase the speed of core production. In each group, the longitudinal and transverse edges of the plurality of ribbons are substantially aligned. Sets comprising a plurality of groups can also be formed to further increase the production speed. In each set, the longitudinal edges of the groups are substantially aligned while the transverse edges of adjacent groups are staggered with respect to each other. The positioning of one group relative to another group in the foregoing staggered relationship is referred to as indexing. The distance between the transverse edges of adjacent groups is referred to as the index distance.

One method for the formation of amorphous metal alloy
distribution transformer cores involves winding a toroidal form using a single ribbon and then cutting the toroidal form in numerous positions which define the desired joint as disclosed in U.S. Patent 4,709,471.
The core is then reclosed and if required, formed into the final shape. Although this method does not require arranging the cut ribbons into groups and sets, the method requires rewrapping the laminations after cutting the core which is difficult because the rewrapped ribbons tend to fluff up which makes the attainment of a tightly closed joint very difficult. Additionally, obtaining the preferred fully overlapping type of joint is difficult with this method.

Machines used for making sets of magnetic ribbon for use in distribution transformer cores and methods for making sets of magnetic ribbon for use in distribution transformer cores are known in the art. One method involves winding a toroidal form using at least one ribbon and then cutting the toroid completely at one position to obtain a stack of cut ribbon. The stack of cut ribbon is then manually divided in order to obtain groups of ribbon which are then nested, i.e. groups of ribbon arranged into a generally circular shape with a defined position for each group. Nesting may be done manually or by using a belted winding machine such as described in U.S. Patent 4,790,064 or a nesting machine which wraps the assembled groups of ribbon around a stationary arbor such as described in U.S. Patent 5,093,981. The core is then mechanically formed into the desired final shape. The manual formation of groups or sets of ribbon is time-consuming and thus, undesirable.

Another method uses a fully automatic machine which cuts ribbon to controlled lengths, arranges the cut ribbon into groups and sets, and wraps the sets around an arbor to produce a core such as described in U.S. Patent 5,093,981. This machine and method are disadvantageous because after each group is cut, the cut group is first advanced to a predetermined position and is then moved transversely of the strip length down an incline to a stacking position on a carrier. Transversely moving the groups to a stacking position is a time-consuming process and involves relatively complicated apparatus for its implementation.
Another method uses a machine for cutting lengths of ribbon and assembling groups and sets from the cut ribbon as disclosed by U.S. Patents 5,063,654 and 5,191,700. Initially, feeding jaws grip the ribbon and move it between cutting blades to a clamp wherein the clamp grasps the ribbon to further move it. After a length of ribbon is cut, the clamp moves the cut ribbon to its stacking position and the process is repeated. After each set is formed, the set is unclamped from the supporting table, lifted off the table, and wrapped about the arbor of a nester. This machine and method are disadvantageous because complicated feeding means, a complicated indexing transport system, and manual transport between the set forming and nesting locations are required.

As such, the need exists in the art for a machine and method which eliminate the need for complicated feeding means, a complicated indexing transport system, and manual transport between the set forming and nesting locations.

SUMMARY OF THE INVENTION

We have developed a machine for making sets of magnetic ribbon for use in distribution transformer cores and also a method of making sets of magnetic ribbon for use in distribution transformer cores which responds to the foregoing need in the art. The present machine comprises: (a) means for moving and cutting a plurality of magnetic ribbons to form a group; and (b) means for assembling a plurality of groups by moving all formed groups of the current assembly from the cutting means by an index distance.

The present machine is advantageous because, unlike the equipment of U.S. Patents 5,063,654 and 5,191,700 which involves a complicated transport system during indexing and manual transport between the set-forming machine and nester, the present machine has a means for assembling a plurality of groups by moving all formed groups of the current assembly from the cutting means by an index distance. Also, the present machine has a simple feeding means and
also advantageously exploits the inherent characteristics of flexibility
and surface slipperiness of amorphous metal alloy ribbon through its
feeding means and transporting and indexing means.

The present invention also provides a method of making sets
for magnetic cores comprising the following steps. In step (a), a
predetermined length of a plurality of magnetic ribbons is fed through
a cutting means, wherein each of the magnetic ribbons has a
longitudinal edge and a transverse edge. In step (b), the length of a
plurality of magnetic ribbons is cut. In step (c), steps (a) and (b) are
repeated as necessary until a group is formed. In step (d), the formed
group is moved from the cutting means by an index distance. In step
(e), steps (a) through (c) are repeated and the later formed group is
formed in a position of substantial contact with the former formed
group. In step (f), the entire assembly is moved from the cutting
means by an index distance. In step (g), steps (e) and (f) are repeated
as necessary until a set is formed.

We have also found that in a combination of a machine which
forms groups or sets of a plurality of magnetic ribbons and a machine
which nests the sets to form a transformer core, the use of a belt for
transporting the formed sets from the set forming machine to the
nesting machine is an improvement.

We have also found that in a machine which forms sets of a
plurality of magnetic ribbons, the use of means for shaping the
magnetic ribbons across their transverse axis into a non-flat profile is
an improvement.

We have also found that in a method for making sets of a
plurality of magnetic ribbons and nesting the sets to form a
transformer core, measuring the circumference of the previously
nested set and adding the lap distance to the circumference
measurement to adjust the next feeding and cutting length.
Additionally, we have found that in a method for assembling a plurality of groups of magnetic ribbons, the step of cutting a group so that after cutting, the cut group without substantial movement thereof is located in a staggered relationship to a previously cut group is an improvement.

Other advantages of the present invention will be apparent from the following description, attached drawings, and attached claims.

**BRIEF DESCRIPTION OF THE DRAWINGS**

Figure 1 is a side view of a group of magnetic ribbons.

Figure 2 is a side view of a set comprising a plurality of the groups of magnetic ribbons of Figure 1.

Figure 3 is a top view of the set of the groups of magnetic ribbons of Figure 2.

Figure 4 illustrates the machine of the present invention.

Figure 5 is a view along the line A-A of the machine of Figure 4.

Figure 6 is a top view near the cutting means of the machine of Figure 4.

Figure 7 is a side view of the machine of Figure 4.

Figure 8 is a view along the line B-B of the machine of Figure 4.

Figure 9 is a top view, without the transport clamp mechanism, of the machine bed of Figure 4.

Figure 10 illustrates groups and sets of magnetic ribbon in a distribution transformer core.
Figure 11 is an enlargement of the joint region of Figure 10.

**DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS**

The term "ribbon" as used herein means a single or individual layer of magnetic material. The term "group" or "subgroup" as used herein means a plurality of ribbons which are assembled so that their longitudinal and transverse edges are substantially aligned. Figure 1 illustrates a group 14 comprising six magnetic ribbons 12. Preferably, a group has about 10 to about 40 ribbons.

The term "set" or "subset" as used herein means a plurality of groups which are stacked so that their longitudinal edges are substantially aligned while transverse edges of adjacent groups are staggered with respect to each other. Set is also known in the art as packet or book. Figure 2 illustrates a set 16 comprising four groups 14 of magnetic ribbon. Preferably, a set has at least two groups.

Figure 3 illustrates the longitudinal edges 18 of each group 14 in substantial alignment and the transverse edges 20 of each group 14 in substantial alignment. Adjacent groups 14 in set 16 of Figure 3 have their transverse edges 20 staggered so that adjacent groups 14 underlap at one end of set 16 and adjacent groups 14 overlap at the other end of set 16.

Although any magnetic material such as silicon-iron steel may be used as the magnetic ribbon in the present invention, ribbons of amorphous metal alloys are preferred. Examples of preferred amorphous metal alloys are the following Metglas® alloys: Fe_{79}Si_{15}B_{13} and Fe_{71}B_{13.5}Si_{3.5}C_{2} which are available from AlliedSignal Inc., Morristown, New Jersey, United States of America. Commonly assigned U.S. Patents 5,035,755 and 4,219,355, which are incorporated herein by reference, disclose alloys useful in the present invention. Other preferred amorphous metal alloys include the Fe_{75}. 
78.5Si_{4.10.5}B_{11.21} (subscripts in atomic percent) compositions disclosed in commonly assigned Canadian Patent 1,215,253 and the Fe_{79.75-80.5}Si_{8.5-10.5}B_{8.75-11.5} (subscripts in atomic percent) compositions disclosed in commonly assigned International Publication Number WO91/12617.

Silicon-iron steel generally has a thickness of about 0.15 to about 0.3 millimeter while amorphous metal alloy has a thickness of about 0.025 millimeter.

A plurality of magnetic ribbons are fed into the present machine. The term "plurality of magnetic ribbons" as used herein means from about 2 to about 40 ribbons. Thus, a plurality of magnetic ribbons may constitute a group or subgroup. The term "plurality of groups" as used herein means at least two groups.

The present machine comprises: (a) means for moving and cutting a plurality of magnetic ribbons to form a group; and (b) means for assembling a plurality of groups by moving all formed groups of the current assembly from the cutting means by an index distance.

Cutting means useful in the present machine may be any means useful in cutting a plurality of magnetic ribbons. Examples of useful cutting means include laser beams and mechanical means such as scissors, shear cutting blades, or abrasive cutters. A preferred cutting means comprises a set of cutting blades.

Means for feeding a plurality of magnetic ribbons to the cutting means may be any means useful in feeding magnetic ribbon. The cutting means cuts a plurality of magnetic ribbons to form a cut subgroup or cut group. Examples of useful feeding means include air grip feeds or feed rollers. In contrast to the moving feeding means of U.S. Patents 5,064,654 and 5,191,700, we have found that a feeding means which remains in a substantially stationary position relative to the plurality of magnetic ribbons being fed simplifies the manufacturing operation. A preferred feeding means comprises feed rollers.
The present machine is illustrated in Figure 4. A plurality of magnetic ribbons (not shown) enters the machine at arrow 22. The plurality of magnetic ribbons are fed over shaking device 24 and into fixed guide 26 in the direction of arrow 28. The shaking device 24 shakes the plurality of magnetic ribbons to separate the layers of magnetic ribbons before they enter fixed guide 26. Feeding the plurality of magnetic ribbons over shaking device 24 eliminates potential damage to the edges of the magnetic ribbons and ensures proper alignment in fixed guide 26.

Feed rollers 30 feed the plurality of magnetic ribbons forward through the machine. Although feed rollers 30 are free to rotate about their longitudinal axes, feed rollers 30 are in a substantially fixed position relative to the plurality of magnetic ribbons being fed through them. Feed rollers 30 have accurate control to feed precise lengths of the plurality of magnetic ribbons. Accurate control may be accomplished by stepper or servo control motor drives in connection with feedback devices.

Feed rollers 30 feed the plurality of magnetic ribbons to the cutting means comprising top cutting blade 32 and bottom cutting blade 34. After the feed rollers 30 have fed a precise length of the plurality of magnetic ribbons to the cutting means, top cutting blade 32 and bottom cutting blade 34 are activated and cut the plurality of magnetic ribbons. If the cutting means becomes contaminated during use, means for removing contamination from the cutting means may be used. For example, a high velocity gas may be used to remove contaminants from the cutting means and thus, increase the life of the cutting means.

As feed rollers 30 feed the plurality of magnetic ribbons between top cutting blade 32 and bottom cutting blade 34, the plurality of magnetic ribbons slide over the top of holding clamp 36 which will be explained in more detail later. Feed-assist device 38 rotates during feeding of a plurality of magnetic ribbons to impart a gentle pushing force so that the plurality of magnetic ribbons
overcome any sliding friction. The first cut plurality of magnetic ribbons travel on support plate 40 with the ribbons' longitudinal edges against straight guide 42 and the ribbons' other longitudinal edges against intermediate angle guide 44 and then angle guide 46.

Reference is made to Figure 5 which is taken along line A-A of Figure 4. A plurality of magnetic ribbons 48 is shown ready to be fed through the cutting means. Having been cut by top cutting blade 32 and bottom cutting blade 34, cut subgroup 50 is shown sitting on support plate 40. One longitudinal edge of the cut subgroup 50 is resting against straight guide 42 while holding clamp 36 clamps the other longitudinal edge of the cut subgroup 50.

Preferably, the present machine additionally comprises means for preventing movement of cut subgroups or cut groups during subsequent feeding of an uncut plurality of magnetic ribbons. Without a movement prevention means, the cut subgroups or cut groups may shift during the subsequent feeding. Any movement prevention means useful in preventing movement of a cut plurality of magnetic ribbons may be used in the present machine. Examples of useful movement prevention means include clamps or magnets. A preferred movement prevention means comprises a clamp. The preferred clamp holds the cut subgroups and/or cut groups while the next plurality of magnetic ribbons feed over the clamped cut subgroups and/or cut groups.

Reference is made to Figure 6 which is a top view near the cutting means of the present machine. The plurality of magnetic ribbons 48 is shown ready to be fed through the cutting means. Having been cut by top cutting blade 32 and bottom cutting blade 34, cut subgroup 50 is shown sitting on support plate 40. Holding clamp 36 has been released from its previous holding position and clamped the first cut subgroup 50 against support plate 40. The overlap distance of the holding clamp 36 is sufficient so that upon clamping, the cut subgroup 50 is substantially stationary during subsequent feeding of the next plurality of ribbons.
The present machine also comprises means for assembling a plurality of groups by moving all formed groups of the current assembly from the cutting means by an index distance. The term "index distance" as used herein means the distance between the transverse edges of adjacent groups in the assembly produced by use of the present machine. The movement of a group from the cutting means by an index distance is also referred to herein as "indexing". Any means which assemble a plurality of groups by moving all formed groups of the current assembly from the cutting means by an index distance may be used in the present machine. Useful assembling means include rollers or a belt. We have discovered that a preferred assembling means is a belt. In contrast to the machine of U.S. Patents 5,063,654 and 5,191,700 which involves a complicated transport system during indexing, the present machine preferably has a belt which is used to assemble a plurality of groups by moving all of the formed groups of the current assembly from the cutting means by an index distance.

Referring to Figure 4, belt 52 of the present machine is illustrated. After the cutting means make sufficient cuts to form a group, belt 52 moves the group from the cutting means by an index distance. The index distance varies depending upon the final core design desired. Belt 52 is typically computer controlled, and in conjunction with a transport clamp to be described later, advances through an index distance so that the cut group is in a correct location for set or assembly formation. A side view of belt 52 is illustrated in Figure 7. Belt 52 is illustrated as being positioned substantially underneath the cut groups. Although belt 52 is illustrated as beginning somewhat after the cutting means, belt 52 may begin immediately at the cutting means. As indicated by arrows 56 in Figure 7, belt 52 transports cut groups and sets away from the cutting means. As will be explained in more detail later, belt 52, in addition to its indexing function, transports a formed set from the machine to a nesting machine, which is not part of the present invention and as such, is represented by box 54 in Figure 4.
Although not illustrated, belt 52 may be in a non-horizontal position relative to the cutting and feeding means in order to utilize gravity during feeding. If a non-horizontal position is used, preferably an angle of about 20 to about 30 degrees is used.

Preferably, the present machine also comprises means for maintaining cut ribbons in substantial contact with the belt during indexing and transporting. Any maintaining means may be used in the present machine. Examples of useful maintaining means include rollers, magnets, moving clamps, or magnetic belts. A preferred maintaining means is a transport clamp.

In Figure 7, carriage frame 58 supports the slide rail on which transport clamp 60 and transport clamp controller 62 are mounted. After a group is formed, transport clamp 60 is activated. Transport clamp 60 is a plate which is forced on top of the group on belt 52. Transport clamp controller 62 is a mechanism which provides transport clamp 60 with an indexing mode and a transporting mode. In the indexing mode, transport clamp controller 62 is always activated and attached to transport clamp 60. When belt 52 advances through an index distance, transport clamp 60 and transport clamp controller 62 travel the same distance because transport clamp 60 is pressing against belt 52. When the indexing is completed, transport clamp 60 is deactivated and transport clamp controller 62 returns transport clamp 60 to its original position and transport clamp 60 is ready to begin another cycle.

In the transporting mode, transport clamp 60 is activated to clamp the formed set to belt 52. This clamping action keeps the set aligned and together. Transport clamp controller 62 is deactivated to release transport clamp 60 to travel with belt 52. By controlling the advancement of belt 52, a formed set travels to nesting machine 54.

Preferably, the present machine comprises means for shaping a plurality of magnetic ribbons across their transverse axis into a non-flat profile. Inclusion of such means provides the shaped magnetic
ribbons with greater rigidity for improved handleability. Also, the shaped magnetic ribbons may be pushed to a greater distance and align longitudinally more readily.

As shown in Figures 7 and 8, front alignment cylinder 64 and rear alignment cylinder 66 push alignment plates 68 against the longitudinal edge of group 14, or a subgroup if a group 14 is not yet formed, to align it to the straight guide 42. In combination with the intermediate angle guide 44 and angle guide 46, the transverse axis of the group 14 assumes a non-flat profile. We have found that if about 10 to about 40 millimeters of the longitudinal edge of group 14 rest on angle guide 46, the handleability, pushability, and alignability of the group 14 are improved. Preferably, the angle of angle guide 46 varies from about 30 to about 60 degrees. Most preferably, the angle is about 45 degrees.

To illustrate the use of the present machine, reference is made to Figures 4, 7, and 9. A plurality of magnetic ribbons are fed in the direction of arrow 28 over shaking device 24 through fixed guide 26 through feed rollers 30 to the cutting means. Top cutting blade 32 and bottom cutting blade 34 cut the plurality of magnetic ribbons. The cut plurality of magnetic ribbons are fed with the assistance of the feed-assist device 38 against straight guide 42, intermediate angle guide 44, and angle guide 46. If the cut plurality of magnetic ribbons does not constitute a group 14, the cut ribbons accumulate under holding clamp 36 until a group 14 is formed. After the first group 14 is formed by either a single cutting action or multiple cutting actions, belt 52 advances the cut group 14 through an index distance with transport clamp 60 and transport clamp controller 62. Subsequent groups 14 continue to form and transport clamp 60 and transport clamp controller 62 index all formed groups to form set 16. Upon completion of set 16, belt 52, in conjunction with transport clamp 62, transports set 16 to nesting machine 54.

If the present machine is used in conjunction with an automated nesting machine which can measure the circumference of a partially
assembled core, feedback may be utilized to control the feed lengths of the next set to be cut. By adding the desired lap distance to the circumference, the initial cutting length for the next set to be cut is obtained. The term "lap distance" as used herein means the desired overlap of a group of ribbons upon itself when wrapped into a core.

In general, wound cores for use in distribution transformers have a distributed gap joint pattern which comprises a series of staggered steps through the build of the core. Each step made from a silicon-iron material generally consists of only one layer. Because amorphous metal alloy is thinner than silicon-iron material, each step made from an amorphous metal alloy consists of a plurality of layers.

Reference is made to Figures 10 and 11. The distributed gap core 70 has a joint region 72. Each group 14 in the joint region 72 has a specified number of magnetic ribbons. Each set 16 has a specified number of groups 14 in the nested core. As shown in Figure 11, ends 74 of groups 14 preferably have a straight, perpendicular profile. By incrementing each cut length rather than incrementing only group lengths, a closer approximation of a trapezoidal shape is achieved in each group. When wrapped into a core, this trapezoidal shape establishes a straight-end profile which provides for more effective control of the open gap and lap length.

After practicing the method of the present invention, a distribution transformer core is made by using known methods. The first step involves nesting the formed sets of magnetic ribbon into a closed shape. After nesting, further manufacturing steps include forming the closed shape into a rectangular shape, annealing the rectangular shape, and restraining the annealed core in its final shape. To feed the core into a transformer coil, the joint is opened to form a U-shaped structure and the legs of the U-shaped structure are then inserted into transformer coils. The legs are then laced to their original closed position.
WHAT IS CLAIMED IS:

1. A machine comprising:
   (a) means for moving and cutting a plurality of magnetic
   5   ribbons to form a group; and
   (b) means for assembling a plurality of said formed groups by
       moving all formed groups of the current assembly from the cutting
       means by an index distance.

2. The machine of claim 6 wherein said assembling means is in
   a non-horizontal position relative to said cutting and feeding means of
   about 20 to about 30 degrees.

3. The machine of claim 1 which additionally comprises means
   for shaping said cut plurality of magnetic ribbons across their
   transverse axis into a non-flat profile.

4. The machine of claim 1 which additionally comprises means
   for removing contamination from said cutting means.

5. The machine of claim 1 which additionally comprises means
   for assisting the feeding of said cut plurality of magnetic ribbons.

6. The machine of claim 1 which additionally comprises means
   for feedback of core circumference from a nesting means to said
   feeding means.

7. The machine of claim 1 wherein said feeding means remains
   in a substantially stationary position relative to said plurality of
   magnetic ribbons being fed.

8. The machine of claim 1 which additionally comprises means
   for maintaining said formed group during assembling in substantial
   contact with said assembling means.
9. The machine of claim 1 which additionally comprises means for preventing movement of cut subgroups or cut groups during subsequent feeding of said plurality of magnetic ribbons to said cutting means.

10. A method for assembling groups comprising the steps of:

(a) feeding a length of a plurality of magnetic ribbons to a cutting means, wherein each of said magnetic ribbons has a longitudinal edge and a transverse edge;

(b) cutting said length of a plurality of magnetic ribbons;

(c) repeating steps (a) and (b) as necessary until a group is formed;

(d) moving said formed group from said cutting means by an index distance;

(e) repeating steps (a) through (c) and forming the later formed group in a position of substantial contact with the former formed group;

(f) moving the entire assembly from the cutting means by an index distance; and

(g) repeating steps (e) and (f) as necessary until a set is formed.
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

IPC 5 H01F41/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 5 H01F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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<td>DE,A,41 00 211 (GENERAL ELECTRIC COMPANY) 18 July 1991 cited in the application see column 6, line 20 - column 7, line 67 see column 22, line 1 - column 23, line 11; claim 24; figures 1-3,14</td>
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<td>EP,A,0 461 829 (GENERAL ELECTRIC COMPANY) 18 December 1991 see column 12, line 45 - column 14, line 22; claims 5,6; figures 3,7,8</td>
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<td>PATENT ABSTRACTS OF JAPAN vol. 4, no. 181 (E-37) (663) 13 December 1980 &amp; JP,A,55 125 619 (TOKYO SHIBAURA DENKI K.K.) 27 September 1980 see abstract</td>
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Further documents are listed in the continuation of box C.

Patent family members are listed in annex.

Date of the actual completion of the international search

9 September 1994

Date of mailing of the international search report

05.10.94

Name and mailing address of the ISA

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