(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
7 December 2000 (07.12.2000)

PCT

(10) International Publication Number
WO 00/74209 A1

(51) International Patent Classification[7]: H02K 1/28, 1/27, 15/03

(21) International Application Number: PCT/US00/14789

(22) International Filing Date: 26 May 2000 (26.05.2000)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
60/136,506 28 May 1999 (28.05.1999) US
60/145,772 27 July 1999 (27.07.1999) US

(71) Applicant: MCCORD WINN TEXTRON [US/US]; 645 Harvey Road, Manchester, NH 03103 (US).

(72) Inventor: SCHMIDT, Howard; 46 Coburn Woods, Nashua, NH 03063 (US).

(74) Agents: GROSSMAN, Steven, J., et al.; Hayes, Soloway, Hennessey, Grossman & Hage, 175 Canal Street, Manchester, NH 03101 (US).

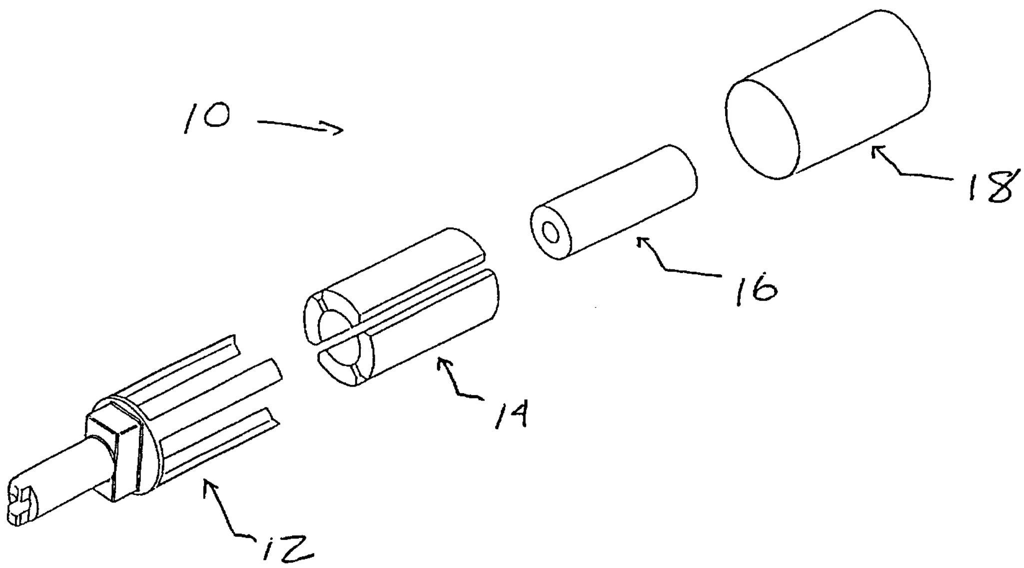
(81) Designated States (national): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, UZ, VN, YU, ZA, ZW.

(84) Designated States (regional): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published:
— *With international search report.*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: SHRINK-FIT TUBING FOR MAGNETIC SEGMENTS



(57) Abstract: A rotor design for stepper and brushless motors is disclosed in which the magnetic segments of the motor are secured in place by a section of non-metallic heat-shrink tubing.

WO 00/74209 A1

SHRINK-FIT TUBING FOR MAGNETIC SEGMENTS

This application claims the benefit of copending U.S. provisional patent application serial No. 60/136,506 filed May 28, 1999 and 60/145,772 filed July 27, 1999, the teachings of which are incorporated herein by reference.

The present invention relates to a rotor design for stepper or brushless motors wherein heat-shrink type non-metallic tubing is applied over the magnet segments to thereby hold said magnets in place.

A variety of permanent magnet rotor structures have been disclosed along with accompanying methods of manufacture. For example, U.S. Patent No. 5,325,009 discloses a rotor assembly which includes a one-piece permanent magnet which is formed as an I-beam structure. Retaining wedges are provided on opposing sides of the permanent magnet. A cylindrical sleeve made of Inconel is said to surround the main core and define an oil containment for the assembled rotor unit. The cylindrical sleeve is then heated to, for example, 1100°F and then the slid over the core portion.

In U.S. Patent Nos. 5,040,286 (1991) and 5,563,463 (1996) there is disclosed a permanent magnet rotor which has a core, a plurality of magnet segments based around the core, and a thin walled retaining shell which is stretched around the core and the magnet elements to hold the elements in position. This patent discloses the thin wall shell as being made from a non-magnetic material, such as stainless steel tubing. The shell is subjected to a cold pressing operation so that the positions between the indicated magnet elements are retained.

U.S. Patent No. 5,774,976 discloses a permanent magnet rotor for an electronically commutated motor (ECEM), which is said to contain a thin-walled retaining shell which has been stretched around the core and magnetizable elements to hold the elements in position. The core and magnetizable elements serve as a mandrel about which the shell is reformed in a cold working operation.

Other patents uncovered in a search of the prior art include U.S. Patent No. 3,531,670, which recites an electric generator or motor comprising a multipole wound stator and a multi-pole rotor having an equal number of poles fabricated from a plurality of circumferentially-arranged, radially-magnetizable permanent magnets, secured to each other by an adhesive, and to both an inner flux conducting ring and supporting rotary structure, the rotor being further structurally stabilized against centrifugal forces by a sleeve tightly embracing the outer peripheral surface thereof. Attention is also directed to U.S. Patent Nos. 4,625,392; 4,594,525; 4,683,393; 4,757,603 and 4,954,736 as other related background art.

In addition, with respect to the use of shrink fit tubing, which use forms a part of the invention described herein, attention is directed to U.S. Patent No. 4,078,910, which discloses the application of heat shrink tubing in glass sleeve fiber joining. In addition, U.S. Patent Nos. 4,418,453 discloses a heating apparatus for shrink tubing wherein heat shrink tubing is selectively placed over the length of a section positioned on the terminated end of a wire lead. U.S. Patent No. 4,858,075 discloses an RF shielded and electrically insulated circuit board structure which makes use of a first layer of shrink-wrap tubing wrapped on a circuit board substrate. Finally, U.S. Patent No. 5,661,842 discloses a method for providing submarine cable joint protection and insulation using heat shrink tubing without utilizing costly molding and x-ray equipment.

Accordingly, the present invention uniquely appreciates the application of non-metallic shrink tubing to hold magnets in place and therein overcomes various of the problems associated with the above prior art designs which rely in general on a high temperature shrink-fit. In addition, the invention herein relates to the use of a non-metallic or plastic shrink-fit tubing either with or without adhesive on the inner wall surface to again retain a plurality of magnet elements. The non-metallic shrink-fit tubing also has the characteristic of being magnetic-flux permeable, and therefore contemplates the use of various types of non-metallic tubing materials as applied for shrink-fit purposes.

For example, shrink-fit tubing can be manufactured of various synthetic and non-metallic polymeric resin materials. More specifically, such materials specifically include polyolefin type resins (polyethylenes/polypropylenes) as well as polyester type materials (polyethylene terephthalate). A suitable tubing is the TAT-125 Series of tubing available from Raychem Corporation. This material has an operating range of -55°C to 110°C, a minimum shrink temperature of 95°C, and a full recovery temperature of 121°C. An alternative tubing for higher temperature applications is available from Raychem Corporation under the tradename KYNAR. This material has an operating range of -55°C to 175°C. Shrink fitting is also specifically achieved by application of heat to a temperature sufficient to cause the shrinking herein to retain the magnets in place during manufacture. The temperature sufficient to cause the shrinking is typically less than 200°C. However, as noted, in the broad context of the present invention, such tubing can be any non-metallic type resin, characterized that said resin has substantial permeability to magnetic flux.

In addition, it is also worth emphasizing that a specific utility of the present invention lies in the fact that the shrink-fit tubing herein is employed at temperatures below that of the high-temperatures normally required for shrink-fitting the metal sleeves of the previously noted prior art design, which high temperatures can lead to serious damage to the magnetic elements. Accordingly, the invention herein provides a unique and novel low-temperature non-metallic shrink-fit tubing and cage structure for the manufacture of a rotor.

In view of the above, it can been seen that one object of the present invention is to provide a novel magnet assembly having a plurality of substantially identically shaped magnetizable elements that are secured together by a non-metallic heat-shrunk material.

Another object of the present invention is to provide a method of making a permanent magnet rotor by arranging a plurality of substantially identically shaped magnetizable elements, surrounding the magnetizable elements with a heat shrinkable material, and heating the heat shrinkable material to a temperature sufficient to cause the heat shrinkable material to shrink.

Another object of the present invention is to provide a novel rotor assembly of the type having a plurality of permanent magnets, wherein the improvement comprises a non-metallic material that upon the application of heat reduces in size to secure the permanent magnets together.

Further objects and features of the invention will become more apparent by reference to the following description taken in conjunction with the following figure, in which:

Figure 1 is an exploded perspective view of the rotor assembly in accordance with the present invention; and

Figure 2 is an exploded perspective view of a second embodiment of the rotor assembly in accordance with the present invention.

FIG. 1 herein illustrates a basic and preferred configuration for the present invention. As shown therein, the rotor assembly 10 contains a cage section 12 that acts to loosely hold the magnetic segments 14 in place. In a preferred embodiment, the magnetic segments 14 are a plurality of substantially identically shaped magnetizable elements. More preferably, the elements have an arcuate transverse cross-sectional configuration. A core 16, if required, can be inserted within the magnetic segments 14. The magnetic segments 14 are secured together by an appropriate section of heat shrink tubing 18. To make a permanent magnet rotor, a plurality of magnetizable elements are arranged, preferably in a cylindrical fashion, the elements are then surrounded with a heat shrinkable material, and the heat shrinkable material is then heated to a temperature sufficient to cause the heat-shrinkable material to shrink. This retains the magnetizable elements. Preferably the temperature sufficient to cause the heat shrinkable material to shrink is less than 500°C, more preferably less than 200°C, and within the range of 100°C and 200°C. In the context of such upper limit of preferred temperature, the invention herein relates to temperatures less than such indicated maximum values, in decreasing 1°C temperature increments. In a most preferred embodiment the temperature for shrinking is about 150°C.

Shrink tubing 18 may or may not have an inner coating of an appropriate heat activated adhesive. In that regard, heat activated adhesives can optionally be selected from the broad family of thermoset type adhesive formulations, including the general family of epoxy type adhesive resins, which epoxy type resin adhesive is itself preferably designed to be particularly suited for an electrical application. Other heat activated systems can make use of polyimide type resins, as well as acrylic type materials, including mixtures thereof.

Additionally, as shown in Fig. 2, a worm gear 20a or 20b can be attached to the cage 12. Worm gear 20a or 20b can include specific gear arrangements 22 for a given application and/or desired rotation rate. Preferably, worm gear 20a or 20b and cage 12 are formed as an integrated assembly. Alternatively, worm gear 20a and 20b and cage 12 can be adapted to be removably affixed to one other (via, e.g., snap fit, friction fit, or other attachment means) to provide interchangeability. Worm gear 20a and 20b can be provided to integrate with a tooling system or rotation mechanism (not shown) as is understood in the art.

In sum, as described and illustrated herein, the current invention allows for lower tooling cost in the preparation of a selected rotor design, as well as a much wider range of tolerances and much lower capital equipment cost as related to rotor manufacture. The use of the shrink-fit tubing as described above therefore finds utility in both stepper and brushless motor designs, as well in other related applications wherein a plurality of magnets must be retained for any given electrical motor application. The shrink-fit tubing material selected herein is such that it does not require the use of a temperature which would result in damage to the magnetic elements , such as a loss in their magnetic flux output.

Although the present invention has been described in relation to particular embodiments thereof, many other variations and modifications and other uses will become apparent to those skilled in the art. It is preferred, therefore, that the present invention be limited not by the specific disclosure herein, but only by the appended claims.

We claim:

1. A magnet assembly, comprising:

a plurality of magnetizable elements secured together by a non-metallic heat-shrunk material.

2. The magnet assembly of claim 1, wherein the non-metallic heat shrunk material shrinks at a temperature less than 200°C.

3. The magnet assembly of claim 1 wherein the plurality of magnetizable elements are substantially identically shaped

4. The magnet assembly of claim 1, wherein the non-metallic heat shrunk material comprises a polymeric resin material.

5. The magnet assembly of claim 4, wherein the polymeric resin material is a material selected from the group consisting of polyolefin type resins and polyester type materials.

6. The magnet assembly of claim 1, wherein the non-metallic heat-shrunk material comprises an adhesive layer in contact with said magnetizable elements.

7. The magnet assembly of claim 1, further comprising a cage to hold the magnetizable elements.

8. The magnet assembly of claim 7, further comprising a worm gear permanently affixed to the cage.

9. The magnet assembly of claim 7, further comprising a worm gear removably affixed to the cage.

10. A method of making a permanent magnet rotor comprising the steps of:

arranging a plurality of magnetizable elements,

surrounding the magnetizable elements with a heat shrinkable material,

heating the heat shrinkable material to a temperature sufficient to cause the heat shrinkable material to shrink.

11. The method of claim 10, wherein the step of surrounding the magnetizable elements comprises inserting the magnetizable elements within a heat-shrinkable tube.

12. The method of claim 10, further wherein the step of arranging the plurality of magnetizable elements comprises holding the magnetizable elements in a cage.

13. The magnet assembly of claim 10 wherein the plurality of magnetizable elements are substantially identically shaped

14. The method of claim 13, further wherein the plurality of substantially identically shaped magnetizable elements each comprise an arcuate transverse cross sectional configuration.

15. In a rotor assembly of the type having a plurality of permanent magnets, wherein the improvement comprises a non-metallic material that upon the application of heat reduces in size to secure the permanent magnets together.

16. The magnet assembly of claim 15, wherein the non-metallic material reduces in size at a temperature less than 200°C.

17. The rotor assembly of claim 15, wherein the non-metallic material comprises a polymeric resin material.

18. The rotor assembly of claim 17, wherein the polymeric resin material is a material selected from the group consisting of polyolefin type resins and polyester type materials.

19. The rotor assembly of claim 15, wherein the non-metallic material comprises an adhesive layer in contact with the permanent magnets.

20. The rotor assembly of claim 15, further comprising a cage to hold the permanent magnets.

21. The rotor assembly of claim 20, further comprising a worm gear permanently affixed to the cage.

22. The magnet assembly of claim 21, further comprising a worm gear removably affixed to the cage.

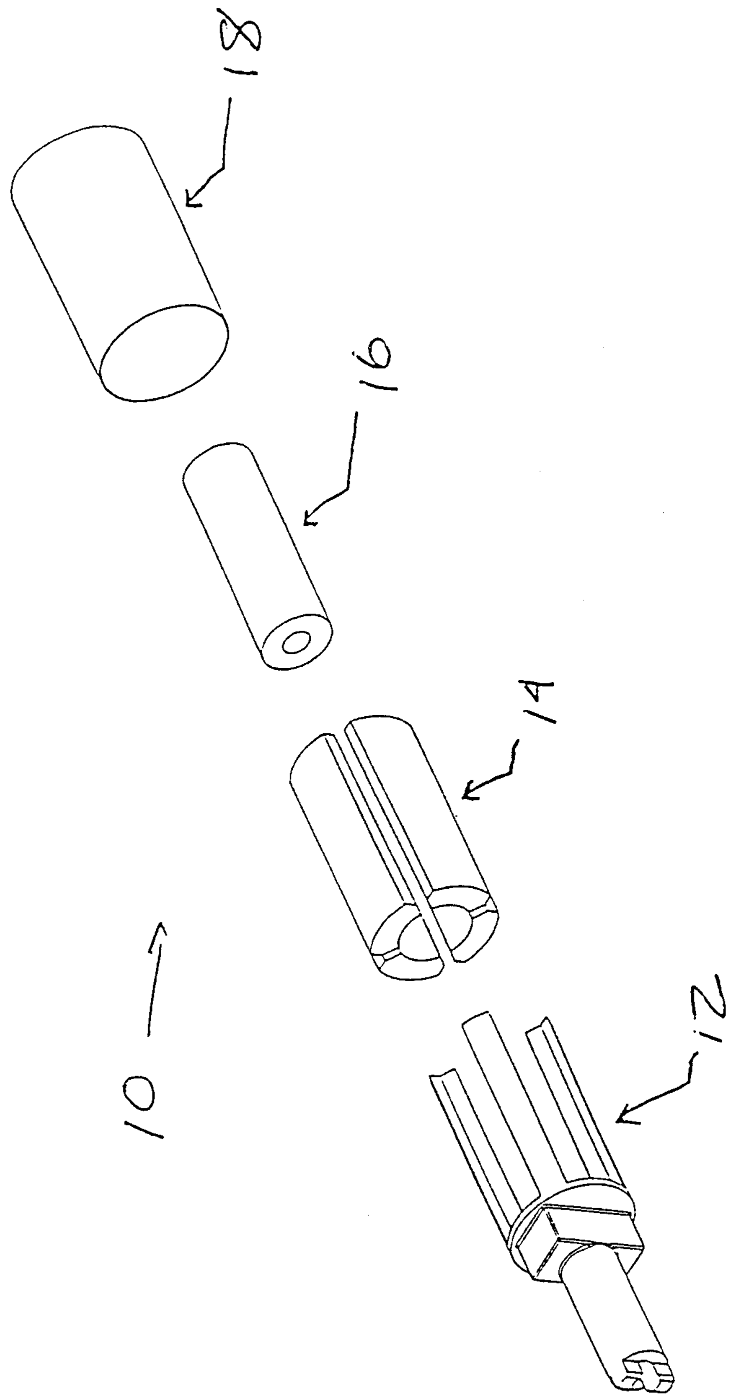
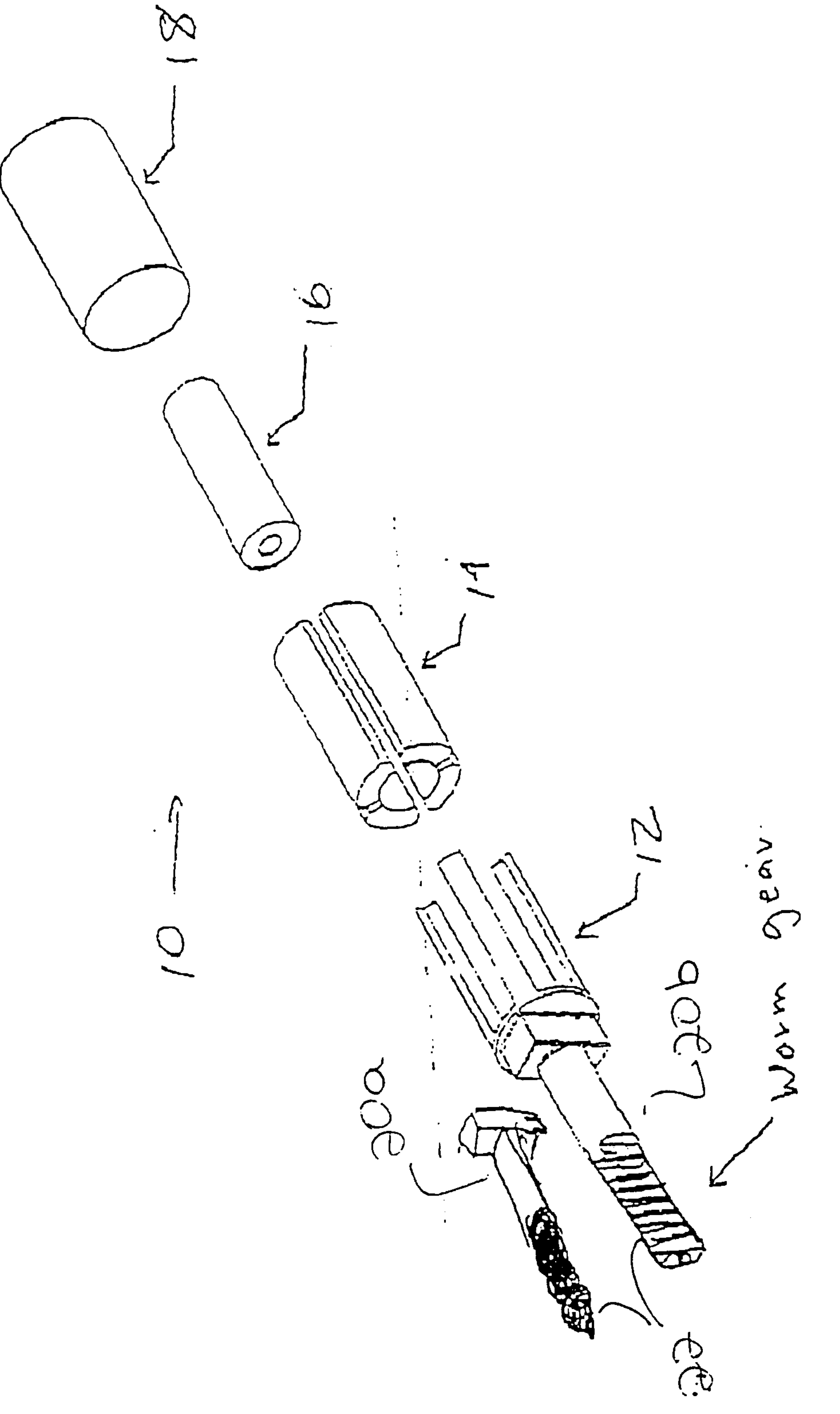


FIG. I

FIG. 2



INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 00/14789

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H02K1/28 H02K1/27 H02K15/03

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 7 H02K

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)

EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	PATENT ABSTRACTS OF JAPAN vol. 8, no. 91 (E-241), 26 April 1984 (1984-04-26) -& JP 59 011756 A (HITACHI LTD.), 21 January 1984 (1984-01-21) abstract; figures 1-3	1
X	PATENT ABSTRACTS OF JAPAN vol. 10, no. 263 (E-435), 9 September 1986 (1986-09-09) -& JP 61 088749 A (YASKAWA ELECTRIC MFG CO LTD), 7 May 1986 (1986-05-07) abstract; figures 1-3	1

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
5 September 2000	12/09/2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Beitner, M

4

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Intern nal Application No
PCT/US 00/14789

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
X	PATENT ABSTRACTS OF JAPAN vol. 18, no. 285 (E-1556), 31 May 1994 (1994-05-31) -& JP 06 054472 A (NIPPON KENTETSU CO LTD), 25 February 1994 (1994-02-25) abstract; figures 1-4 ---	1
X	PATENT ABSTRACTS OF JAPAN vol. 1997, no. 12, 25 December 1997 (1997-12-25) -& JP 09 224339 A (NIPPON SEIKO KK), 26 August 1997 (1997-08-26) abstract; figures 2,3 ---	1
X	PATENT ABSTRACTS OF JAPAN vol. 9, no. 159 (E-326), 4 July 1985 (1985-07-04) -& JP 60 035945 A (YASKAWA ELECTRIC MFG CO LTD), 23 February 1985 (1985-02-23) abstract; figures 1,2 ---	1
A	PATENT ABSTRACTS OF JAPAN vol. 11, no. 41 (E-478), 6 February 1987 (1987-02-06) -& JP 61 207162 A (TOKYO SANYO ELECTRIC CO LTD), 13 September 1986 (1986-09-13) abstract; figures 1-4 ---	1
A	FR 2 732 828 A (SOCIETE ELECTROMECANIQUE DU NIVERNAIS SELNI) 11 October 1996 (1996-10-11) abstract page 5, column 15-23; figures 4,5 ---	1,3,7, 10-13, 15-17,20
A	US 5 403 454 A (TANIGUCHI ET AL.) 4 April 1995 (1995-04-04) abstract column 2, line 38 -column 3, line 13; figures 1-4 ---	7
A	US 4 774 643 A (MC GINNIS ET AL.) 27 September 1988 (1988-09-27) abstract column 5, line 8-25; figures 1,2,5-13 ---	1,2,4,5, 10,11, 16-18
A	US 5 137 478 A (GRAF ET AL.) 11 August 1992 (1992-08-11) abstract column 4, line 21-65; figures 1-6 --- -/--	1,2,4,5, 10,11, 16-18

4

Inter   onal Application No
PCT/US 00/14789

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 97 23924 A (RAYCHEM S.A.) 3 July 1997 (1997-07-03) abstract page 3, paragraphs 2-7; figures 1A,1B ---	1-6,10, 16-19
A	FR 2 739 218 A (LEGRAND SOCIETE ANONYME) 28 March 1997 (1997-03-28) page 1, line 25 -page 2, line 19 page 3, line 11-14 page 4, line 5-11; figures 1-3 -----	1-6, 10-13, 15-19

4

INTERNATIONAL SEARCH REPORT

Information on patent family members

Inter   nal Application No
PCT/US 00/14789

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
JP 59011756 A	21-01-1984	NONE	
JP 61088749 A	07-05-1986	NONE	
JP 06054472 A	25-02-1994	NONE	
JP 09224339 A	26-08-1997	NONE	
JP 60035945 A	23-02-1985	NONE	
JP 61207162 A	13-09-1986	NONE	
FR 2732828 A	11-10-1996	NONE	
US 5403454 A	04-04-1995	JP 2866727 B	08-03-1999
		JP 4135735 A	11-05-1992
		US 5368811 A	29-11-1994
		DE 69129485 D	02-07-1998
		DE 69129485 T	01-10-1998
		EP 0477944 A	01-04-1992
US 4774643 A	27-09-1988	NONE	
US 5137478 A	11-08-1992	NONE	
WO 9723924 A	03-07-1997	NONE	
FR 2739218 A	28-03-1997	NONE	